

**ABSTRACTS - 2006**  
**JOINT MEETING OF ICHTHYOLOGISTS & HERPETOLOGISTS**  
**COMPILED BY M.A. DONNELLY AND K.E. COOPER**

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Alternative mating tactics in high and low density populations of the bluntnose minnow, *Pimephales notatus*

The bluntnose minnow, *Pimephales notatus*, is a hardy cyprinid fish found ubiquitously throughout Eastern North American drainages. This minnow has an extended breeding season ranging from mid-April to late August. Females deposit eggs in a monolayer on the underside of a slab rock that the male has prepared. The males of this species vigorously defend their nests and provide parental care to the developing eggs. The aims of this study were to determine if different alternative mating tactics were being employed by males in a high-density population versus a low-density population. By using five highly polymorphic microsatellite loci, we were able to genotype embryos from several nests along with their associated guarding males. By comparing the multilocus genotype of the guarding male to the multilocus genotypes of the guarded embryos, the genetic signature of certain alternative mating tactics, such as cuckoldry, nest-guard swapping, and nest takeover events were revealed. The frequency of these events in the high-density population was then compared to the frequency of occurrence in the low-density population. Our findings support those found in a similar molecular parentage study on *Pimephales promelas*. In the high-density population the guarding males sired an average of 81% of the eggs in the nest. However, in the low-density population this percentage dropped to only 69%. The total number of parents that contributed to each nest was similar for both populations, averaging around 6 adults including the guarding male. Allopaternal care via nest-guard swapping was heavily employed in the low-density population (occurring in all of the 5 nests sampled), compared to allopaternal care in 1 of the 5 nests sampled in the high-density population.

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### Relationships between predation and palatability of larval anurans in eastern Texas

Larval anurans occur along a gradient of water permanency ranging from ephemeral to permanent. Larval anuran predators also occur along this gradient. In permanent waters, fish are the dominant predators while ephemeral pools are dominated by invertebrate predators. Larval anurans must possess anti-predator mechanisms in order to survive with these predators. We tested a secondary anti-predator mechanism (palatability) in twelve species of anuran larvae (*Acris crepitans*, *Bufo valliceps*, *B. woodhousei*, *Gastrophryne carolinensis*, *Hyla cinerea*, *H. versicolor*, *Pseudacris crucifer*, *P. triseriata*, *Rana catesbeiana*, *R. clamitans*, *R. sphenoccephala*, and *Scaphiopus holbrookii*) using four common predators (*Lepomis cyanellus*, *L. macrochirus*, *Anax junius*, and *Procambrus nigrocinctus*). Palatability was determined by presenting larvae to predators and recording the behavior of the predator to determine if the larvae were distasteful. We also tested for ontogenetic shifts in palatability in the twelve species of anuran larvae. We observed differences in palatability among the twelve species and some species also showed ontogenetic shifts in palatability. These differences may be attributed to differences in life history traits and/or evolutionary histories.

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### Population dynamics of the Grotto Sculpin (*Cottus carolinae*) in Perry County, Missouri

The Grotto Sculpin, endemic to caves in Perry County, was listed as a federal candidate species in 2002 and assigned a priority number of 2, indicating an imminent threat to the species exists. Due to the unstable nature of the cave environment in Perry County, Missouri, it was imperative to obtain baseline data on the population ecology of Grotto Sculpin and factors influencing their ability to repopulate caves in response to a catastrophic event (e.g., a contaminant spill). As with most cave species, few quantitative data are available on general life history characteristics. The objective of this study was to examine population dynamics of the Grotto Sculpin in two cave populations and their primary resurgence stream. Cave sites were divided into 10 m increments and individual fish were tagged using unique alphanumeric VI alpha tags at four to six week intervals beginning August 2005. A total of 605 fish were tagged during the study. Approximately 70% of individuals in cave populations moved less than 20 meters between sampling intervals with almost equal upstream and downstream movement. Maximum movement of an individual was 270 meters between August and February. There

was no correlation between eye size and movement patterns. A fish kill was observed in the upstream portion of one of the cave sites. In the six months subsequent to the fish kill only three to four individuals were observed, with no upstream movement of tagged individuals into the affected region of the cave. Based on our data, the relatively sedentary nature of the Grotto Sculpin may limit their ability to recolonize habitats. Population estimates and habitat use for each sampling site will also be discussed.

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### A spatial analysis of young fish communities in off-channel habitats of Pool 25, Mississippi River

Reproductive success of fishes inhabiting modified river systems has been impacted by alterations in flow regimes and loss of nursery habitat. Effective management and restoration is hindered by a lack of understanding of nursery habitat requirements for riverine fishes. During late spring/early summer of 2000, 2001, and 2002, we sampled young (late larvae/early juvenile) fish communities with a fine-meshed seine at 14 off-channel sites in a 10.0-km reach of Pool 25, Mississippi River. Sites represented three habitat types based on geomorphology and distance from the main channel: backwaters (lentic habitats > 1 km from the main channel), island borders (slack-water areas bordering islands), and island sloughs (lentic habitats on islands). Fifty taxa were collected, including some that are rarely collected in high numbers during early life stages (e.g., *Cycleptus elongatus*, *Macrhybopsis storeriana*, *Percina shumardi*, and *Hypophthalmichthys* spp.). Nonmetric multidimensional scaling and multi-response permutation procedures identified significant structuring ( $p < 0.05$ ) of young fish communities along a gradient from backwaters to island borders during all three years. Community patterns generally corresponded with spawning characteristics of adults, where backwater sites and island borders primarily provided nursery habitat for species that spawn in lentic (e.g., centrarchids) and lotic areas (e.g., *Cycleptus elongatus*, *Carpiodes* spp., and *Hiodon tergisus*), respectively. Island sloughs were intermediate, providing nursery habitat for species spawning in both lentic (e.g., *Ictiobus* spp. and *Lepisosteus* spp.) and current (e.g., *Notropis atherinoides*, *Aplodinotus grunniens*, and *Percina shumardi*) habitats. With the reduction and degradation of floodplain habitat, islands within the mainstem are providing important nursery areas for river fishes. This study demonstrates the value of conserving or creating heterogeneity within off-channel areas to provide nursery habitat for a diversity of riverine fishes.

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### Fish community structure and environmental gradients in floodplain wetlands of the Arkansas River

Large rivers and associated floodplains were historically dynamic, diverse ecosystems, but most have been modified to varying degrees. Lack of data typically hinders conservation/restoration efforts in these regulated systems. We initiated a study of fish communities in floodplain wetlands of the Arkansas River to understand current patterns of diversity and environmental gradients. During summer 2005, we sampled fishes with a seine (3.1-mm mesh), mini-fyke nets (3.1-mm mesh), and experimental monofilament gill nets (3.8 to 8.9-cm mesh) at 31 sites along a 174-km reach of the Arkansas River (Pool 5 to Pool 9). Sites ranged in size from 0.5 to 390 ha and varied in degree of connectivity to the main channel (contiguous, intermittent, and isolated). We collected 62 taxa, and richness ranged from 5-32 species across sites. Samples contained a number of species with few previous records from the Arkansas River system (e.g., *Carpionodes cyprinus*, *Etheostoma fusiforme*, *Lepomis symmetricus*, and *Notropis maculatus*). Nonmetric multidimensional scaling ordination identified structuring of the fish community along a gradient from intermittently connected and isolated floodplain wetlands characterized by high vegetative cover, low dissolved oxygen, and low pH (e.g., *Centrarchus macropterus*, *Elassoma zonatum*, *Amia calva*, and *Aphredoderus sayanus*) to contiguous backwaters having low vegetative cover and relatively high dissolved oxygen and pH (e.g., *Dorosoma petenense*, *Menidia beryllina*, *Carpionodes carpio*, *Lepomis megalotis*, and *Opsopoeodus emiliae*). These data underscore the value of submergent vegetation to wetland fishes and suggest a mosaic of wetlands supporting a diversity of fishes continue to occur along the Arkansas River despite extensive modifications to the system.

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### Convergent evolution of an erectile spine apparatus in loricarioid fishes

The opercular apparatus in teleost fishes is known for its implication in mouth opening, where opercular rotation is mechanically coupled to mandibular depression, whether directly (through the interopercular bone) or indirectly (through the hyoid bar). In at least two lineages of loricarioids, the opercular system has independently become involved in a system for aggressive behaviour. First, hematophagous trichomycterids (Vandelliinae) are known to use an erectile apparatus with spines to anchor themselves in gill cavities of fishes (or other unfavourable cavities). Secondly, some loricariids, especially those of the Ancistrini,

have an apparatus that allows a rapid erection of large cheek odontodes during agonistic behaviour, especially between males. Even though both systems superficially seem similar, the underlying skeletal and muscular elements show two different evolutionary strategies towards a superficially similar but mechanically different biological role. In this study, we compared the erectile spine apparatus of a vandelliine trichomycterid with that of an ancistrine loricariid, as well as compared it with the spineless opercular apparatus of other loricarioids (a basal trichomycterid and callichthyid, as well as some other loricariids). The detailed morphology of skeletal, muscular and ligamentous components was investigated, including the use of graphical 3D-reconstructions. The main differences involve the skeletal element supporting the spines (interopercule and opercule *vs* cheek plates), which may be related to the absence of the interopercular bone in loricariids, and the implication on the spines themselves (none or spreading of the spines). Similarities involve the rocker bone that causes the erection of the spinous apparatus (*i.e.* opercule with anterior process) and the muscles responsible for it (*i.e.* opercular muscles), including degrees of muscular hypertrophy.

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Loricarioid morphology: What makes a scraper?

Scraping food items from a solid substrate has proven to be a successful way of feeding in several teleost lineages. However, being efficient in doing so requires some morphological adaptations. Structural transformations can be observed at different levels, with the oral dentition being the most common one. However, within the lineage of the Loricarioidea, evolutionary decoupling events have resulted in an astonishingly gradual transformation of skeletal and muscular elements of the cranial system that can be considered an improvement of algae scraping mechanisms. The most striking examples are (1) the evolution towards an increased mobility of the premaxillary bones, but coupled to an increased motor control of their movements, and (2) a spatial reorientation of the lower jaw and associated mouth opening and mouth closing muscles. Exactly 20 years and 10 years after the publications by Schaefer and Lauder, providing morphological evidence for the decoupling hypotheses in loricarioids, an update is given. New evidence is provided based on the microscopic anatomy of both ontogenetic and adult specimens in some loricarioid representatives, as well as based on preliminary kinematic analyses of feeding in loricariids.

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## Reconstruction of phylogenetic relationships of the Cypriniformes (Actinopterygii: Teleostei) using the nuclear rhodopsin gene

Cypriniformes constitute one of the most diverse orders of freshwater fishes in the world. One of the main objectives of the collaborative Cypriniformes Tree of Life (CToL) project is to resolve the phylogenetic relationships for 1000 representative species of the group using molecular and morphological evidence. The current research will report on preliminary results demonstrating the utility of the nuclear gene rhodopsin in helping to resolve cypriniform relationships. Rhodopsin is a member of the opsin gene family, and arose due to a duplication event prior to the diversification of vertebrates. Rhodopsin also lacks introns in bony fishes, a feature unique among opsins. This line of evidence highlights the usefulness of rhodopsin in understanding evolutionary relationships within vertebrates. Specimens were collected from several worldwide locations including the China, Canada, Japan, Mexico, Taiwan, and United States. Rhodopsin sequence (850 base pairs) was obtained for 175 cypriniform species from each of the six cypriniform families (Cyprinidae, Psilorhynchidae, Cobitidae, Balitoridae, Gyrinocheilidae, and Catostomidae). Sequences were analyzed using maximum-parsimony (MP), maximum-likelihood (ML), and Bayesian methods. The results will be discussed, with special emphasis on both the usefulness of rhodopsin in molecular systematics and whether the major clades within Cypriniformes comprise monophyletic groups.

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## The geography of adaptive radiation: Gene flow and natural selection acting on threespine stickleback in an Alaskan lake/stream system

How do organisms diversify? The relative influence of gene flow and natural selection on evolutionary diversification in nature is a long-standing question lacking a clear answer. Understanding the relative importance of these factors has implications for both the origin of diversity within species and the origin of species. Threespine stickleback fish (*Gasterosteus aculeatus*) are an excellent system to assess the influence of gene flow and natural selection. Natural selection has clearly played an important role on the evolutionary diversification of post-glacial stickleback populations, but gene flow may also constrain adaptive divergence under certain circumstances, as indicated by previous research on populations at lake-stream ecotones. In this study, I evaluate the importance of these factors on diversification of stickleback populations throughout the Little Meadow Creek system in Cook Inlet, Alaska. The system includes stream and lake populations occurring in close proximity, with the lakes differing considerably in availability of benthic (shallow water with complex structure) and limnetic (deep water lacking structure) habitat.

The association between body shape phenotypes and habitat-types was evaluated taking geographic distances among populations into account. In addition, the relationship between genetic distances (based on microsatellite markers) and phenotypic distances was evaluated in a geographic context. The results are complex, but the distribution of microsatellite alleles indicate high levels of gene flow among geographic neighbors regardless of the habitat-type, homogenizing neutral genetic variation. In contrast, natural selection based on the habitats populations occupy acts to maintain phenotypic differences. In some cases, gene flow or local extinction and recolonization from lakes appears to strongly influence the microsatellite and body shape variation of stream populations. This may be due to differences in population size between lake and stream populations or the inability of stickleback to overwinter in certain stream sites.

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#### Distribution of the swimbladder parasite *Anguillicola crassus* in American eels in the Northeastern Atlantic

In 1995 the swimbladder nematode *Anguillicola crassus* was first discovered in the United States in wild American eels (*Anguilla rostrata*) from South Carolina and later in Southeastern MA in 2003. To explore the spread of this invasive parasite into the northeastern Atlantic coastal regions, yellow stage American eels were collected in the summer of 2005 by electrofishing from 26 freshwater locations where the presence of the parasite had never been documented. Sites ranged from the Pawcatuck River, RI (Lat: 41°26.265N) to the East Machias River, ME (Lat: 45°00.054N). To document a change in prevalence, silver phase eels were also collected during the fall migration from the Paskamansett River (S. Dartmouth, MA) in both 2003 and 2004. All Rhode Island (n=3) and Massachusetts (n=10) sites were infected, with site prevalence ranging from 7% to 76%. Cape Cod did not create a natural barrier for the northern spread of the parasite as eels were infected in the 6 Northern Massachusetts sites and in 7 of the 13 in Maine. Parasite prevalence increased in silver eels between 2003 and 2004. Parasitic infection did not have a significant effect upon log<sub>10</sub> weight/length relationships in 24 of the 26 sample locations. Parasites varied in length from 2-32 mm with intensity ranging from 1-18 worms. Mean parasite intensity ranged between 1.4 to 5.3 parasites per eel. Our findings suggest the current northern limit of *Anguillicola crassus* may be near the Penobscot River watershed, ME (Lat: 44°45.306N). Prevalence in the 26 freshwater sites did not represent a significant latitudinal trend however, high prevalence corresponded with busy shipping ports, suggesting that parasite distribution may be related to ballast water transfer.

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## Species richness and cladal diversity of the North and South American ichthyofaunas.

The diversity profiles of the North and South American ichthyofaunas are characterized by a few highly diverse taxa, in which the majority of the species are members of just two clades, and also a 'long tail' of species-poor taxa, in which a majority of clades are represented by only one or two species. This sort of frequency distribution with the shape of 'hollow curve' characterizes most regional faunas, and is well described by a power function with an exponent close to -1. Power laws describe empirical scaling relationships in a broad range of natural phenomena and are widely used to explain the ecological mechanisms that constrain biodiversity. However, the relationships between species richness and higher-level cladal diversity remain poorly understood and the mechanisms that promote differential net diversification at a regional level are almost entirely unknown. Here we use newly compiled datasets of freshwater fishes from the Mississippi and Amazon super-basins to show strong correlations of species-richness with the mean body size, phylogenetic age, and the geographic range of clades. The taxa investigated include the 6,651 species representing at least 146 phylogenetically independent clades in freshwaters. Relationships between species richness and cladal diversity closely match those of null models based on universal scaling functions, providing expected values for assessing disparities in the species richness of otherwise comparable clades.

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### 'Cope's rule' as an exception to the rule in fish

Cope's rule, which describes phyletic body-size increase, is a commonly presumed trend in animal evolution and has recently been attributed to putative selective and ecophysiological advantages. However, the validity of this 'rule' has been questioned from many theoretical and empirical perspectives. We report results of a newly compiled dataset of size records for more than 24,000 living and fossil fish species, including representatives of all principle fish clades (i.e., the 14 post-Ordovician clades, c. 443 Ma.) and taxa inhabiting most of the worlds aquatic habitats and biogeographic regions. This dataset is the largest of its kind to date and provides the first opportunity to assess global patterns of vertebrate size evolution. Phylogenetic and statistical analyses recover little evidence for directed trends in size; rather, the pattern for most clades is an origin at small size (10-20 cm) and an early increase in size diversity. Ancestral sizes estimated from extant taxa alone are approximately 5-

fold larger than estimates from fossils, with the estimates from fossils regarded to be more reliable. Among living fish families 35% exhibit a right-skewed size frequency distribution, 12% exhibit a left-skewed size frequency distribution, and 53% exhibit size distributions that do not deviate from a uniform distribution.

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Reproductive biology of the massasauga (*Sistrurus catenatus*) from south-central Illinois

This study was conducted at Carlyle Lake, Clinton County, Illinois. Preserved specimens examined for this study are housed in the Illinois Natural History Survey collection. Based on preserved snakes females initiate vitellogenesis in the summer/fall. Vitellogenic follicles reach 20 mm in length by late September. Follicles overwinter at this size and resume growth in the spring. Ovulation occurs the later in the spring. Spermatogenesis begins June and peaks in August and September. The diameter of the seminiferous tubules is less than 200  $\mu$ m in May and reaches a diameter of 300  $\mu$ m in late July to early September. The sexual segment of the kidney parallels the diameter of the testis. Sexual segment tubules are lowest in the early part of the active season and peak in diameter and secretory activity in August through September. Mating and male-male combat occur primarily in the summer when the sexual segment of the kidney is hypertrophied. As in other species of snakes, the sexual segment of the kidney never regresses completely, indicating that testosterone levels are elevated throughout the year. Elevated plasma testosterone may be necessary for long-term sperm storage in the vas deferens. This elevated testosterone may also account for the presence of reproductive behaviors sometimes observed in snakes.

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Molecular genetic assessment of the effects of urbanization on salamander populations in the greater Charlotte, North Carolina area

With the global population now over 6 billion people, urbanization and resulting habitat fragmentation is rapidly becoming one of the greatest threats faced by wildlife. As suitable habitat for species are reduced to smaller and smaller patches that are farther and farther apart, species become exposed to a host of problems associated with population fragmentation. Specifically, smaller and more isolated

populations become prone to extinction due to greater susceptibility to environmental and demographic stochasticity and can suffer from genetic problems associated with a small gene pool (decreased variation, inbreeding depression, and genetic drift). Therefore, studies of the effects of urbanization on gene flow between populations are urgently needed. This study examined the effects of habitat fragmentation on within and among population processes in spotted salamanders (*Ambystoma maculatum*) in the greater Charlotte, North Carolina area. We addressed two primary hypotheses: (1) degree of connectedness among populations across the fragmented landscape is inversely related to distances between populations and intensity of urbanization and (2) genetic variation within populations is inversely related to level of degradation of surrounding habitat. To address these hypotheses, we studied five populations of salamanders that varied in distance from nearest neighboring population and in quality of surrounding habitat. Genetic analyses were performed using genotypic data of 30 individuals per population at six microsatellite DNA loci. We used GIS to quantify habitat and distance variables. Results will be discussed in the context of habitat management, specifically the need for establishment of metapopulations such that multiple populations and breeding ponds are interconnected by contiguous habitat.

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### Molecular phylogenetics of the minnow genus *Pteronotropis* (Teleostei: Cyprinidae)

The genus *Pteronotropis* (originally recognized as a subgenus of *Notropis*) consists of nine species distributed along the Gulf Slope from Louisiana to Florida, and along the Atlantic Slope as far north as South Carolina. One species, *P. hubbsi*, has a disjunct distribution in Southern Arkansas and Northern Louisiana. These fish have distinctive coloration patterns that include bright red-orange to yellow striped dorsal, caudal and anal fins, and a broad dark lateral band extending from the head to the caudal peduncle. The genus is divided into two groups based on morphological characteristics. The first group contains the species *P. hubbsi* and *P. welaka*; these are relatively slender bodied fish that develop enlarged dorsal fins. The second group, consisting of *P. euryzonus*, *P. hypselopterus*, *P. merlini*, *P. grandipinnis*, *P. stonei*, *P. metallicus*, and *P. signipinnis*, comprises more deep bodied fish that lack an enlarged dorsal fin. Preferred habitat ranges from backwater bayous to small sluggish tannin stained streams with ample vegetation. Phylogenetic relationships within *Pteronotropis* have been controversial for some time, with no study supporting monophyly of the genus. However, only one of these studies focused solely on the genus. That study, using sequences of the mitochondrial gene cytochrome *b*, failed to show support for the monophyly of *Pteronotropis*; however, existence of a monophyletic group could not be ruled out. Using variation in the first intron of the ribosomal S7 nuclear gene and the nuclear coding gene RAG1 with parsimony and Bayesian methods of analysis, I address the phylogenetic relationships within this genus.

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### Differences in herpetofaunal communities at three Sonoran Desert golf courses varying in age

Golf courses are often promoted as providing open space for wildlife, and in the arid southwestern United States, golf courses also provide supplemental water from irrigated landscape, runoff, and water features, such as ponds. In 2004, we surveyed for reptiles and amphibians on three desert style golf courses, which ranged in age from 4 to 20 years, near Tucson, Arizona. We conducted diurnal visual encounter surveys on foot for reptiles in areas immediately surrounding each golf course (on-course) and in nearby desert areas (off-course). At night, we surveyed for reptiles and amphibians along the golf cart path while riding a bicycle or golf cart. We completed 72 morning on-course surveys, 24 off-course surveys, and more than 200 nocturnal cart path surveys. We encountered more lizards per hour on golf courses than in nearby desert areas, and the oldest golf course had the greatest number of lizards. We found the highest diversity of snakes at the newest golf course. We discuss how our results may reflect changes in reptile and amphibian communities on golf courses over time, and the extent to which golf courses may provide sustainable habitat for reptiles and amphibians.

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### Preliminary list of fishes from the Smithsonian Tropical Research Institute Expedition to Curacao with comparison to previously formulated lists

In 2005, the Smithsonian Tropical Research Institute sponsored a collecting trip to Curacao and Klien Curacao, as part of a grant to Ross Robertson, to document the fishes of the greater Caribbean region. The Curacao Sea Aquarium provided support and accommodations for the research team. Collections were made at 29 stations between 2 January and 13 January 2005. Most of the collections were made using rotenone, which is the only effective method of collecting the cryptic fishes. A total of 6,114 specimens of 119 taxa were collected. Along with those documented by

Metzelaar (1919), Fishbase, and several web-based museum collections, we present our findings from Curacao to document a preliminary list of fishes from that region.

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Variation in edge association among different habitat types by a local population of the Timber Rattlesnake

Patterns of edge association have been studied extensively in a variety of taxonomic groups (particularly birds, mammals, insects, and plants). However, we currently lack sufficient data on edge association for many reptiles and amphibians. In this study we examined patterns of edge association by a local population of timber rattlesnakes, occupying a suburban wildlife area in western St. Louis County, Missouri. The study landscape consists of a variety of natural and human-maintained habitats that timber rattlesnakes are known to utilize (e.g. upland forest, bottomland forest, prairie, and glade) set in a matrix of linear and rectilinear non-habitat (e.g. streams, roads, buildings, and pasture). Our specific goals were to: 1) characterize patterns of edge association among different habitat/non-habitat boundaries; 2) test whether or not such patterns were non-random within patches, and 3) discuss the implications of our results for classification-based analyses of habitat selection for this species.

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Utility of GIS information and GARP modeling in detecting and predicting critical habitat: Examples from the diverse ichthyofauna of Alabama

One may wonder if agencies and private conservation organizations have identified necessary critical habitats of imperiled species (listed or not) and if these habitats are receiving protection for species? One may also wonder how these agencies and organizations are determining what habitat is appropriate for species, and what characteristics of species are being used in estimates? Recent advances in information sciences and modeling of species distributions, their use of habitats, and large-scale coverages of different information in a georeferenced system like GIS have provided powerful findings that far surpass a standard 'consultant's' or 'politician's' view of what is or should be considered protected habitat for imperiled species. This has been done primarily through GARP or Species Analys, both powerful tools for the synthesis of biotic and abiotic information related to the locations where an imperiled species is and is not found to exist. Critical habitat is defined in the endangered

species act of 1973 as areas within a listed species' current (at time of listing) range that contain the physical or biological features that are essential to that species' conservation or that for some reason require special management. This research project will use the GARP modeling system to predict the distribution of all freshwater species deemed imperiled in recent publications on the Alabama fish fauna, and three threatened and endangered Alabama Fishes: Gulf Sturgeon (*Acipenser oxyrinchus desotoi*), Slackwater Darter (*Etheostoma boschungii*), and Alabama Cavefish (*Speoplatyrhinus poulsoni*). Predicted distributions will be compared to critical habitat determined by the USFWS and protected habitats by the State of Alabama. Furthermore, predicted habitat of these fishes will be projected onto the CCM3 climate model to predict future range shifts. These analyses will provide insight into which aquatic systems should be designated as critical or protected habitats for these fishes.

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**On the road with herps: The importance of asking for directions**

As the amount of research on the impacts of roads on reptiles and amphibians increases, scientists find themselves at a stage where determining the appropriate management and conservation direction is critical. While many road impacts have long-term effects, researchers are hampered by the inevitable time constraints imposed by funding agencies and, in the instance of many reptiles, the human life span in relation to their study organism. These complications are subsequently confounded by the necessity to prioritize research. Having science-based conservation decisions answer all questions on all species in all locations over a variety of spatio-temporal scales would be ideal, but is not achievable. The difficulty of long-term complex studies can be mitigated by performing shorter-term or smaller studies that elucidate general trends while specifying areas of research prioritization. Data are presented from recent studies conducted on the Savannah River Site, South Carolina, USA on behavioral and demographic trends of snakes surrounding roads and researcher detection biases. Combined results yield an information sum that is greater than the whole. These pooled data serve as a case study to demonstrate how short-term studies can effectively be used to identify species of concern and prioritize research topics. Additionally, this synthesis is indicative of the research mileage that can be covered when using multiple studies to assess an ecological issue. Further discussion includes the status of existing data on road impacts on herpetofauna. Lastly, current and recommended management approaches and the feasibility of solution articulation are presented.

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## The *Atelopus* Initiative: A regional collaborative response to amphibian population declines in the tropical Andes

Global amphibian declines are among the worst current biodiversity loss events; it is estimated that almost one third (32.5%) of amphibian species are globally threatened. In the New World, which hosts more than half of the recognised amphibian species of the planet, 39% of species are threatened with extinction. One of the centers of amphibian diversity - and extinction - in the New World is the tropical Andes hotspot, comprised by the nations of Bolivia, Colombia, Ecuador, Peru and Venezuela. All of these countries can be found among the 15 most amphibian-diverse nations in the world, together hosting over 1400 species, comprising 24% of global amphibian diversity. The *Atelopus* Initiative (AI) arises as a response to address the critical situation of tropical Andean amphibians. It is a multinational collaborative and integrative effort that entails the tropical Andean nations of Bolivia, Colombia, Ecuador, Peru and Venezuela, and together with scientists from other regions, seeks to boost research and conservation of amphibians and places of high amphibian diversity in the region. The main goal of the *Atelopus* Initiative is to address the amphibian extinction crisis in the tropical Andes through capacity building (field courses training young researchers in standard amphibian survey and monitoring techniques), research (allocation of seed grants towards projects addressing amphibian declines and conservation status of amphibians), proposals of conservation priorities (consolidated recommendations and plans resulting from AI sponsored research), conservation strategies (integration of results into a general framework with specific working plans) and outreach (e.g. mass production of multi-authored identification field guides of endangered amphibians, making them freely available to all interested parties). The *Atelopus* Initiative is thus an important stepping stone in the regional implementation of the recently proposed global Amphibian Conservation Action Plan, which outlines current and future research and conservation priorities for declining amphibians.

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Investigating the factors that influence species distributions: A multidisciplinary approach using the Mountain Chorus Frog (*Pseudacris brachyphona*)

The factors that shape species distributions have been a central concern for evolutionary biologists, biogeographers, and ecologists, for hundreds of years. However, it has become increasingly important to understand the abiotic and biotic influences on species distributions for conservation purposes. Global warming, invasive species, and habitat fragmentation have escalated the need to understand these factors and how they may coalesce to create species boundaries.

Phylogeography has been used extensively as a way of determining the effects of geographic features on species distributions and to explain intra-specific genetic patterns. However, relying entirely on geographic features to explain patterns of genetic variance may overlook other abiotic influences on a species distribution, such as climate. This study combines traditional phylogeographic techniques with bioclimatic modeling in order to gather a more complete understanding of the abiotic factors that regulate the distribution of the Mountain Chorus Frog (*Pseudacris brachyphona*). *P. brachyphona* is a small woodland frog that is found in high elevations in areas of the Appalachian mountain chain. Intra-specific genetic lineages were established using 12S-16S and Cyt-b mitochondrial sequences. Climatic niche models were then created for each lineage. These climatic niche models were integrated into traditional phylogeographic techniques. Preliminary data suggests that the boundaries between disjunct populations of *P. brachyphona* may have been maintained by climatic barriers.

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Can morphology be misleading in loricariid phylogenetics?

The rapid increase in the number of molecular phylogenies has been a boon to systematics and understanding the evolution of morphology. Although no particular dataset has an advantage over others, when repeated patterns emerge in different genes, but are different from a morphological hypothesis, it may be the morphology that is in error. In the Loricariidae, there are published datasets on 12s and 16s rRNA genes and our Cytochrome-b dataset. All of the molecular datasets do not have near the taxon sampling that the morphological datasets do, but they are all showing at least one consistently different pattern from the morphology. Where the morphology has the Ancistrini of the Hypostominae a monophyletic sister group of the Pterygoplichthini, and this clade sister to the Hypostomini, the molecular hypotheses suggest a paraphyletic, basal Ancistrini and a paraphyletic Pterygoplichthini. In the morphology, the support for the Ancistrini is weak in terms of number of characteristics, but thought to be strong in terms of type of characteristic. The derived opercle morphology of ancistrins serves to operate a patch of evertible cheek plates with hypertrophied odontodes. This morphology is not seen in any other fishes; however, it could potentially be a misleading characteristic. Indeed, even in the morphology, the character has been lost once and weakened several other times. In addition to the characters aligned with evertibility, characters of derived jaw morphologies are also supporting clades that do not appear in the Cytochrome-b dataset. Here there may be an even clearer indication of undetected homoplasy in the morphology, as it is clear that the derived, highly-angled jaws and supporting characteristics have evolved multiple times even in the morphological dataset. With consistent evolutionary pressures to develop similar morphologies, highly selected traits should be examined with caution.

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### Preliminary identification and assessment of causes of the recent declines in river herring populations

Both species of river herring (Alewife, *Alosa pseudoharengus*, and Blueback Herring, *Alosa aestivalis*) exhibited significant population declines along the U.S. east coast in spring, 2005, following several years of slower declines. In Massachusetts, the number of adult spawners observed in most rivers decreased from 50-90%. While river herring populations tend to be cyclical in nature, the present downturn is greater and more persistent than any previously observed. Several factors were identified that may have caused this recent decline. These factors are acting on populations that were previously stressed from degradation/loss of spawning habitat and inadequate fish passage. Catch curves indicate that total mortality is high ( $Z=1.6$ ) and few fish are repeat spawners. Additionally, the age structure is truncated with a lack of fish older than age 5. Natural mortality is likely increasing as many important river herring predators including striped bass, seals, and cormorants are increasing in number. By-catch of river herring in offshore fisheries has been identified as a potentially important source of mortality but expansions from sea sampling data are highly variable. Our coastal trawl survey identified smaller year classes from 2000 and 2001 resulting from drought conditions in those years. These smaller year classes contributed to the observed decrease in abundance in the spawning runs in spring, 2005, as age 4 and 5 adults make up the majority of spawners. At present, no single factor can be identified as the key to the river herring population declines. Rather, the recent declines were likely the result of several factors acting in concert.

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### Caudal skeleton in cypriniforms and other ostariophysans: Distal radials

Distal radials are generally poorly known in actinopterygians, especially the distal caudal radials in teleosts. This could be due to the fact that they have been overlooked because of their small size, their distal position and by being hidden between lepidotrichia. Distal caudal radials are cartilaginous plates or nodules of cartilage or small bones placed posterior to the cartilage-capped distal end of the last few hemal spines, hypurals, and posterior neural spines. Distal caudal radials may be

present posterior to one or more of these structures, but not posterior to all. A study of many teleosts reveals that an elongate cartilaginous plate is associated to the distal cartilage-capped distal end of the hemal spines, parhypural and hypurals 1 and 2 in elopiforms. In addition, small distal radials are associated to the dorsalmost hypurals. In contrast to this pattern, series of cartilaginous plates are associated to many neural spines in some argentinoids whereas only two well-developed plates are present in gobiids. Others, like channids, lack distal radials. Among ostariophysans, gonorynchiforms and characiforms may have a reduced ventral plate associated to the last hemal spines, and occasionally, a few nodular distal cartilages. Siluriforms seem to lack distal caudal radials. The diversity found in cypriniforms may include two plates in the ventral lobe plus the addition of dorsal plates in certain cyprinid genera, the presence of small distal radials in other genera, to the absence of distal radials in cobitids. Preliminary research permits the identification of distinct patterns characteristic of certain genera and families and also evolutionary trends within cypriniforms, as well as in other teleostean groups. The phylogenetic significance of these elements have not been investigated yet.

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Assessing predation on *Thamnophis sirtalis* exhibiting a potential aposematic cue

The *Thamnophis sirtalis* (garter snake)–*Taricha granulosa* (newt) system is an example of a reciprocal interaction where predation by the snake has led to increased tetrodotoxin (TTX) toxicity in the newt which has in turn led to increased resistance in the snake. We hypothesize that *T. sirtalis* have evolved the ability to eat toxic newts at least in part due to multi-level trophic interactions. *T. sirtalis* is one of the most generalist predators among *Thamnophis* and there is no evidence suggesting that newts comprise a significant proportion of *T. sirtalis*' diet, so they need not risk ingesting a potentially fatal meal for nutritional reasons. Therefore, other selective agents such as higher level predation on the snakes may be driving the reciprocal relationship between resistance and toxicity in this system. The ability of *T. sirtalis* to consume toxic newts and sequester the toxin in their liver for up to seven weeks makes them a potentially harmful prey item for avian predators. In addition, among populations of TTX resistant garter snakes, resistance is correlated with red coloration, which may function as an aposematic cue to visual predators such as birds. We tested the adaptive function of the red color morph as an aposematic cue by placing model snakes of the red and non-red color morphs in the field to measure avian attack rates. In populations where the red color morph has evolved, we predicted that birds would attack the non-red color morph with greater frequency

than the red color morph. We conducted an additional test using both stationary and moving snake models to determine which is a more efficient and effective field tool.

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Seasonal ultrastructure of the oviduct of the American Alligator, *Alligator mississippiensis*: Sperm storage as a possible reproductive tactic

Sperm storage is widespread in female reptiles but has not definitely been demonstrated in crocodylians. This study describes seasonal variation in the microscopic anatomy of the oviduct of the American alligator, *Alligator mississippiensis*, with primary objectives of determining whether sperm storage and special glands for sperm storage exist. The region of the oviduct where sperm storage occurs and the time frame during which sperm are stored are of interest because of the variation known in other vertebrate groups and possible phylogenetic implications. Female alligators are being collected in southern Louisiana at four main points throughout the year: before mating, directly after mating but prior to ovulation (i.e., the sperm storage period), during nesting, and after the nesting period. Microscopic anatomy is described using light microscopy, transmission electron microscopy, and scanning electron microscopy. The results presented are preliminary, as this is the initial year of a two year sampling effort.

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The genetic response of *Taricha granulosa* to the 1980 eruption of Mount St. Helens

With widespread amphibian declines becoming more prevalent, the ability of amphibians to recover, numerically and genetically, from environmental disturbance is a major concern. I examined the effects of the 1980 eruption of Mount St. Helens on the genetic structure of three populations of *Taricha granulosa*, the Rough-skinned newt. The new population consisted of newts that colonized ponds 10 years after their formation by the eruption's landslide. The recovery population consisted of survivors and recolonists captured in lakes of the blowdown zone, the area impacted by the high heat and strong winds of the lateral blast. Reference populations were found in unimpacted areas south of the volcano. With microsatellites as the molecular marker, I used standard population genetic metrics and predicted that new populations would have less genetic diversity (fewer alleles per locus and lower heterozygosity) than recovering or reference populations. All five loci examined to date were polymorphic and informative. Preliminary results show that alleles and genotypes were not evenly distributed across all populations, indicating genetic

differences between populations. New populations had fewer numbers of alleles per locus than either of the other two populations and blowdown populations had fewer alleles per locus than reference populations for four of five loci. As expected for an amphibian capable of long dispersal, gene flow as indicated by  $F_{st}$  values across all populations and alleles was high. This study is unique in that it is the first to examine the genetic response of any animal to the 1980 eruption of Mount St. Helens.

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### The thermal biology of two tropical rainforest lizard species

We studied the thermal biology of two tropical rainforest lizards, the Four-lined Ameiva (*Ameiva quadrilineata*) and the Basilisk (*Basiliscus basiliscus*), during the early rainy season 2005 at the Northern Kentucky University Center for Undergraduate Research and Tropical Studies (CURTS) on the Osa peninsula of Costa Rica. We evaluated lizard thermoregulation through measures of environmental temperatures, and with body temperatures collected from lizards in both field and under thermogradient conditions. These lizard species use different feeding strategies linked to their phylogeny with *A. quadrilineata* moving through the habitat as an active forager and *B. basiliscus* remaining as a wait-ambush forager. Lizard activity was determined through hourly walks of a 300m habitat transect. These data suggested that *A. quadrilineata* have a unimodal activity period with peak activity for at 9:00 am and *B. basiliscus* was active uniformly throughout the day. Our observations indicate that *A. quadrilineata* readily occupied the forest floor in filtered sun, while previous studies suggested that they were restricted to openings and forest edges. Semi-natural sun-to-shade thermogradients (with up to a 20 °C range) that reflected potential environmental conditions were used to determine the preferred lizards body temperature ( $T_{set}$ ). Field lizard body temperatures ( $T_b$ ), preferred lizard body temperatures ( $T_{set}$ ), and data logger measures of environmental temperatures ( $T_e$ ) were used to calculate the thermal quality of the habitat and the accuracy of the body temperature. These calculations were used to determine the deviation from thermoconformity by these lizard species.

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### New insights into the systematics of Caribbean gobies from larvae and DNA barcoding

As part of an effort to identify the larvae of coral-reef fishes of Carrie Bow Cay, Belize, we have been rearing net-collected larvae through transformation to the juvenile stage. To augment this identification method, we have begun the work needed to genetically match larvae and adults using mitochondrial cytochrome c oxidase I (CO1), or DNA barcoding (the CO1 sequences also will serve as a Smithsonian contribution to the FISH-BOL project). In comparing CO1 sequences of larval and adult gobies, we have identified several problems in need of further study. For example, several larval types tentatively identified as *Coryphopterus glaucofraenum* by Baldwin and Smith (2003) based on morphology do not match adult *C. glaucofraenum* (one matches *C. eidolon*); a previously unidentified larval *Coryphopterus* type does not match any of the known adult species; and there is confusion regarding the number and identities of *Bathygobius* species in the area. In studying larval morphology, we have also identified promising leads for additional study, including the potential utility of chromatophore patterns in diagnosing supra-specific taxa, for example the genera *Bathygobius* and *Coryphopterus*. Future efforts will include an attempt to DNA barcode all adult marine gobies from the Caribbean. In addition to providing a more complete database of adult DNA sequences for purposes of identifying larval stages, this work will contribute a set of information to the proposed goby tree-of-life project that is currently unavailable and that may be useful in identifying species-level taxonomic problems.

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### Description of *Pachydactylus* (Squamata: Gekkonidae) hemipenes with notes on evolutionary patterns

While snake hemipenes have been used extensively in systematic studies, lizard hemipenes have been underutilized as systematic characters. They have been employed in a limited capacity in studies of higher order relationships and have been used as diagnostic features to distinguish between similar species within selected lizard genera. I examined, described, and illustrated the hemipenes of representative taxa within the southern African clade of *Pachydactylus*-group geckos. Relationships within this clade, which includes the genera *Rhoptropus*, *Pachydactylus*, *Elasmodactylus*, *Chondrodactylus* and *Colopus*, have recently been resolved using mitochondrial and nuclear sequence data. I mapped hemipenis characters on to this

phylogeny in order to infer aspects of hemipenis evolution. Significantly different hemipenial morphologies characterize each of the major subclades within the *Pachydactylus* group. The potential utility of hemipenial characters for gekkotan phylogenetics is reassessed.

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**Spatial ecology and habitat use of Blanding's turtles (*Emydoidea blandingii*) in northeastern Illinois**

The Blanding's Turtle (*Emydoidea blandingii*), once common throughout much of the northern two-thirds of Illinois, has declined with the loss of suitable wetland habitats due to urbanization and development. Effective conservation measures require knowledge of the habitat preferences and spatial requirements of all life stages of this species. We radio-located 26 individuals (5 males, 13 females, and 8 juveniles) from May thru December 2005 at a northeastern Illinois preserve. Turtles were tracked from 3 to 7 times a week from May thru October and 1 to 2 times a month November-December. All coordinates were plotted on an aerial photograph and movement paths and home ranges were created using ArcView 3.2 and the Animal Movement extension. Juveniles moved shorter distances than adults. On a per move basis, males made the longest moves but over the active season females traversed the longest distances. We estimated home range areas using the minimum convex polygons (MCP) and adaptive kernel (95%, 75%, and 50% isopleths) methods. Although juveniles had smaller home range areas than females and males, there was no significant difference among the groups because home range area varied considerably within the groups. Turtles used numerous habitat types but preferred cattail marsh and pond habitats.

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**Diet of *Bathyraja magellanica* (Chondrichthyes, Rajidae) off southern Argentinean Patagonia**

The Magellan skate, *Bathyraja magellanica*, inhabits Chilean and Argentinean Patagonian waters. The diet and feeding strategy of this species on southern Argentinean continental shelf (48°-55°S) were investigated through stomach content

analysis. Specimens were collected from three research cruises carried out by Instituto Nacional de Investigación y Desarrollo Pesquero during March-April 2004 and February-March-April 2005. Stomach contents were fixed in formalin 4%. Prey were counted, weighted, and identified to the lowest possible taxonomic level. Of a total of 129 stomachs examined, 65.89% contained food. Twenty two prey taxa were identified in the stomach contents. According to the Index of Relative Importance expressed as a percentage, teleost fishes (69.73%) were the most important prey group in the diet of *B. magellanica*. Secondary prey groups were amphipods (19.50%) and isopods (9.92%), while brachyuran and anomuran crabs, cephalopods and polychaetes were uncommon prey groups. The graphical method of prey-specific abundance against frequency of occurrence and the law value of niche breadth (Levins' standardised index = 0.107) suggested that *B. magellanica* displayed a specialisation towards teleosts. The results presented are part of an ongoing study about ecology, biology and biodiversity of *Bathyraja* species on the Argentinean continental shelf.

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### Trophic dynamics of the Atlantic Angel Shark in the northern Gulf of Mexico

Atlantic angel sharks (*Squatina dumerili*) were collected for stomach content analysis from a trawl fishery in northeastern Florida on 11 February (n=50) and 29 April (n=59) 2005. Angel sharks consumed mostly teleost fishes (90% occurrence in stomachs containing food), with Atlantic croaker (*Micropogonias undulatus*) being the most common fish species in both diets. Other prey items that contributed to the diet but were less important than teleosts overall were squid (*Loligo sp.*) and crustaceans, occurring in 17% and 14% of non-empty stomachs, respectively. Cumulative prey curves were used to assess the sample sizes for both sampling trips and indicated that the diets were well described in both cases. To estimate the potential prey size and abundance available to angel sharks, portions of the trawl catch in which angels sharks were landed were sampled using a stratified random design during normal sorting operations. These samples were used to quantify prey availability based on total catch numbers recorded by the fishery. Prey items from stomach contents were roughly proportional to prey abundance, though squid, Atlantic croaker, and some eels (F. Ophidiidae) were preferred. Stomachs previously collected (n=442) will be used to assess prey size selection, and ontogenetic and seasonal shifts in diet.

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### Response of fishes to floodplain connectivity following a 500-year flood event in the unimpounded Upper Mississippi River

We examined data collected on fish assemblage structure among three differing floodplain types (broad, moderate, and narrow) during the 1993 flood in the unimpounded reach of the upper Mississippi River. This 500 year flood event provided a unique opportunity to investigate fish-floodplain function because the main river channel is otherwise typically disjunct from approximately 82% of its floodplain by an extensive levee system. Fishes were sampled during three separate periods and 42 species of adult and young-of-the-year (YOY) fishes were captured. The numerically abundant families (adult and YOY catches combined) on the floodplain included Centrarchidae, Ictaluridae, and Cyprinidae. Both native and non-native fishes were captured on the floodplain, and several of the numerically abundant species that were captured on the floodplain peaked in catch-per-unit-effort 1-3 years after the 1993 flood event. This suggests that some species may have used flooded terrestrial habitat for spawning, feeding, or both. The findings from this study provide much needed insight into fish-floodplain function in a temperate, channelized river system and suggest that lateral connectivity of the main river channel to less degraded reaches of its floodplain should become a management priority not only to maintain faunal biodiversity but also potentially reduce the impacts of non-native species in large river systems.

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### Deep-water submersible sampling for taxonomic research: Discovery of *Hydrolagus* from the Galápagos Islands (Chimaeriformes: Chimaeridae)

A new chimaeroid species, *Hydrolagus* sp. nov., is described from the Galápagos Islands. This species represents the second member of the family Chimaeridae known from the eastern equatorial Pacific and the first record of a chimaeroid from the Galápagos Archipelago. Discovery of chimaeras within the Galápagos archipelago is likely due to improvements in sampling technology (i.e. submersibles).

The steep slopes and rough volcanic terrain characteristic of deep-water environments in the archipelago have impeded thorough investigation of fish communities with traditional trawling methods. In a joint expedition of the California Academy of Sciences, Smithsonian Institution, Discovery Channel and Imax, ltd., the submersible *Johnson Sea-Link II* sampled the Galápagos archipelago to depths of 1000 m. Nine *Hydrolagus* sp. nov. were observed at depths from 396–506 m along slope habitat composed of igneous boulders, cobbles and pebbles. A single specimen was collected with a suction hose, allowing the individual to retain fresh coloration and natural morphology for surface observation. *Hydrolagus* sp. nov. can be distinguished from congeners by a combination of the following characters: small head with short, blunt snout; dorsal spine, when fully depressed against the body, extending well beyond both the distal tip of the first dorsal fin and the origin of the second dorsal fin; preopercular and oral lateral line canals branching from the same node off the infraorbital canal and sharing a short common branch; dorsum medium brown with numerous narrow, sharply delineated circular and elongate white blotches; ventrum white to tan with extremely fine brown mottling. This study demonstrates the benefits of using submersibles as a method of taxonomic research, allowing identification of a new species from limited type material while yielding information on live body color, behavior, distribution and habitat associations with accuracy and precision that would be otherwise unavailable from deep waters.

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*Eurycea cirrigera* abundance and growth: Watershed and local habitat effects

As the human population continues to grow, it becomes increasingly important to understand the effects of different land uses (e.g., urban areas or agriculture) on natural resources. Freshwater resources and their associated biota, in particular, have been the focus of much research across land use gradients. Stream biologists have given particular emphasis to how insects and fish respond to land use; however, the sensitivity of stream-dwelling amphibians to varying land uses in the watershed remains understudied. We estimated *Eurycea cirrigera* (Two-lined Salamander) abundance across a 500 m reach within each of 18 Southern Piedmont streams and repeated this four times over a one-year period. The sampled streams are located within watersheds subject to different predominate land uses (e.g., mixed deciduous forest, pasture, urban). We tested the relative role of watershed land uses along with smaller scale stream- and transect-level factors in predicting *E. cirrigera* abundance. We found that *E. cirrigera* maintains very low abundance across all seasons in urban watersheds. Other human-modified land uses, such as pasture, did not result in *E. cirrigera* abundance that was consistently lower than mixed forest watersheds. Across all streams, the amount of cover along the stream bed was the best predictor of *E. cirrigera* abundance. Along a subset of sampled transects, we measured the length and weight of all captured salamanders. Size data indicate that (1) the larval period of *E. cirrigera* within the study area is at least one year, and (2) larvae from streams in

mixed deciduous forest are significantly smaller than larvae from streams in other land-use categories. Potential reasons for a size difference include variation among streams in temperature or breeding duration. *Eurycea cirrigera* is a habitat generalist; consequently it is disconcerting that the abundance of this species appears to be impacted by factors associated with urbanized watersheds.

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### Phylogenetic relationships of cypriniform fishes inferred from coding sequences of the nuclear growth hormone gene

The growth hormone gene (GH) is a single-copy gene that codes for a pituitary-specific hormone essential for promotion and maintenance of somatic growth in vertebrates. Recent studies suggest that GH is an effective locus for estimating phylogenetic relationships in vertebrates. In this study, we used sequences from four of the five GH exons to infer phylogenetic relationships among select cypriniform fishes, representing all families and most of the currently recognized subfamilies. We use representatives of other ostariophysan orders as outgroups. GH coding sequence divergence among cypriniform families ranges from 8-17%. Substitutions show little evidence of saturation or loss of phylogenetic signal within cypriniformes, even at the third codon position. Consensus trees of parsimony and Bayesian analyses resolve Order Cypriniformes as monophyletic. However, resolution is poor for major groups within Cypriniformes. Catostomids and Cobitoids (Cobitids, Gyrinocheilids, Balitorids) resolve as monophyletic groups. Cyprinids are not monophyletic with the inclusion of *Danio rerio*. We compare phylogenies based on GH to those based on morphology and mitochondrial DNA sequences.

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**BARUN, ARIJANA; \*PERRY, GAD; HENDERSON, ROBERT W.; POWELL, ROBERT**

(AB) *Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN, 37996, USA;* (GP) *Dept. of Range, Wildlife and Fisheries Management, Box 42125, Texas Tech University, Lubbock, TX, 79409-2125, USA;* (RWH) *Section of Vertebrate Zoology, Milwaukee Public Museum, Milwaukee, WI, 53233-1478, USA;* (RP) *Department of Biology, Avila University, Kansas City, MO, 64145, USA*

Morphometric characteristics, activity patterns, and habitat use in *Alsophis portoricensis anegadae* (Squamata: Colubridae)

From 2001 – 2005, we collected and individually marked 219 *Alsophis portoricensis anegadae* from Guana Island, British Virgin Islands, during the months September – October to determine morphometric characters, evaluate incidence of scarring and tail damage, and assess habitat use and activity. Males were longer than females and significantly heavier and heavier per unit length. Sex ratio was almost exactly 1:1 (102 M: 103 F). Undamaged tails of males were significantly longer than those of females, but rates of tail damage did not differ by sex. Scarring and tail damage were more abundant posteriorly on the body and tail, and were cumulative, occurring with significantly greater frequency in larger individuals. Most damage was probably attributable to unsuccessful predation attempts by Soldier Crabs (*Coenobita clypeatus*). We found snakes in all habitats except an open grassy plain. Activity appeared to be bimodal, with a depression during the heat of the day. Although usually diurnal, three snakes were observed active at night. Most snakes were on the ground, but a small number were in water or climbing on vegetation or human-made structures. Most were in full shade and very few in full sun when first observed. Snakes most frequently were sprawled, rarely coiled, and many were first seen while moving.

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**\*BASLER, AARON H.; SNODGRASS, JOEL; RICHARDSON, AMANDA**  
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#### Comparison of female reproductive cycles between urban, suburban, and rural Blacknose Dace (*Rhinichthys atratulus*) populations

As urbanization of watersheds proceeds at a rapid pace, the resultant increase in impervious surface cover causes major changes in stream hydrology, channel morphology, and ultimately, overall habitat quality. It remains unclear what ecological factors allow a few tolerant species to persist in degraded habitats and whether they become adapted to conditions in urban streams. Blacknose Dace (*Rhinichthys atratulus*) are stream minnows that are able to persist in highly degraded urban streams. To investigate the potential influence of watershed urbanization on blacknose dace reproductive cycles, we examined the ovaries of 437 female dace from eight populations occurring across an urban-rural gradient. The reproductive condition of each set of ovaries was assessed based on stage of maturity according to an established classification scheme. Overall, ripe ovaries were found from April through June in all populations and the number of females with ripe ovaries declined throughout this reproductive season. Following the reproductive season, from July through February, the frequency of ovaries containing eggs in later stages of maturation increased. When urban, suburban, and rural dace collected during winter months (November-February) were compared, a portion of small dace from suburban, and to a greater extent, urban streams contained ovaries with eggs in early stages of maturation. The recruitment of small size dace into suburban and urban breeding populations during winter months suggests these individuals are maturing within their first year of life. Taken together, our results suggest that in urban streams, female dace are allocating more energy to reproduction in their first year of life.

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Systematics of south Asian *Hemidactylus* (Squamata: Gekkonidae)

Geckos of the genus *Hemidactylus* are among the most widely distributed and speciose of all gekkotan lizards. Recent phylogenetic analyses have revealed several radiations of *Hemidactylus* corresponding to discrete geographical regions and have confirmed long-held suspicions that certain small or monotypic gecko genera are embedded well within *Hemidactylus*, rendering it paraphyletic. We examined relationships among the previously unstudied endemic South Asian members of the genus, occurring chiefly in India and Sri Lanka, using a combination of mitochondrial (cyt *b*, ND2, 12S rRNA) and nuclear (RAG-1) sequence data. Members of this geographic assemblage form a monophyletic group that includes several poorly known terrestrial *Hemidactylus* from peninsular India and a clade of large-bodied forms in south India and Sri Lanka, as well as the two members of the Indo-Pakistani genus *Teratolepis*. In addition, data from Indian and Sri Lankan populations of several species previously assigned to different subspecies reveal that Sri Lankan *Hemidactylus* are moderately to highly divergent from their Indian counterparts.

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**BAUER, BLAKE A.**

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The natural history of the Rubber boa (*Charina bottae*) in Kittitas County, Washington state

I studied the Natural History of the Rubber Boa (*Charina bottae*) in Taneum Canyon, a site located 36 km west of Ellensburg, WA. I collected dead-on-road- and live snakes by driving slowly through the canyon for a total of 75 hours from April to August 2005. Live snakes were sexed, weighed, measured, and palpated for stomach content. Reproductive status was determined in females and live snakes were released at site of capture. Dead snakes were brought into the lab. I recorded the time of capture, as well as body, air and substrate temperature. I found 30 snakes active on 11 days. Preliminary data show that snakes were active at a mean air temp of 15.9° C with a mean cloacal temperature of 20.6° C. Out of 20 females, 5 appeared to be gravid with between 2 and 5 ova present. Snakes were active between 21:00h and 02:30h. Snakes were active at night at temperatures down to 12° C. Snakes were out regardless of moon phase and were even out during dry periods.

**BEAMER, DAVID A.**

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A re-evaluation of competitive exclusion in terrestrial salamanders of the Genus *Plethodon*

Competitive exclusion has been hypothesized to play a major role in delimiting the range extent of two closely related species of terrestrial salamanders (*Plethodon*) and is believed to be responsible for the largely allopatric distributions of the *jordani* and *glutinosus* complexes throughout the southern Appalachians. Three ecological niche modeling techniques (GARP, BioClim, and GLM) were used to predict the distributions of these species using a suite of climatological data. The resulting models were generally congruent, each demonstrating that the two species complexes occupy discrete, largely non-overlapping niches. Although these predictions are consistent with allopatry observed in the field, they are not consistent with competitive exclusion.

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**\*BEAMER, DAVID A.; LAMB, TRIP**

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Population status of coastal plain *Desmognathus*

The plethodontid salamander genus *Desmognathus* is distributed throughout the Gulf and Atlantic Coastal Plain, where two species, *D. conanti* and *D. auriculatus*, inhabit this broad physiographic province. Historically, these species were distributed from below the Fall Line of southern Virginia west to the San Jacinto River drainage in eastern Texas. Recently, severe declines have been documented for populations in Florida and Georgia, some of which involve relatively pristine areas in National Forests and State Parks. Unexplained declines in these salamanders parallel the ambiguities of similar declines in other amphibian orders. As part of a comprehensive investigation on the systematic relationships of Coastal Plain *Desmognathus*, we have sampled appropriate habitat in all of the independent river drainages encompassed by the ranges of these two species. This extensive survey entailed visits to several historical localities documented by museum specimens as well as many new sites containing habitat suitable for *Desmognathus*. We compiled our field sampling efforts as presence/absence data to determine whether regional patterns in decline are detectable across the Coastal Plain.

**BEAUPRE, STEVEN J.**

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### On the estimation of body condition in snakes: Statistical and theoretical pitfalls

A non-invasive technique for estimating body condition (weight relative to length) allows improved understanding of organismal responses to environmental variation. Among snakes, variation in body condition results from changes in physiological condition, temporal and spatial variation in resource availability, and in response to experimental resource manipulation. The uses of body condition are varied, and include the estimation of thresholds for reproduction, comparisons within individuals at different time points, and comparisons among groups (sexes, experimental treatments, or populations). For snakes, researchers have utilized simple weight / length and weight / length<sup>3</sup> ratios, as well as residuals from mass-length regressions. Each of these methods makes assumptions regarding the underlying physiology and the appropriate statistical model relating mass to length. I analyze three mass-length data sets from North American pit vipers, (each of which poses different challenges) and demonstrate statistical consequences of adopting each approach. The use of residuals from weight-length regressions is considered in detail. Typically such relationships are estimated from log-log regressions which have their own properties and problems. Notably, log-log regressions back-transformed to an allometric scaling relationship are biased with respect to the original data (because they are fit to geometric means rather than arithmetic means), and assume that the relationship passes through the origin. The problems may be alleviated by use of non-linear regression on untransformed data. In general, the most appropriate method for analyzing body condition depends on the biological question. Specific recommendations include the use of non-linear regression residuals for estimating body condition thresholds and comparing temporal changes within individuals, whereas analysis of covariance on log-transformed data is most appropriate for comparing among groups

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### Phylogenetic implications of *Trachemys scripta* proopiomelanocortin (POMC) sequence

Polypeptide hormone precursor sequences have been shown to be useful in phylogenetic analyses because they contain conserved as well as variable regions. A hormone precursor sequence of phylogenetic significance is proopiomelanocortin (POMC), a pro-hormone for adrenocorticotropin (ACTH, which controls adrenal secretion), the opioid hormone -endorphin, and melanocyte-stimulating hormone (MSH). The regions coding for ACTH, -endorphin, and MSH are conserved regions

of the POMC gene sequence, allowing for the lining-up of sequences from different vertebrates. The spacer regions show significant sequence variation, allowing for the elucidation of phylogenetic differences between organisms. Little information is available with respect to phylogenetic relationships of reptilian species in relation to other vertebrates at the cDNA level. Accordingly, we have generated a full-length cDNA sequence of the red-eared slider turtle (*Trachemys scripta*) POMC. Our turtle POMC cDNA sequence includes approximately 1,255 bases. Our phylogenetic analysis shows that the *Trachemys* POMC full length cDNA is most closely related to that of the soft-shell turtle (*Pelodiscus sinensis*), the only other turtle for which the full-length cDNA has been cloned, and that of the chicken (*Gallus gallus*). We have also compared the predicted amino acid sequence of *Trachemys* POMC with known amino acid sequences from representatives of different vertebrate classes. The phylogenetic tree generated from POMC amino acid sequences shows the closest relationship (90% similarity) to the amino acid sequence of the soft-shell turtle. Taken together the results of the phylogenetic analysis indicate that POMC is an excellent tool to study phylogenetic relationships among vertebrate taxa at the class level. We are now exploring the usefulness of this tool to resolve phylogenetic relationships among reptilian groups.

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Observations of courtship and mating in the Nurse Shark (*Ginglymostoma cirratum*), in Cartagena, Colombia

The nurse shark courtship and mating behavior in the Rosario Islands Aquarium in Colombia is described on 10 days direct observations (7 daily hours) on the captivity sharks, during June 2002. A general ethogram was obtained, in where four courtship events were identified (precoupling, coupling, positioning and alignment), and also three mating events (insertion, copulation and postcopulation). Twenty-two sharks were observed (14 males and 8 females) with more than 50 mating attempts. Each mating event had a mean length of 2 minutes, although a 15 minutes length was registered. The short lengths of these courtships and mating events is because of the fact that captivity shows a safe environment, in where distractions are rare, so females don't run away and there were few males competing for females. Most of mating events were successful, taking place mainly during early morning. The released semen into the water was detected at the end of copulation when the male's clasper was extracted from the female's cloaca. Behavior observations were made in the group of sharks, and as well as in other surveys, males competed for females or helped each other for copulation. Four births were registered after capsules were found empty in the sharks' enclosure. Only a 270 mm long male was found associated to these births, maybe because the others went out trough the enclosure

mesh. This survey extends the given information by other investigations on the species, since these are incomplete or short.

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**BEKKER, KENT; \*STANFORD, KRISTIN**

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Status and Distribution of the Eastern Fox Snake, *Elaphe gloydi* in Ohio

The Eastern Fox Snake, *Elaphe gloydi*, is a large, seemingly conspicuous, constrictor inhabiting the five Northwestern most counties surrounding Lake Erie. However, relatively little is known about this snake, and it is presently classified as a species of special concern in Ohio. This lack of basic information coupled with the rapid fragmentation of its remaining habitats within the state, necessitates a thorough investigation of the status of its remaining populations. Distributional records are being collected from all major nearby museums and are in the process of being entered into a database. A poster campaign requesting additional records and sightings began in Spring of 2005 and has generated seven new records, several of which indicate that the Fox snake may be present outside its known historic range. There have been 110 individuals marked at MBSP with a total of 146 captures, and 75 adult individuals have been marked with 111 captures on the Lake Erie Islands. Schumacher-Eschmeyer and Jolly-Seber population estimation techniques were used for the 2005 MBSP data and the 2001-2005 Lake Erie Island data, respectively, yielding population size estimates of 398 animals (density = 4.47/hectare) for MBSP and a mean estimate of 467 (range=1057-87) for the islands. We compared growth intervals between males and females using regression analysis and found that males appear to grow faster than females and also that males have never been found to reach their predicted asymptotic size. Radio-transmitters were implanted in 8 snakes; four snakes came from MBSP (3 males and 1 female), three from Middle Bass Island (2 males and 1 female), and one male from Gibraltar Island. Initial results allowed for home range estimates to be generated using Minimum Convex Polygons (0.81 - 43.01 acres) and Fixed Kernel Analysis (75% = 0.24 - 42.41 acres; 50% = 0.08 - 15.45 acres). Several interesting observations were made as a result of radio-telemetric relocation including extended periods of arboreality, female oviposition sites and prey consumption. Initial assessments indicate that the Eastern Fox snake appears to be thriving in remaining habitat, however, continued mark-recapture, distributional examination and new radio-telemetry sites will help to provide a more thorough understanding of the status of this species in Ohio.

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Mark-recapture study of oak openings turtles targeting the Blanding's Turtle *Emydoidea blandingii*

Turtle populations are becoming increasingly fragmented and isolated in Ohio and throughout much of United States due to land development. The Blandings turtle, *Emydoidea blandingii* is a species that is particularly susceptible to local extirpation due to several life history traits that have coevolved with longevity. The Blanding's turtle and several other chelonian species have long been a documented member of the Oak Openings region herpetofauna. Trapping and mark-recapture techniques were initiated to assess the turtle population of a wetland system within a Toledo Metropark. Five turtle species were documented and the system contained a reproducing population of the Midland Painted turtle, *Chrysemys picta marginata*. The population health of the Blanding's turtle and several other species is still in question.

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**BELLEGGIA, MAURO; MABRAGAÑA, EZEQUIEL; SCENNA, LORENA B.; BARBINI, SANTIAGO A.; \*FIGUEROA, DANIEL E.; DIAZ DE ASTARLOA, JUAN M.; COUSSEAU, MARIA B.**

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Food habits of *Bathyraja brachyurops* (Chondrichthyes, Rajidae) on the Argentinean continental shelf

The broadnose skate, *Bathyraja brachyurops*, inhabits southern South America waters. Food habits of this species were studied based on analysis of stomach contents of specimens collected from research cruises carried out by Instituto Nacional de Investigación y Desarrollo Pesquero during 2003-2005 on the Argentinian continental shelf (35°S–52°S). Prey items were counted, weighted and identified to the lowest possible taxonomic level. Diet composition was assessed using the Index of Relative Importance expressed as percentage (%IRI). The degrees of dietary overlap between sexes and size classes were compared by Schöener Index (SI), using %IRI. Trophic level (TR) was calculated to determine the position of the broadnose skate within the food web. For this purpose prey items were assigned into five groups. A total of 265 stomachs was examined, of which 75,5% contained food. Twenty-nine prey taxa were identified in the stomach contents. *B. brachyurops* fed mostly on fish (75.4%) and crabs (14.7%) and to a lesser extent on isopods (8.2%) and squids (0.97%) suggesting that the broadnose skate is a tertiary consumer (Trophic

level = 4.04). A high degree of dietary overlap between sexes (SI= 0.71) was found, although females showed higher %IRI of fish prey than males. However, size classes variation in diet was observed. Smaller skates consumed both fish (46.2%) and invertebrates (28.8% isopods and 23.6% crabs), whereas larger individuals fed almost exclusively on fish (86%). Dietary changes with the size of the predator were reported for several ichthyophagous skate species. These results presented are part of an ongoing study about ecology, biology and biodiversity of *Bathyraja* species on the Argentinean continental shelf.

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**BENARD, MICHAEL F.**

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Local adaptation or phenotypic plasticity? A test with Pacific treefrogs

Despite substantial work on predator-induced defenses, few studies have tested if predator-induced defenses themselves exhibit local adaptation to environments that differ in predator types. I tested for population differences in predator-induced plasticity of larval morphology and life history traits in Pacific treefrogs (*Pseudacris regilla*) found in two types of environments: permanent ponds with centrarchid fish, and ephemeral ponds with predaceous diving beetles. Previous work has shown that bluegill sunfish cause *P. regilla* to induce qualitatively different phenotypes than predaceous diving beetles. Further, these phenotypes exhibit a survival trade-off between the two types of predators. Using a common environment experiment in which tadpoles from these pond-types were raised in the laboratory and exposed to cues from no predators, bluegill sunfish, predaceous diving beetles, or combined cues from bluegill and predaceous diving beetles, I found evidence for main effects of both pond-type (fish pond or beetle pond) and induction cue on some tadpole morphological traits, and some metamorphic traits. However, for relative tadpole tail depth, one of the primary traits that respond to predators, I found no evidence for a pond-type effect when tadpoles were exposed to a single cue. There was an interaction of pond-type and induction cue; tadpoles exposed to combined fish-and-beetle cues developed the tail depth appropriate to the primary predator in the pond they originated from. These results demonstrate that amphibian populations respond to variation in predator types through both inducible defenses and local adaptation.

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**BENARD, MICHAEL F.**

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Predators and mates: Conflicting selection on male frogs

The conspicuous breeding aggregations of frogs have made them model systems for studies of sexual selection. These same aggregations make the breeding frogs

vulnerable to predators. Despite the large amount of work on frog mating systems, the potential role of predators as an agent of selection on breeding adults has rarely been investigated. In this study, I use data from multiple populations of pacific tree frogs (*Psuedacris regilla*) to demonstrate that sexual selection from mating favors larger males but natural selection from predation by giant water bugs favors smaller males. Thus, predation can be an important agent of selection that counteracts sexual selection in anurans.

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**A tale of two tide pools: Nursery habitat use among two species of *Kuhlia* in Hawai'i**

Flagtails, members of the Genus *Kuhlia*, are Indo-Pacific fishes found in marine and freshwater habitats. Known in Hawaii as holehole, they are important food fishes and were often used in traditional ceremonies. Although two morphotypes had long been noted by local fishermen and biologists, prior to 2001 only one species, *K. sandvicensis*, was recognized in the scientific literature. Recent studies and revision of the genus now describe the big-eyed morphotype as *K. xenura*, which appears to be endemic to Hawaii. Meanwhile, the small-eyed morphotype retained the name *K. sandvicensis*. While these two species exist sympatrically in certain nearshore habitats, differences in juvenile habitat preferences do exist. Macro and microhabitat data collected on the Big Island of Hawaii indicate that *K. sandvicensis* juveniles prefer tide pools that retain open connections to the ocean, even at low tide, as well as shallow reef flats. *Kuhlia xenura* were commonly observed in these areas, but they were found along rocky shorelines, in estuaries, and in freshwater streams as well. Principal component analysis of the fish observations showed strong differences in habitat use for some ecological variables. Specifically, *K. sandvicensis* were found in relatively high salinity habitats and were in waters nearer to the open ocean. Meanwhile, *K. xenura* were noted as far as 1.63 km upstream of the ocean at one site and were found in salinities ranging from 0 to 36 ppt. These results have important implications for future aquacultural research involving development of efficient protocols for farming these desirable food fishes. Furthermore, *Kuhlia* are vulnerable to human perturbations which result in the destruction of nearshore and intertidal nursery habitats. Understanding their nursery habitat ecology will further aid resource managers in conserving critical coastal zones to encompass the habitat needed by these two newly redescribed species.

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Status of freshwater stingray ornamental trade: From Rio Negro to the world

The artisan techniques of capture to the commercial exploration of freshwater stingrays as ornamentals based at the Negro river basin includes transport from fishing grounds, reception at distributor, wellbeing (quarantine), and shipping to international markets. Information of post-capture mortality either from fishing grounds to distributor center is around 7 %, and this is species-dependent. However, mortality data from distributor (at Manaus) to external markets is not known yet. The objectives of this work are to provide information about the mortality rate of these species during transport, considering time of the year and import country facility. Also, work will show briefly how this market is structured and the social economic impact on the riverine people. The data was obtained from mortality reports sent by the customer to the ornamental fish industry based at Manaus, Amazonas state. The average mortality for stingrays shipped is average 10 %, some factors can alter this variable such as time of the year, handling, and government regulations. With the reduction of mortality rates the fishermen will receive more money, however, the fishing effort over the species will not be effected. In conclusion, the best practices of fishing, handling, and transporting are important to guarantee conservation of the species and to continue the employment of the fisherman at the Rio Negro basin.

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The temperature-dependence of sprinting performance in day geckos

We studied the sprinting velocity, acceleration, deceleration, and power output between 15°C and 35°C in the diurnal gecko, *Phelsuma dubia*. We studied unsteady-state sprinting performance using high speed video recordings of lizards running up a vertical race track. Specifically, we focused on short bursts of locomotion with high degrees of acceleration and deceleration, and examined how maximal velocity, acceleration, deceleration, and mass-specific power output are influenced by changes in temperature. Our findings indicate that temperature affects all of these performance measures in a similar fashion. All of these performance measures increased during unsteady-state sprinting with increases in temperature across the range studied. Power output was most sensitive to temperature, increasing almost 4 fold between 15°C and 35°C. Deceleration was least sensitive to changes in temperature, but specific experiments may be required to adequately elicit maximal decelerative capacity. Increases in running speed are modulated by both increases in stride length and frequency. However, duty factor is unchanged across the temperature range. Our findings for sprinting parameters match those expected from

the literature. Performance measures are discussed in the context of their differential ecological relevance.

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**BERNSTEIN, PETER**

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The inner ear and the endolymphatic organ in lungfish

The inner ear in lungfish differs in morphology from that of other gnathostomes with respect to a couple of features. While in most vertebrates the saccule is the most prominent structure of the inner ear, in lungfish the utricle by far exceeds the saccule in size. Another example is the situation of the semicircular canals. Whereas in most other vertebrates the semicircular canals are enclosed completely by cartilage or bone, the same structures in lungfish are only partly embedded in skeletal material. All living species of lungfish have endolymphatic ducts which arise from the medial side of the utricle and proceed into the cranial cavity. Here the ducts ramify into many small pouches resembling the endolymphatic organ in amphibians where these extensions of the endolymphatic duct even leave the cranium through the foramen magnum and enter the vertebral spine. In lungfish the endolymphatic pouches do not leave the cranium but there are a couple of similarities in morphological appearance to the amphibian condition. The character complex of the endolymphatic organ is described for all three living species of lungfish based on serial sections. To clarify the complicated network of endolymphatic ducts in the lungfish cranium a computergenerated three-dimensional reconstruction of this organ is presented of the African genus *Protopterus*. This reconstruction allows for the comprehension of the enormous space occupied by the endolymphatic pouches inside the cranium thus resembling in extent and appearance the situation in many amphibians.

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**\*BESSERT, MICHAEL L.; ORTI, GUILLERMO**

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Population genetics of *Cycleptus elongatus* (Catostomidae) in the Upper Missouri River

The Blue Sucker, *Cycleptus elongatus*, is a widespread catostomid fish that inhabits mainstem rivers of the Mississippi basin in central North America. There is growing concern for the conservation of these fishes as they are considered vulnerable to critically imperiled (S1-S3) in every state where they occur. From 1952-1963, six major impoundments were constructed on the Upper Missouri River by the Army Corps of Engineers, with the southern-most dam (Gavins Point) occurring along the Nebraska/South Dakota border. The resulting reservoirs have inundated and fragmented large river habitat from Yankton, South Dakota to the Missouri River headwaters in Montana. Blue suckers still occur in the stretches between reservoirs;

however, little is known about reproduction, recruitment, and population structure in this system. At best, enough reproduction and recruitment occur within these stretches to maintain viable populations and allow a moderate level of one-way, downstream gene flow. In order to address these questions, we developed a battery of 15 genus-specific microsatellite markers. Tissue samples were collected from 15-30 individuals in each target area and genotyped at all 15 loci. Allele frequencies were calculated and used to estimate gene flow and other relevant population genetic parameters. This information will assist governing agencies in making well-informed decisions regarding conservation and management of *C. elongatus* in the Upper Missouri drainage.

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**\*BESSLER, SCOTT M.; CLEVES, ANGELA L.; LUBBERS, BRAD;  
DURTSCHKE, RICHARD D.**

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#### Determination of larval anuran gut pH levels with a newly developed solid-state micro-electrode

Evaluation of environmental pH conditions on small spatial (micro) scales is often limited by the size of the measuring instrument. We designed and fabricated a solid-state microelectrode for pH measurements in a variety of microenvironments. Our initial use for these probes was pH measures along the digestive tracts of developing anuran larvae (frog tadpoles). The electrodes were constructed from flame pulled borosilicate glass pipettes with a platinum core and an iridium oxide pH-sensing layer. The microprobe tip (2-10 M dia.) was coated with a Nafion ion exchange resin to protect the pH sensing layer. Temperature (10-40 °C) and stirring speed (50-100 rpm) tests found these probes to be highly stable, and to provide highly accurate readings (> 94%) over a wide range (2-10) of pH levels. Measurements of gut pH in green frog tadpoles (*Rana clamitans*) were taken by puncturing the wall of the extracted gastrointestinal tract with the microelectrode using a micromanipulator at 10 m serial steps, and recording pH changes as the probe entered into the lumen of the gut. Levels recorded from the anterior of the foregut to the posterior hindgut revealed drastic fluctuations in pH concentrations. The area of the manicotto glandulari (what we consider a functional stomach) was found to have lower pH levels than any other portion of the digestive tract. We also found an enlarged portion of the colon to have lower pH than surrounding areas, suggesting fermentation byproducts of short chain fatty acids.

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The *Cathorops mapale* (Siluriformes: Ariidae) species complex from the southern Caribbean

The sea catfish genus *Cathorops* comprises about 15 species distributed on either the Eastern Pacific or the Western Atlantic sides of the Americas. The marine and brackish water representatives occurring from Belize to Brazil in the Western Atlantic have been traditionally treated as *Cathorops spixii*, a species described from equatorial Brazil. *C. mapale* was recently described from the central and southwestern coasts of the Colombian Caribbean. According to mitochondrial evidence, *C. mapale* is more closely related to the *C. fuerthii* species group from the Eastern Pacific, than to the *C. spixii* species group (including *C. arenatus* and probably other six species with uncertain status), which is probably restricted to Brazil and the Guyanas. Although it is still unclear the status of the marine species of *Cathorops* distributed northwestwards to *C. mapale* (from Panama to Belize), we herein present molecular and morphological data supporting the occurrence of a new entity, closely related to *C. mapale*, from northern Colombia to eastern Venezuela. Preliminary phylogeographic evidence, based on cytochrome *b* and ATP synthase 8/6 mitochondrial markers, indicates that *C. mapale* and the northern Colombia-eastern Venezuela entity are reciprocally monophyletic. Combined mitochondrial distances between Colombian haplotypes of *C. mapale* and of the new entity, separated by about 200 km of coast line, are 0.94%; whereas the distances among haplotypes of the new entity, distributed along about 2000 km of coast line, are 0.10-0.31%. A principal component analysis based on 36 morphometric variables failed to discriminate both entities; however, they can be separated by the modes of two meristic variables and the averages of a morphometric ratio. These data suggest incipient speciation, raising the dilemma of giving specific status to the new entity or expanding the limits of *C. mapale*. The reproductive strategies of ariids (i.e. oral incubation vs. planktonic larvae in other marine groups) promote speciation, particularly in the genera *Cathorops* and *Notarius*.

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Diet of the roundel skate *Raja texana* from the northern Gulf of Mexico

Skates are an important component of benthic marine ecosystems. Fishery management stresses the need for an ecosystem approach, but skates have often been ignored. To evaluate trophic role, the diet and feeding habits of the Roundel Skate *Raja texana* have been examined from offshore waters in the northern Gulf of Mexico.

Diet was assessed by life-stage and quantified using six indices: percent by number, percent by weight, frequency of occurrence, the index of relative importance (IRI), IRI expressed on a percent basis (%IRI), and %IRI based on prey category (%IRI<sub>PC</sub>). Preliminary analysis of stomachs from 31 juveniles (25 non-empty; mean DW=23.5 cm) and 46 mature individuals (39 non-empty; mean DW=32.2 cm) indicate shrimp make up 95 %IRI<sub>PC</sub> of juvenile skate diet with Family Solenoceridae as the most important (22.1 %IRI). Osteichthyes (*Micropogonias undulatus* and *Ophidium* sp.) were also found in the diet of juvenile skates although in much smaller amounts (0.9 %IRI and 2.9 %IRI, respectively; 3.2 %IRI<sub>PC</sub> overall). Mature skate diet was also predominantly shrimp (58.6 %IRI<sub>PC</sub>). Crab and other crustaceans (e.g., *Squilla* sp.) were also found in the diet (2.3 and 17.4 %IRI<sub>PC</sub>, respectively). Osteichthyes (all unidentifiable) made up 21 %IRI<sub>PC</sub> of mature skate diets. Preliminary analysis does not indicate ontogenetic diet shifts; however, mature individuals consistently have larger and more than one prey item or type in their stomachs.

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#### A survey and comparison of Ulcerative Shell Disease and trace metal bioaccumulation in aquatic turtle species in an urban lake

This study surveys the occurrence and severity of Ulcerative Shell Disease (USD) in emydid freshwater turtles in an urban lake in southeastern Virginia and investigates whether bioaccumulation of metals is related to its occurrence. The causes of this affliction have not been thoroughly investigated. It is a condition affecting both free ranging and captive turtles. It is chronic, yet self-limiting, afflicting both the carapace and plastron. Bioaccumulation of certain heavy metals has been implicated in the suppression of the immune system, impairment of calcium uptake and skeletal calcification. In aquatic environments, metals can exist as bioavailable and toxic free ions which are easily absorbed by aquatic organisms, especially algae and plants. Turtles were captured using dip nets, and baited hoop nets and basking traps. Severity of USD was ranked according to the percentage of the plastron affected. Shell samples were collected from left and right marginal scutes. Samples were washed and dried then wet-digested in trace metal nitric acid prior to analysis. We found differences in the occurrence and severity of USD between and among turtle species. *Trachemys scripta* had a greater occurrence of USD than *Psuedemys rubriventris*, 51.6 % and 35.8 % respectively. Within both species female turtles had both a higher occurrence and greater severity than male turtles. Within *T. scripta*, no males were found with major to severe USD; 75.7% were uninfected whereas only 31.7% of females were uninfected. Within *P. rubriventris*, no captured males showed evidence of USD whereas 52.7% of captured females had evidence of USD. Qualitative trace metal analysis indicates that concentrations of both lead and cadmium are higher in turtles with greater severity of USD. Quantitative analysis,

through graphite furnace atomic absorption spectrophotometry, to determine bioaccumulation concentrations of these metals in shell fragments is currently in progress.

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**BISHOP, SETH; \*CUPP, PAUL V., JR.**

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**Habitat use of the Eastern Slender Glass Lizard, *Ophisaurus attenuatus longicaudus***

Eastern slender glass lizards (*Ophisaurus attenuatus longicaudus*) were studied in southeastern Kentucky to determine if a habitat preference exists, or if more than one habitat type is used to meet the basic requirements for survival and reproduction. Previous work indicates that the habitats used most by glass lizards are woodlands and grassy areas, but no attempt has been made to determine if one of these habitat types is used more than the other. This study attempted to answer this question by trapping glass lizards in three different habitats: grassy areas, woodlands, and ecotones (power line rights-of-way). Glass lizards were marked with passive integrated transponder (PIT) tags for identification purposes and the total number of glass lizards caught at each site was compared to determine if preferences for particular habitats existed. During the study, only two individuals were captured in woodlands, compared to 48 in grassy areas and 29 in ecotones. These results indicate that eastern slender glass lizards prefer open, grassy habitats, such as grassy areas and ecotones, over wooded habitats. Further comparison of these habitats is being conducted to determine possible reasons for this preference and to determine characteristics of each habitat that make them suitable for glass lizards. Such information may be useful in managing areas to better suit the survival and reproductive needs of these animals.

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**Comparative feeding ecology of four sympatric skate species (*Bathyraja* and *Raja* spp.) off central California**

The big (*Raja binoculata*), California (*R. inornata*), longnose (*R. rhina*), and sandpaper (*Bathyraja kincaidii*) skates are the most common batoids taken over soft-bottom regions of the central California continental shelf and upper slope. Based on the results of previously conducted species-specific diet studies, the feeding ecology of this assemblage was compared to evaluate the degree of trophic separation among species. Specimens were collected from 2002-2005 NMFS, Santa Cruz Laboratory trawl surveys conducted between 18-823 m. Using single (%W, %N) and compound

(%IRI) index values, overall, ontogenetic, spatial, and temporal diet composition were compared with traditional (e.g., similarity indices) and multivariate (e.g., Principal Components Analysis, MANOVA) techniques. *Raja binoculata* consumed primarily demersal teleosts (e.g., *Citharichthys* spp., *Porichthys notatus*, *Sebastes* spp.), crustaceans (e.g., crangonid shrimps, *Cancer gracilis*, *Mursia gaudichaudii*), and cephalopods (e.g., *Octopus rubescens*, *Loligo opalescens*). Diet composition of *R. inornata* was similar, consisting mainly of crustaceans (e.g., *M. gaudichaudii*, *C. gracilis*, crangonid shrimps), demersal teleosts (e.g., *Chilara taylori*, *Citharichthys* spp., *P. notatus*), and cephalopods (e.g., *L. opalescens*). The diet of *R. rhina* was comprised largely of demersal teleosts (e.g., *Sebastes* spp., pleuronectiforms, *Merluccius productus*), shrimps (e.g., *Neocrangon resima*), euphausiids (e.g., Euphausiidae), and cephalopods (e.g., *O. rubescens*). *Bathyraja kincaidii*, the smallest of the studied species, ingested euphausiids (e.g., Euphausiidae), polychaetes (e.g., Onuphidae, Nephtyidae), cephalopods (e.g., Teuthida), shrimps, and teleosts (e.g., Myctophidae). The trophic ecology of this skate assemblage was further investigated to elucidate its role in benthic food webs off central California.

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Using spatio-temporal ecological niche modeling to determine seasonality of fishes collected in benthic trawls

Ecological niche modeling (ENM) has proven useful in aquatic systems. Additionally, data are available to support the effectiveness of satellite-derived environmental data for predicting marine species' distributions. This paper will expand these methods to derive temporally explicit models using monthly mean MODIS satellite data (from multiple bands and combinations of bands) combined with other benthic data sets to predict the seasonality of several marine taxa. Data from benthic surveys were divided into individual species and separated into monthly and seasonal (e.g. tri-monthly) periods. DesktopGARP [DG] and MaxEnt [ME], machine-learning approaches for predicting species distributions from disparate environmental coverages (satellite data), were used for ENM building for each species at each time period. Locality data and MODIS data from any given month or season were used to predict the changes in species distributions in different time periods and then validated with coinciding species locality data. Preliminary results indicate that DG and ME are successful at detecting seasonal signals and can be used for spatio-temporal analyses. These results suggest that such modeling approaches can be useful for evaluating unknown or under-investigated migratory patterns of species of interest, or for improving species' specific management decisions.

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Environmental variables influencing the distribution of *Eleutherodactylus* (Anura: Leptodactylidae) at five sites in southeast Peru

Although many researchers have compared herpetofaunal assemblages over large geographical locations, comparisons on a microgeographic scale have been scarce, thus the goal of this study was to compare species diversity of *Eleutherodactylus* on a smaller geographic scale. This was accomplished by conducting herpetofaunal surveys at five sites in the Tambopata region of southeast Peru, including Reserva Amazonico, EcoAmazonia, Explorers Inn, Sachavacayoc Centre, and Tambopata Research Center. Along with sampling and identifying all species and sexes of *Eleutherodactylus* captured, several environmental variables were collected and analyzed, including time of year, time of day, substrate type, capture height, leaf litter depth, tree cover, air temperature, prey availability (Las Piedras), and individual frog length and mass. The goal was to determine what, if any, variables contributed to frog diversity. Total frog abundance, species richness, diversity, and similarity differed significantly between sites. More individuals were captured at SC and TRC than any other site, whereas more total species were captured at TRC and EI. Diversity of the two most abundant species, *Eleutherodactylus toftae* and *Eleutherodactylus peruvianus*, was also significantly different among sites, with one species rarely encountered when the other was extremely abundant. Generally, similarity between sites was not closely related to geographic proximity. For most of the ecological variables analyzed, there were few, if any, site-to-site differences. However, significant site differences existed for capture height and leaf litter data. I conclude that three main factors are contributing to the observed difference in diversity among the five sites and include phylogenetic factors, differences in vegetation and forest type, and certain modern ecological variables, including interspecific competition. Future studies are needed that will thoroughly examine the influence of forest type on herpetofaunal diversity, and look at how current ecological processes such as competition may exclude certain species of *Eleutherodactylus* from their congeners.

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**Trophic ecology of the Banded Guitarfish, *Zapterix exasperata*, in the central Gulf of California**

The banded guitarfish, *Zapterix exasperata* is one of the most important ray caught in the Sonora artisanal fishery. Stomach contents of 475 banded guitarfish were analyzed. The rays were caught in the central portion of the Gulf of California close to Guaymas and Bahia de Kino from November 2004 to July 2005. Stomach content was found in 33% of the specimens examined. The main prey species found were the daisy midshipman, *Porichthys margaritatus* (54%), followed by the northern anchovy *Engraulis mordax* (6.84%) and striped cusk eel, *Ophidion galeoides* (6.35%). The trophic niche breadth (Levins Index) and diversity index (Shannon-Wiener) indicated that banded guitarfish is a specialist feeder, because predate mainly in one species (*P. margaritatus*). We found a trophic overlap (Morisita-Horn index= 0.75) between sexes, but no between juveniles and adults (Morisita-Horn= 0.23).

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**Response of fishes and aquatic invertebrates after Hurricane Ivan affected Chandeleur Island (Louisiana) seagrass communities**

Hurricanes regularly disturb aquatic communities associated with coastal seagrass habitats. Depending upon their intensity and frequency, these storms may confer either positive benefits (e.g., re-suspended nutrients) or negative impacts (e.g., habitat destruction). The Chandeleur Islands, a transgressive barrier island chain located approximately 100 km east of New Orleans, possess a large (ca. 57 square km) seagrass meadow comprised of five seagrass species. In September 2004, the eye of Hurricane Ivan passed within 60 km and did extensive damage to the barrier islands. To assess the responses of aquatic organisms to this disturbance, I sampled non-vegetated habitats and habitats consisting of four seagrass species (*Thalassia testudinum*, *Syringodium filiforme*, *Halodule wrightii*, *Halophila engelmanni*). This sampling was conducted monthly from April 2004 through May 2005, in a relatively undisturbed embayment. This time frame allowed both pre- and post-hurricane collections of fishes and invertebrates. Fish assemblages collected in April-May 2004 were not significantly different than those collected in April-May 2005 (ANOSIM, Global R = 0.017, p = 0.054), suggesting either a lack of impact on fishes or quick

assemblage recovery. Invertebrate communities, though, differed significantly between these two periods (ANOSIM, Global R = 0.051, p = 0.008). These results indicate that Chandeleur Island fishes possess resilience to natural impacts like hurricanes while less mobile aquatic invertebrates may require longer recovery times even in relatively undisturbed seagrass habitat.

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Congruence of morphological and genetic variation in lower Atlantic Slope and upper Tennessee River populations of the *Etheostoma flabellare* species complex (Percidae: *Catnotus*)

The Fantail Darter, *Etheostoma flabellare* is highly variable morphologically across its geographic range and has long been recognized as a species complex. Several different species and subspecies have been recognized from the lower Atlantic Slope drainages and upper Tennessee River systems. However, there is no consensus regarding the taxonomic status or distributional limits of these forms. Previous molecular systematic work has revealed a high degree of genetic structuring of fantail darter populations from this region, including subdivision within previously recognized subspecies and across relatively short geographic distances. Here, I compare patterns of genetic differentiation to patterns of morphological variation (meristics and nuptial male pigmentation) to assess congruence between the two data sets and to further evaluate the taxonomic status of previously recognized species and subspecies. The genetic structure of populations in the lower Atlantic Slope and upper Tennessee rivers is generally congruent with the observed geographic variation in morphology. Congruence of these two data sets provides support for the recognition of several distinct forms of *E. flabellare* from this region. However, many genetically distinct populations share similar morphologies, suggesting that populations are more subdivided than predicted by morphology alone. Therefore, both morphological and genetic data sets require careful consideration for future taxonomic decisions.

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Occurrence of juvenile white sharks (*Carcharodon carcharias*) in fisheries throughout the Southern California Bight

Much of what is known about the distribution of white sharks (*Carcharodon carcharias*) off the coast of California has come from fishing data and field observations, with a majority of these observations focused on subadult and adult sharks. Adults are

typically observed north of Point Conception, while juveniles are thought to be more common in the Southern California Bight (SCB). However, the degree to which white sharks are influenced by local fisheries in southern California is unknown. We analyzed fisheries data to describe juvenile white shark distribution throughout the SCB and examine the degree of fishery interaction. Sources examined included: (1) scientific observers and fisherman logbooks from the drift gillnet fishery in the SCB; (2) DFG and NMFS tagging research; (3) recreational landing and shark tournament records; and (4) sightings from fishers and lifeguards. The degree of fishery interaction varies widely by fishery and over time. Juvenile white sharks are caught by both recreational and commercial fisheries closer to shore. Based on data from southern California only, it is unclear whether historic changes in fishing methods have significantly decreased juvenile white shark catch and to what extent sharks may interact with fisheries off Baja, Mexico.

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### Relative fitness of wood frogs in a managed forest

Forest harvesting creates a stressful environment for organisms with limited mobility by increasing solar radiation, wind speed, and temperature at ground level and can lead to the loss of local populations within the harvested area. We conducted a series of experiments on larval and juvenile wood frogs (*Rana sylvatica*) to investigate the response of this amphibian to forest harvesting. We measured survival and growth of wood frogs from egg to metamorphosis in 1500 L aquatic mesocosms (N = 28) placed in open canopy (< 10% cover), partial canopy (50% cover), and full canopy (> 90% cover) conditions. Metamorphosing frogs were randomly transferred to 14.4 m<sup>2</sup> terrestrial enclosures (N = 32) within the same treatment from which they emerged (e.g., open canopy to clearcut) to investigate the survival and growth of juveniles in response to four forest harvesting treatments: clearcut with coarse woody debris (CWD) removed, clearcut with CWD retained, 50% canopy cover partial cut, and unharvested, full canopy forest. Time to metamorphosis was shortest ( $69 \pm 0.2$  days; mean  $\pm$  2 SE) in the open canopy mesocosms and longest ( $93 \pm 0.2$  days) in the full canopy mesocosms ( $F_{2,25} = 281.8$ ;  $P < 0.001$ ). Survival was lowest ( $F_{2,25} = 6.7$ ;  $P = 0.004$ ) but metamorphosing frogs were largest ( $F_{2,25} = 39.1$ ;  $P < 0.001$ ) for larvae reared in full canopy mesocosms. Conversely, survival of juvenile frogs in the terrestrial environment was lowest in the clearcut treatments ( $F_{3,28} = 4.7$ ;  $P = 0.009$ ). Size of juvenile frogs from all treatments at the end of the activity season was similar ( $F_{3,24} = 0.5$ ;  $P = 0.659$ ). Wood frogs may respond to a stressful larval environment by metamorphosing earlier and at a smaller size. Small size may result in decreased survival but allows a longer growth period in the terrestrial environment.

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Molecular systematics of the Tribe Menidiini (Atherinopsidae) with emphasis on the genus *Chirostoma*, a group of freshwater silversides endemic to Mexico

The Tribe Menidiini (Atherinopsidae) consists of four genera including *Poblana*, *Chirostoma*, *Menidia*, and *Labidesthes*. *Chirostoma* and *Poblana* are endemic to the Mesa Central of Mexico and account for the 24 of the 32 species in the Tribe. *Chirostoma* is the most diverse genus in the Tribe with 23 recognized species/subspecies. Previous research suggested that *Chirostoma* diversified via an adaptive radiation; however this has not been adequately tested in an evolutionary framework. Recently, it has been suggested that *Chirostoma*, and *Poblana* should be synonymized with *Menidia* due to the lack of morphological characters to differentiate the genera. The objective of this study was to develop a robust phylogeny of the Tribe Menidiini 1) to examine the species relationships within each of the genera and 2) to assess the monophyly of the genera within the Tribe. The complete mitochondrially encoded ND2 gene (1047bp) was sequenced for six species of *Menidia*, four species of *Poblana*, multiple populations of the monotypic *Labidesthes sicculus*, and fifteen species and multiple populations of *Chirostoma*. Results indicate that the Tribe Menidiini is monophyletic. *Chirostoma*, as currently recognized does not represent a natural assemblage, as species of *Poblana* nest within *Chirostoma*. The taxonomic implications of these results will be discussed.

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Macroecological patterns of body size in island herpetofaunal assemblages

Macroecological studies have revealed non-random patterns of body size in species assemblages at various spatial scales. Specifically, examination of insular faunas has provided evidence for optimal body sizes among mammals, birds, fish and snakes. This study investigates the relationship between body size and landmass area among monophyletic groups of amphibians and reptiles (Anura, Caudata, Gekkota, Scincidae, Lacertiformes, and Testudines). We obtained data from published literature on island faunal assemblages. For each island, we obtained landmass area and body sizes of the largest and smallest species within that assemblage. For some groups (e.g., Anura, Gekkota, and Testudines), we found significant relationships for the largest and smallest species found in assemblages whereby the size of the largest species increased and the size of the smallest species decreased, with an increase in landmass area. This pattern is consistent with data from mammals, birds, fish and snakes. The intersections of best-fit lines through these data were used to predict body sizes of single-species (i.e., competition-free) islands (7.9, 6.8, and 42.7 cm for

Anura, Gekkota, and Testudines, respectively). The concordance of these results with those from mammals and birds supports the notion that selection towards an optimal body size is important in structuring local ecological communities.

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New species of the South American catfish genus *Gladioglanis* Ferraris & Mago-Leccia, 1989 (Siluriformes: Heptapteridae): Adding pieces to a phylogenetic puzzle

The phylogenetic position of *Gladioglanis* is still controversial. The highly distinctive morphology of *Gladioglanis machadoi* (type species of *Gladioglanis*), described from the Negro and Orinoco River basins of Brazil and Venezuela, prevented its allocation to any of the three pimelodid subfamilies then recognized. Among these modifications are the absence of vomer and the presence of a straight-bordered transverse process of vertebra 4. The discovery of a new species, *Gladioglanis conquistador*, from the Amazon River basin of Ecuador, with intermediate states of those characters, allowed assignment of the genus to the pimelodid subfamily Rhamdiinae (= family Heptapteridae). Later, *Gladioglanis* was tentatively assigned to a well-corroborated clade composed of heptapterids with highly developed jaw adductor muscles that extend dorsally onto the cranial roof. This monophyletic group, the *Phreatobius* clade, also includes the genera *Brachyglanis*, *Leptorhamdia*, *Myoglanis*, and *Phreatobius*. However, hypertrophy of the adductor muscles was thought to be reversed in *Gladioglanis*. Four new *Gladioglanis* species have been discovered in the collections of the 2003 Transcontinental Catfish Expedition and existing museum collections: one from the Madeira River basin, one from the Madeira and Purus River basins, one from the Jaú River basin, and one from the Tapajós River basin, all from Brazil. Two of these undescribed species represent successive basal lineages of *Gladioglanis*. The most basal species exhibits several plesiomorphies, including a typical vomer and well developed adductor muscles, corroborating *Gladioglanis* as a member of the *Phreatobius* clade. This study is an interesting example of how the discovery of new basal taxa may elucidate the knowledge about the phylogenetic relationships of groups formerly known from their most derived members. This study is supported by the All Catfish Species Inventory (ACSI/NSF), CNPq, and FAPESP.

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Biotelemetry monitoring of alligator snapping turtles (*Macrochelys temminckii*) with analysis of thermal preference using dataloggers

Between May 2005 and March 2006, 10 alligator snapping turtles (*Macrochelys temminckii*) of various age classes were radio tagged and tracked, with 8 turtles captured at two sites, and two turtles obtained from professional trappers. Three of the 10 turtles were translocated to a site not known to harbor *Macrochelys* (Red River National Wildlife Refuge), while the remainder were tracked in their native environment (Cross Lake). All radio tagged turtles carried thermal dataloggers, whose data collection was staggered to allow for a full season of recording time. Turtle movement was analyzed and compared between native versus non-native turtles, age class, and thermal preference.

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Cadmium loads in turtle populations, with consideration of watershed arrangement and water flow around a major urban area

Between March and October 2005, turtles were trapped in and around watersheds surrounding Shreveport and Bossier City, Louisiana. This metropolitan complex covers approximately 373 square kilometers, and is drained by several creeks and rivers. Water flows roughly Southeast in this area. Turtles were collected from lakes to the Northwest (Cross Lake) and South (Wallace Lake) of the two cities. The species of turtles collected were intended to represent different dietary habits and family-level disparity in heavy metal accumulation due to diet. Families included the Emydidae (*Trachemys*), Kinosternidae (*Sternotherus*, *Kinosternon*), and Trionychidae (*Apalone*). Cadmium levels were analyzed in the liver using atomic absorption. Notable differences in trapping success were observed between the two sites, with Wallace Lake having fewer turtles and of different population demographics than Cross Lake.

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### Lateral-line canals in cyprinids: Their morphology and its application in species identification, phylogeny and systematics

Characters of lateral-line canal pattern hold a strong potential for investigating phyletic relationships, taxonomy and systematics in the family Cyprinidae. In this study the placement and configuration of lateral-line sensory canals on head and body have been analyzed as a large number (over 150) discrete characters which form in their turn numerous sets of morpho-functionally interconnected units of different levels and combinations of apparently independent characters. The assessment of character polarity is based on specimens from over 500 species and local morphs/subspecies of the Cyprinidae and 24 cypriniform outgroup species. The cyprinid species covered virtually the whole range of distribution of the family. Plesiomorphic states of the characters and character sets have been determined for the family as a whole as well as for some subfamilies and phyletic lineages within them. It became apparent that there is a "web of parallelisms" in most characters, especially those based on overall reduction of the canals which occurs in all larger branches in consideration. In addition, phylogenetic character reversal plays a significant role. However, a number of irreversible trends have been found, mainly connected with the supraorbital and preoperculo-mandibular canal transformations. Along with data on the definitive structure of lateral-line canals in adults, developmental data are used based upon examination of series of larvae and juveniles of several species from four tribes of the Leuciscinae. An ancestral cyprinoid pattern is hypothesized (among extant taxa it is present in the lower leuciscines). Based on these results it is also possible to assess the phyletic interrelationships within the Leuciscinae sensu lato and substantiate the hypothesis on the basal position of the Pseudaspinini ("phoxinins") within this assemblage. The study is a part of the "Cypriniformes Tree of Life" Project.

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### Delineating and describing the freshwater ecoregions of the former USSR based on fishes distribution

WWF defines an ecoregion as a large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions. The boundaries of an ecoregion encompass an area within which important ecological and evolutionary processes most strongly interact. Within a major project devoted to synthesizing a global map of freshwater ecoregions

and associated biodiversity data, we analyzed the distribution patterns of freshwater fishes of the former USSR and adjacent territories that is a large part of Eurasia continent. There were delineated 50 ecoregions from the Barents Sea basin, South Baltic Lowland and Dniester/Lower Danube in the west to Chukotka, Kamchatka and Sea of Japan in the east, large Siberian drainages in the north and Northern Turkey, Western Mongolia and Tarim depression in the south. Each freshwater ecoregion description includes ecoregion name, justification for its delineation, boundaries, drainages flowing into, main rivers or other water bodies, topography, terrestrial habitats, freshwater habitats (including key ecological processes), list of all taxa (from family to subspecies and even local morphs whenever necessary), distinguishing features of fish fauna, list of endemic fishes (and other noteworthy fishes) and their characterization, ecological phenomena (e.g. mass migrations, unusual species assemblages/interactions) and evolutionary phenomena (e.g. species radiations, relict taxa). The catchment-by-catchment inventories made possible the comparison of distribution patterns across different taxonomic groups and the identification of "hotspots" of richness/endemism. Thus, the most pronounced "hotspot" of richness within the area under consideration is Khanka Lake (Amur River basin, China and Russia) while that of endemism is River Talas drainage area (Kazakhstan and Kirghizia). The resulting data sets are used for the goals of the Cypriniformes Tree of Life Initiative, too, as they serve for examining the biogeography of cypriniform fishes, the Eurasian's most diverse group of freshwater fishes.

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Using the AmphibiaTree of Life to decipher patterns of life history evolution in salamanders and caecilians

Extensive progress is being made in resolving the evolutionary relationships among amphibian species. Our goal is to generate a comprehensive morphological and molecular dataset to complement previous work and to add new markers for resolving relationships throughout the AmphibiaTree of Life. The goal of a robust phylogenetic hypothesis for many parts of the Tree is in sight, and it will provide a framework for analyzing patterns of evolution and diversity. Here we use our working phylogenetic hypothesis to examine patterns of life history evolution in salamanders and caecilians. The presumed ancestral life history mode of amphibians is that of an aquatic larval stage followed by metamorphosis to a more terrestrial adult form. However, different lineages have deviated from this ancestral pathway in many ways leading to conditions such as paedomorphosis, direct development, and viviparity. We evaluate and analyze patterns of homology and homoplasy that result in similar life history features and strategies exhibited by closely related and by independent and often distantly related lineages of salamanders and caecilians.

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Large-scales spatial dynamics of white sharks (*Carcharodon carcharias*) in the south Pacific Ocean using satellite tags: A case of foraging migrations?

Recent discoveries about white shark movements using satellite tags have helped scientists draw an increasingly detailed and complete picture of the behavioural patterns of space utilization of the most prominent marine apex predator. All previous information on long-range movements of white sharks using satellite technology has been gathered from only three geographical areas: the waters around Australia, off Southern Africa, and the northwest Pacific Ocean. Here we report on preliminary results from the first study in New Zealand using satellite tags to study sharks. The goals of our study are to unveil the meso- and macro-scale movements, habitat use, and migratory patterns of white sharks from New Zealand waters, as well as the interactions among Southern Hemisphere populations of white sharks. During two expeditions to the Chatham Islands east of mainland New Zealand (April 05 and March 06), an international team of scientists and institutions tagged white sharks using pop-up archival tags and real-time satellite tags. Pop-up archival tag results from the 2005 expedition show most of the tagged white sharks having long-distance northward movements of 1,000-3,000 km towards the open ocean as well as tropical areas in the South Pacific. Our preliminary results confirm recent findings of fast oceanic travel and extremely well oriented and directed navigation to specific sites apparently well-known and commonly visited by white sharks. Circumstantial information suggests that the visits of NZ white sharks to some of these sites might be regular foraging migrations. Further data from the 2006 tagging campaign will be reported in this presentation. The information gathered from our study will be used to support proposals for the conservation of white sharks in New Zealand and the South Pacific Ocean.

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**BORCZYK, BARTOSZ**

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Evolution of the skull and jaw musculature in Coronellini (Serpentes: Colubridae)

Recent progress in the phylogeny reconstruction makes it possible to understand the evolutionary process shaping the morphology better. The Coronellini (ratsnakes, kingsnakes and their allies) is a snake group common in Eurasia and North and Middle America. Recently several papers have been published on their phylogeny, clearing the view of their relationships. My aim was to describe the pattern of

diversity in morphology of this group and to find if there is any general pattern of evolution of the studied characters. I studied members of the following snake genera: *Bogertophis*, *Coelognathus*, *Coronella*, *Elaphe*, *Euprepiophis*, *Gonyosoma*, *Lampropeltis*, *Oocatochus*, *Oreocryptophis*, *Orthriophis*, *Pantherophis*, *Rhinechis* and *Zamenis*. I used the recent hypotheses on their phylogeny to trace the changes in morphology of the skull and jaw musculature. I assume the phylogeny to be true, however, I have tested alternative tree topographies, too. The general pattern of skull structure and muscle pattern is typical for colubrid snakes. The musculus adductor mandibulae externus superficialis is not divided into two parts, thus there is lack of m. levator anguli oris. Both, bone and muscle characters show a high level of homoplasy. It suggests numerous, diverse factors involved in the evolution of their morphology. The pattern of ossification of the skull structures suggests numerous events of paedomorphosis or peramorphosis. *Gonyosoma* exhibits several specific characters, supporting the view of exclusion this genus from Coronellini.

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Sexual dimorphism in head size and shape in the sand lizard, *Lacerta agilis* L. (Sauria: Lacertidae): Do males really have larger head?

Sexual dimorphism is a widespread phenomenon in the animal kingdom. The sexual dimorphism in the sand lizard (*Lacerta agilis*) involves differences in body coloration (males are green, whereas females are brown), the number of femoral pores, body proportions, behavior and ecology. It is commonly assumed, that male aggressive mating behavior is the most important factor that leads males to evolve larger head, better designed for strong bite. We tested sand lizard males and females really differ in head size, shape, and teeth number. We took several measurements of the skull length, width, and high and the snout-vent length (SVL). There are no statistically significant differences between males and females in teeth number. As expected, males have longer, wider, and higher skulls than females at any SVL. When scaled to the SVL, all skull dimensions show higher growth rate for males, than females. However, when scaled to the skull length these differences do not became significant. There are no statistical differences between males and females in several skull ratios (i.e. width/length, width/high etc.) defining the skull shape. It is possible, that the sexual differences in head size are not results of selection for stronger and bigger jaws in males, but selection for larger body cavity in females, enabling them to produce bigger clutch. We are discussing the evolution of sexual dimorphism in this species and problems with choosing the most appropriate character to scale the animal size.

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**\*BORTONE, STEPHEN A.; MARTIGNETTE, A.J.; GREENAWALT, JAIME M.; MILBRANDT, ERIC C.; KLEMENT, BRAD W.**

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Potential ichthyological catastrophies: The response of mangrove-associated fishes to a hurricane and red tide

Large-scale catastrophic, natural events can have profound effects on coastal-dwelling organisms. For example events such as hurricanes can have significant impacts on mangroves. Hurricane Charley (Category 4) hit southwest Florida in August 2004 and destroyed up to 80% of the mangrove canopy cover on Sanibel and Captiva Islands. The waters proximate to the mangrove shoreline experienced increased exposure to sunlight and an increased amount of decomposing organic matter. The response of fish communities in close proximity to mangrove shorelines was examined before and after the hurricane to test the hypothesis that a reduction in mangrove canopy cover would decrease fish diversity and abundance. Overall fish diversity and abundance, based on distance from the eye wall, were examined. No statistically significant changes in diversity were found following Hurricane Charley; however, there was lower diversity after the hurricane compared to the diversity during the dry and wet seasons. In addition to the hurricane impacts, the changes in communities after two red tide blooms were also examined to assess the biological response to another catastrophic disturbance. Fish diversity from sampling with a seine during a bloom that occurred during the summer and fall of 2005, along with fish diversity determined for 2003 using an otter trawl, were examined. During the 2003 bloom, species diversities were lowest for the year. During the 2005 bloom, diversity was significantly lower than the previous six months. This decline in diversity was not observed during 2004, suggesting that it is not a seasonal change, but rather a result of the red tide.

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Phylogenetic utility of mitochondrial and nuclear gene DNA sequences in darters (Teleostei: Percidae)

Most molecular phylogenetic analyses of darters have relied primarily on mitochondrial DNA (mtDNA) sequences, and almost all studies have used the cytochrome *b* (*cytb*) gene. Inferring relationships within and between closely related species using a single locus gene tree is potentially confounded by introgression as well as retention of ancestral polymorphisms. This can lead to incongruence between the gene tree and the species tree. Considering that darters are a clade with documented interspecific hybridization and many species with a recent evolutionary origin, it is important to analyze both mtDNA and nuclear genes in attempting to

reconstruct phylogeny. In addition, *cytb* phylogenies of darter clades have resulted in limited phylogenetic resolution of internal nodes. Our objectives were to determine the phylogenetic utility and congruence of DNA sequences of *cytb*, an additional mtDNA gene (ND2), and at least seven nuclear genes. We sampled 30 darter species representing all darter genera. We analyzed each gene separately and assessed phylogenetic congruence among the individual gene regions. We then determined if combining gene regions into a super matrix increased resolution in the darter phylogeny.

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**BOUNDY, JEFF**

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Natural history of coral snakes (*Micrurus*) in Louisiana

I examined 242 specimens of *Micrurus* for morphology, prey, and reproductive characteristics. A discriminate function analysis confirmed the presence of two morphotypes, separated by the Mississippi River floodplain. Morphotypes were distinguishable on the basis of classic color patterns used to separate the taxa *fulvius* and *tener*, with no indication of introgression. Sex ratio was 123 males, 103 females. Males averaged 81% female SVL. 25.4% of snakes contained prey, with the genera *Scincella*, *Storeria* and *Virginia* comprising 69% of prey items. Prey items were 3-18% of snake weight, with two exceptions of 50 and 60%. Mean prey diameter was 50% snake diameter, and was correlated with snake diameter. Snakes with prey were collected from early March to mid-November. Two activity peaks were evident, centered about late April and late September. Testes began to enlarge in snakes over 430 mm SVL, and testes volume was not correlated by time of year. Oviductal eggs averaged 5.3 (range 4-9). There was no correlation between ova count and SVL. Ova began to enlarge in early April, through late June. No snakes collected after June contained eggs.

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Viking mythology and conservation biology: Examples from the fishes

Is conservation dedicated to genes, species, or ecosystems? Proponents of phylogenetics and ecology both claim primacy over the foundations of conservation biology, a debate that has deep roots in philosophy and science. A more recent claim is that conservation efforts should protect evolutionary processes that will allow diversification. Phylogenetics, ecology, and evolution all have legitimate roles in conservation, when viewed in a temporal perspective. Phylogenetic studies identify

the bioheritage of *past* species radiations, ecology preserves the life support systems for these lineages in the *present*, and evolutionary processes allow adaptation of these lineages to novel challenges in the *future*. The concept of temporal domains in conservation (past, present, future) has an appropriate metaphor in the Norse worldview known as the Orlog. In this body of mythology, three sisters tend the tree of life, and fend off a dragon gnawing at the roots. The names of these sisters, Urd, Verdandi and Skuld, translate to Past, Present, and Future, corresponding to the fields of phylogenetics, ecology, and evolution. In Viking mythology, the threads of life cannot persist without the cooperation of these sisters. In modern conservation biology, they represent three scientific disciplines that can only succeed with a spirit of familial cooperation. All three conservation priorities (genes, species, ecosystems) can be illustrated with endangered or threatened fishes.

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#### Surf-zone fish assemblages at Wrightsville Beach, North Carolina: Short-term responses to beach renourishment

We describe results of an ongoing investigation of the assemblage structure, seasonality and recruitment patterns of ichthyofauna utilizing shallow (<1.5m) surf-zone habitats at Wrightsville Beach, North Carolina. Our study area represents exposed ocean beach characterized by intermediate particle sizes, high turbulence and moderate to heavy wave action. Sampling was initiated in May 2004 and is conducted at biweekly (May to September) or monthly (October-April) intervals using a 30 x 2 meter bag seine deployed parallel to the beach. Sampling sites include areas subject to periodic beach renourishment as well as control areas. To date, 150 seine hauls have yielded a total of 25,112 individuals representing 46 species and 24 families of fishes. Numerically-dominant species include *Membras martinica* (44% of total individuals), *Anchoa hepsetus* (19%), *Trachinotus carolinus* (14%), *Menticirrhus littoralis* (4.0%), and *Opisthonema oglinum* (3%). While spatial and diel variability in assemblage structure is generally low, seasonal variability is pronounced. Fish densities, species richness and species diversity were all positively correlated with water temperature, peaking during summer/early fall and reaching a minimum during late winter. Surf-zone habitats at Wrightsville Beach serve a nursery function for several commercially-important species, including *T. carolinus* and *M. littoralis* which recruit as small (<20 mm TL) juveniles during May/June and reside within the study area until December. Short-term responses of the surf-zone fish assemblage to beach renourishment will be discussed.

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### An investigation into the helminth parasites of testudines of southern Oklahoma

Testudines are a heavily parasitized group of poikilotherms and are commonly host to multiple species infections. There is a paucity of current data on the helminth parasites of Oklahoma Testudines. Much of the available data is in excess of fifty years old. Our findings show much needed information on parasites of Oklahoma Testudines and adds to the current knowledge. This will provide data for further studies. In this study, a total of fifty red-eared slider turtles, *Trachemys scripta elegans*, were collected from five counties in southern Oklahoma as well as two counties in eastern Texas. These were dissected, size and sex recorded, and all organs were inspected for parasites. Parasites were preserved in a formalin solution. Representative samples of each type of parasite found from each host were stained and histologically prepared for study. We are currently identifying these representative parasites to a specific level. Upon completion of identification, density of each species within *Trachemys scripta elegans* will be tabulated. Data will also be tabulated to provide information on parasite prevalence and frequency with relation to age and sex of the Testudines as well as a regional correlation of species. This data will be compared with previously recorded information to show changes in parasite density, abundance, prevalence, and incidence. We also expect to be able to show differentiation of the parasitic community of *Trachemys scripta elegans* based on the geographical location of the host.

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### Patterns of disease prevalence during an epidemic of chytridiomycosis in Central Panama

We intensively sampled amphibians along terrestrial and riparian transects for the chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*) along an elevational gradient (80 – 760 m) that ran from Pacific slope Coclé Province northward into Parque Nacional Omar Torrijos, El Copé, Coclé, Panama from January 2004 to January 2005. Prevalence of chytridiomycosis (% individuals infected) was epizootic in nature, increasing from zero to high levels in >4 months, and prevalence increased more rapidly along riparian than terrestrial transects resulting in greater numbers of individuals and species lost. ANCOVA of prevalence by time indicated homogenous prevalence and slope along both 3 terrestrial and 4 riparian transects, and ANCOVA of combined regression lines indicated a more rapid increase in prevalence along

streams ( $F = 13.55$ , d. f. = 1,  $p = 0.0005$ ). Logistic regression indicated differences in prevalence among sites ( $\chi^2 = 114.18$ , d. f. = 5,  $p < 0.0001$ ), habitats ( $\chi^2 = 20.10$ , d. f. = 1,  $p < 0.0001$ ), and lifetime aquatic index (AI) ( $\chi^2 = 10.57$ , d. f. = 2,  $p < 0.0051$ ) but not elevation ( $\chi^2 = 0.059$ , d. f. = 1,  $p < 0.81$ ). Aquatic and terrestrial species differed in prevalence levels ( $\chi^2 = 100.92$ , d. f. = 6,  $p < 0.0001$ ) by an order of magnitude. Highest prevalence levels (0.86 – 0.89) were detected in riparian communities at 335 m, although mortality was only noted above 680 m elevation where surveys were concentrated. In contrast, populations of *Colostethus panamensis* at both the highest and lowest elevations had the highest prevalence levels while mid-elevation sites had <1% prevalence. These data suggest complex patterns of infection by *Bd* in nature.

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The role of tadpoles in energy flow in a Neotropical headwater stream, and implications following population declines

Tadpoles are abundant in Neotropical mid-elevation streams, and because of their complex life cycles constitute an important energetic link between terrestrial and aquatic habitats, playing an important energetic role in both environments. Yet no study has described the amount of energy produced by tropical tadpoles, or how much energy they transfer to terrestrial ecosystems. We calculated tadpole production (turnover in biomass and energy over time) in a Panamanian stream prior to population declines. Monthly surveys provided density ( $17.42$  tadpoles/ $m^{-2} \pm 15.63$ ) and biomass estimates, and rearing tadpoles in growth chambers in situ provided instantaneous growth rates. Growth rates varied among taxa. Overall growth rates for all taxa was related to initial size ( $y = -0.017 \ln(x) + 0.057$ ,  $r^2 = 0.663$ ,  $p = 0.001$ ). Applying growth models to monthly field densities indicated annual habitat-weighted production was  $1.21$  g AFDM  $m^{-2}y^{-1}$  for all tadpole species, with *Hyla* ( $0.59$  g AFDM  $m^{-2}y^{-1}$ ) and *Colostethus* ( $0.50$  g) more productive than centrolenids ( $0.078$  g) or *Rana* ( $0.034$  g). After the decline, between September 2004 and June 2005, tadpole densities were reduced rapidly to  $1.49$  tadpoles  $m^{-2} \pm 1.33$ . After January 2005, no more centrolenids tadpoles and very few tadpoles of other species were seen in the streams. This decline brought down the overall tadpole productivity by 80% ( $0.23$  g AFDM  $m^{-2}y^{-1}$ ); *Hyla* ( $0.12$  g AFDM  $m^{-2}y^{-1}$ ), *Colostethus* ( $0.10$  g), centrolenids ( $0.032$  g) and *Rana* ( $0.024$  g). This low productivity is comparable with the one obtained at Fortuna (Eastern Panama, decline 1997), where overall tadpole productivity was  $0.034$  g AFDM  $m^{-2}y^{-1}$ . Our results demonstrate the importance of tadpoles in energy flow within tropical streams and export to terrestrial habitats, and highlight ecological consequences of amphibian population declines.

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**BRIGGS, VENETIA S.**

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Sexual selection and larval performance of Neotropical treefrogs of the Chiquibul Forest Reserve, Belize

Female mate choice can be driven by selection for males with high genetic quality who in turn may produce genetically superior offspring. A male frog's genetic quality may be encoded in body size and/or vocalizations and female preference has often involved a large-male mating advantage. Males possessing these preferred traits are disproportionately mated; however the genetic quality of these males is usually unknown. A female's choice affects her own fitness and has consequences for the fitness of her offspring and larger males may contribute higher quality gametes which enhance larval performance traits. In frogs, mortality during the tadpole stage is catastrophically high. Therefore, larval performance traits prior to and during metamorphosis are critical to fitness as an adult. Thus, the female's choice of mates may be the ultimate factor that determines offspring fitness. To determine if larger males sire offspring with enhanced traits, I conducted a controlled breeding experiment to produce maternal half-sibships between large and small sires. To assess paternal size effects on larvae, I measured a suite of larval performance traits in offspring (developmental and growth rates, duration of metamorphosis, and size and mass at metamorphosis). I collected natural pairs and single males of red-eyed treefrogs, *Agalychnis callidryas* and *A. moreletii* during the breeding season of May-August 2004 and 2005 in the Chiquibul Reserve, Belize. In natural pairs, males were larger and heavier than unpaired males for both species. Fertilization success was correlated with parental size ratio and larger-sized pairs produced a greater number of viable eggs. Further analyses will be done to determine the effect of sire size on mass and snout-vent-length of the 126 clutches that yielded 982 metamorphosed froglets. These findings will provide information to determine whether higher quality males produce offspring with enhanced larval traits as a direct result of female choice.

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Ultraviolet light survey of semi-aquatic snakes at the Old Sabine Bottom Wildlife Management Area

Ultraviolet light of the wavelength 295nm has been shown to convert provitamin D to previtamin D which is thermally isomerized into vitamin D3. Vitamin D3 is important in vertebrate calcium regulation. Squamate reptiles in the suborder Sauria have been shown to utilize UVB in regulating Vitamin D3 levels. The present study surveyed the UVB exposure of the suborder Serpentes at a river bottom habitat in East Texas. *Agkistrodon piscivorous* showed the lowest mean UVB exposure, while *Nerodia erythrogaster* experienced the highest mean UVB exposure, and *Thamnophis*

*proximus* showed an intermediate UVB exposure. The UVB exposure of the snakes was compared with that of several lizards previously studied.

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Osteology of the genus *Paedocypris* comprising some of the smallest vertebrates (Cyprinidae, Teleostei)

The two recently described species of the genus *Paedocypris* are extraordinarily small cyprinids with a large number of developmentally truncated features. We describe the osteology of *P. progenetica*, and *P. micromegethes* in detail. The two taxa share absence of the following bones: parietals, nasals, vomer, preethmoid, circumorbitals (except lachrymal) in the neurocranium, angular in the lower jaw, ectopterygoid in the hyopalatine arch, posttemporal and postcleithrum in the shoulder girdle, supraneural 2 and epural in the axial skeleton, and scales on the body. Cartilaginous elements that fail to ossify include kinethmoid, basibranchials, ceratobranchials, epibranchials and pharyngobranchials, except ceratobranchials 4 and 5, and proximal-middle radials of dorsal and anal-fins. Cartilaginous distal pectoral radials are lacking in the pectoral fin. Bones in a reduced state are the narrow frontals that fail to meet in the dorsal midline and the intercalarium of the Weberian ossicles that is reduced to a splint. In contrast to these characters resulting from developmental truncation, *Paedocypris* shows several progressive characters, most of which are related to the marked sexual dimorphism: the presence in males of a hypertrophied pelvic basipterygium, strongly ossified and enlarged first pectoral radial and three dorsal most pectoral fin rays, a stout lateral flange on the outer arm of the os suspensorium, a dentary flange to support a series of nuptial tubercles, and the presence in females of a strongly ossified and enlarged first dorsal pterygiophore and anterior dorsal-fin rays. We compare the osteology of *Paedocypris* with that of other miniaturized cyprinids and speculate about its possible affinities.

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Geographic variation in tetrodotoxin resistance in four species of garter snakes

Previous work has demonstrated that the garter snake *Thamnophis sirtalis* has evolved resistance to tetrodotoxin (TTX), present in newts of the genus *Taricha*, and that this resistance is highly variable geographically. Despite extensive sampling, *T. sirtalis* was the only known predator resistant to TTX. Here we present a progress report on the examination of three other garter snake species (*T. atratus*, *T. couchii*, *T. elegans*) where they are sympatric with both *T. sirtalis* and the newt *Taricha*. Although distantly related to *T. sirtalis* and one another, each of these species has evolved resistance to TTX in at least some populations. We report on the extensive geographic variation in resistance to TTX in this group and compare the patterns observed in each species.

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**BRODMAN, BOB**

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One weird salamander: Ecology and natural history observations of *Siren intermedia nettingi* (Western Lesser Siren) in northern Indiana

The Lesser Siren (*Siren intermedia nettingi*) is a two-legged gilled salamander with an unusual distribution. Very little is known about the natural history and ecology of this species and what is known is primarily from southern populations inhabiting the Atlantic and Gulf Coastal Plains. I made observations of population trends, body size, diet, habitat preference, and aestivation of lesser siren populations in the northernmost parts of its range over an eight year period. Sirens were sampled from 21 aquatic sites using minnow traps. The number of sirens captured fluctuated with spikes in abundance in 1998 and 2001 followed by declines over the following two years. The mean TL and proportion of adults to juveniles significantly increased over time. Sirens were significantly more abundant at sites that had greater abundance of crayfish and fish, and very poorly drained loamy fine sand substrates with near neutral pH. Sirens kept in captivity were observed to eat a wide variety of prey, including fish, tadpoles and crayfish that were too large to be swallowed whole. Sirens were observed to kill and eat large prey and also to scavenge carcasses by taking bites of flesh. Natural prey items were identified from the stomach contents and dragonfly naiads, caddisflies, aquatic beetles, and ostracods made up 75% of the prey items. Juveniles ate significantly more caddisflies, ostracods, and snails, and significantly fewer tadpoles than adults. Parasitic nematodes were found in four of the adult sirens. In a laboratory experiment adult sirens entered aestivation sooner than juveniles, however all of the sirens in drying treatments entered aestivation when there was 1-5 cm of standing water over the substrate. Drying treatments had a

significant affect on the survival of sirens with the greatest mortality occurring in the fastest drying treatment.

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Herpetofaunal assemblages in relation to different flooding regimes at a bottomland hardwood site in NE Louisiana

Boeuf Wildlife Management Area (BWMA) is a state-owned property in northeastern Louisiana. It consists of approximately 50,971 acres of bottomland hardwood forest and wetland habitat. The terrain is flat and poorly drained, with numerous backwater lakes, sloughs, and bayous. Low elevation areas of BWMA are subject to frequent flooding from the Boeuf River and Bayou Lafourche nearly annually in winter-early spring. Twenty-two 500-meter transects were marked at locations that represented either riparian (low elevation) or non-riparian (higher elevation) areas of the WMA. At these transects, visual encounter surveys (VES) and drift fence surveys with funnel traps have been conducted, and incidental encounter data has been recorded. Surveys were conducted September 2004 to November 2005. A total of 240 individuals of 25 species was collected with VES, and a total of 394 individuals of 24 species was collected with drift fence surveys. All sampling methods combined resulted in a total species richness of 38. This study was supported by funds provided by LDWF and USFWS, Division of Federal Aid, through the State Wildlife Grants Program.

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Swim bladder morphology differences in Red Snapper and Red Grouper

Depth-induced mortality due to injuries sustained during rapid decompression is common in red grouper (*Epinephelus morio*) and red snapper (*Lutjanus campechanus*) and may be related to morphological and physiological aspects of the swim bladder. Red snapper have smaller but thicker swim bladders than red grouper, and swim bladder-ruptures tend to be smaller and less frequent. Red grouper between 318 and 381 mm FL develop a secondary vascularized structure on the dorsal surface of the swim bladder that is not seen in red snapper; this secondary structure contains rete but no gas gland. Histological analyses of swim bladders from 62 red snapper (123 to 674 mm FL) and 138 red grouper (205 to 766 mm FL) showed rete area significantly ( $p < 0.05$ ) increased with body length (FL) for both species, but gas gland area was not

significantly related to FL in red snapper. Red snapper had a significantly higher percentage of rete area in the swim bladder than did red grouper, although there were no differences between species in the percentage of gas gland area. However, red grouper had a significantly higher percentage of the rete area occupied by gas gland than did red snapper. The percentage of fish showing hemorrhaging in both rete and gas gland increased significantly with FL for both species, but retal hemorrhaging was significantly higher in red grouper when adjusted for fish length. These differences in structures of the swim bladder may have implications in depth-induced mortality. Funded in part by NMFS No. NA17FF2010.

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**\*BRUCE, BARRY D.; STEVENS, JOHN D.; BRADFORD, RUSSELL W.**  
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### Coastal migrations, temporary residency and site fidelity of white sharks in Australian waters

Recent studies on white sharks have revealed diverse and extensive patterns of movement. The movement patterns of white sharks in Australian waters were investigated using pop-off archival transponding tags (PSATs), direct satellite tracking (SATs) and long-life acoustic transmitters (RCODEs) monitored by listening station arrays moored on the sea floor. Sharks were tagged at various locations around southern Australia and tracked for periods of up to two years. All three electronic tag types recorded extensive movements of individuals covering the species range in Australia from northwest Western Australia around the south coast to central Queensland. Sharks showed a combination of directed long-distance coastal movements, temporary residency at common hotspots and repeatedly returned to selected sites (site fidelity). Movements were generally confined to shelf waters; however, limited offshore excursions were recorded, coupled with dives to a maximum depth of 570 m. In one case a PSAT tag attached to a 3.0 m shark was consumed by what we deduced to be another white shark and disgorged after two weeks. These electronic data, combined with our previous conventional tag data, support the broad-scale mixing of white sharks in Australian coastal waters and across the Tasman Sea to New Zealand.

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### Insight into bull shark, *Carcharhinus leucas*, behavior in the south Pacific

Shark Reef Marine Reserve in Fiji is one of the very few places where up to eight different shark species can be encountered together in a relatively small area. Among them are bull sharks, *Carcharhinus leucas*, which occur in reasonable numbers for

most of the year. Since 2003, the different shark species as well as other vertebrate taxa are monitored on a regular basis. These data allow estimating the local population size by using natural marks and resightings information. I used a modified Petersen estimate to calculate the bull shark population size at Shark Reef at the end of each month in 2004. The total population size was estimated to be 57. The ecology and behaviour of bull sharks are still largely unknown. To address these questions, 11 bull sharks were equipped with pop-up archival satellite tags in 2004. All except one tag reported back and gave insight into the behaviour of the bull shark in the South Pacific. Nocturnal and diurnal depth distributions were not identical. Bull sharks spent more time in deeper water during the day and more time in the top 30 m of the water column during the night. Occasional deep dives were made to a maximum depth of 204.4 m. Ambient water temperatures encountered were between 21.37 and 28.57 C and most time was spent in water of 26-27 C. These data help to better define the ecological niche of this charismatic species.

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**BUBLEY, WALTER J.**

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Life as a single parent can be hard: Life history of a simultaneously hermaphroditic fish, *Diplectrum formosum*

Sand perch, *Diplectrum formosum*, is a serranid found along the western Atlantic coast from Virginia, United States of America, to Uruguay, including the Gulf of Mexico and Caribbean Sea. The gonads (ovotestes) of mature sand perch were shown to contain active ovarian and testicular tissue concurrently, confirming that it is a simultaneous hermaphrodite. Simultaneous hermaphrodites may have different life history strategies from fishes that are gonochorists or sequential hermaphrodites because of the added stresses placed on the fish from developing and maintaining both sexual tissues. This study examined the gonad morphology, growth rate, maximum size and age, size and age at maturity, reproductive cycle, and possible mating strategies of sand perch and how they compare to typical gonochoristic and sequential hermaphroditic fishes found in the area. Sand perch were sampled with a variety of gear types from the Atlantic waters along the southeastern United States from North Carolina to Florida during April 2000 through August 2005. The physiological, morphological, and behavioral traits of sand perch differ compared to those of similar species. These differences between species may be due to the overall demands of simultaneous hermaphroditism.

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Use of remote laser sensing equipment to determine deep body temperatures of small lizards

Many lizards maintain their body temperature within a fairly narrow range, despite spatial and temporal variation in microclimates. The ability to measure these temperatures is central to studying lizard physiology. Non-intrusive methods are preferred because they cause the least disruption to the animal's natural behavioral patterns. We modified the Alberts and Grant (1997) model of non-contact temperature prediction of Cuban rock iguanas (mass range 120-850 g) for use on four species of smaller lizards (mass range 2-7 g). The relationship between skin surface temperature ( $T_s$ ) and internal body temperature ( $T_b$ ) was determined by regression. At any known ambient temperature ( $T_a$ ), an animal's estimated internal body temperature can be predicted within  $0.2 \pm 1.43 \text{ SD}^\circ\text{C}$  from its dorsal skin surface temperature. Additional heating and cooling studies were performed in the lab to determine preferred temperatures and heat/cool rates with various heat sources and sinks. The lizards appeared to be unable to maintain their preferred temperatures precisely in the field. Chase studies in the lab showed that there was no significant change in the internal body temperatures of the lizards if they were chased to and from heat sources and sinks over a ten-minute period.

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Phylogenetic analysis of the Hypoptopomatinae and monophyly of *Hisonotus* (Teleostei, Loricariidae)

The phylogenetic position of seven undescribed species of Hypoptopomatinae from the Tapajós, Xingu and Araguaia drainages in the southern Amazonian region is investigated. Recent discovery of two additional species with accessory teeth from southeastern Brazil lead us to reassess the phylogenetic relationships of the Hypoptopomatinae. Such teeth were previously known only from representatives of the genera *Eurycheilichthys*, *Epactionotus*, *Niobichthys*, and a few species of *Parotocinclus*. Fifty-seven morphological characters were coded for cladistic parsimony analysis, including 46 previously used in phylogenetic studies by S.A.Schaefer, and 11 new characters. The data matrix included representatives from 31 species, corresponding to 16 genera currently recognized as valid. Nine species of *Parotocinclus* were included in order to establish the phylogenetic distribution of accessory teeth. The parsimony analysis yielded 153 equally parsimonious

cladograms requiring 170 character-state transformations. All cladograms differ considerably from previously published studies. According to our results the tribe Othothrini is paraphyletic, and the genus *Parotocinclus* is polyphyletic. In spite of exhibiting the characters traditionally used to diagnose *Hisonotus*, the seven undescribed species from central Brazil do not form a monophyletic group with *Hisonotus notatus*, the type species of the genus. Instead, they constitute a paraphyletic cluster associated with *P. collinsae*, *Otocinclus*, and members of the tribe Hypoptopomatini. The taxonomic assignment of these new species according to the principle of monophyly requires considerable nomenclatural changes. (Research support from CNPq Proc.473652/2003-0, 308387/03-1, 301748/2004-7, PRONEX; Fundação Vitae; FAPERGS 02/0779.5).

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### Catalog of Brazilian freshwater fishes

Availability of reliable data about the status and distribution of species is essential for the study, conservation and sustainable use of fish biodiversity. In Brazil the last catalog of freshwater fishes was published by Henry W. Fowler more than half a century ago and is considerably outdated. To eliminate the gap of knowledge about this important group of vertebrates, we organized a database with basic information about all freshwater species with vouchered occurrence in Brasil. The compilation of data was performed by 36 authors. The distribution of each species recorded from Brazil was established based on data from scientific collections, taxonomic revisions, and systematic studies based on voucher specimens. The structure of the database allows for interactive search integrated with a multi-institutional fish collection database and on line rendering of geographic distribution maps. Over 2309 valid species belonging to 39 families of freshwater fishes have confirmed occurrence in Brazil. They belong to about 482 genera. The most diverse families are the Characidae (551 spp.), the Loricariidae (372 spp.), Rivulidae (152 spp.), Trichomycteridae (127 spp.), Cichlidae (120 spp.), Callichthyidae (115 spp.), and Heptapteridae (99 spp.). The number of known species continues to grow significantly, with an increase of over 15% during the last decade (341 spp.). Such growth reflects the increase in knowledge about the small-sized fish fauna from headwater streams and temporary environments, especially the Characidae (77 spp.), Loricariidae (73 spp.) and Rivulidae (51 spp.). (Research support from CNPq Proc.473652/2003-0, 308387/03-1, PRONEX; Fundação Vitae)

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#### Niche evolution in phylogeographic lineages of *Coluber constrictor*

A trend among published phylogeographic analyses is to report the geographic range of distinct lineages and assume that genetic disconnection among the lineages is due to currently existing physical barriers (i.e., rivers, mountains etc.). However, if the disconnection among lineages cannot be correlated with any known modern barriers, then other factors must account for this discordance. One explanation may be that ancient barriers no longer in existence severed gene flow among lineages and, while in isolation, these lineages adapted to specialized fundamental niches associated with their particular geographic areas. Moreover, the lineages associated with these particular niches currently cannot invade the foreign niches occupied by other lineages, resulting in distinctly geographically defined clades. We investigate these phenomena in our phylogeographic analysis of the transcontinental *Coluber constrictor* using both mtDNA and scnDNA sequences. Our analyses have revealed six ancient geographic lineages of *Coluber constrictor*, with the oldest lineage occurring in peninsular Florida. Combining divergence date estimates of these lineages using likelihood and Bayesian inference methods with a multivariate statistical description of the fundamental niche of these lineages using the BIOCLIM model, we determine if there was an ancient and/or a current physical barrier separating lineages, if fundamental niche better describes the range of lineages, and if greater niche differences are associated with the earlier divergence of lineages.

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#### Preliminary phylogeography of two *Agkistrodon* species, *Agkistrodon contortrix* and *Agkistrodon piscivorus*

The North American Copperhead (*Agkistrodon contortrix*) and the Cottonmouth (*Agkistrodon piscivorus*) are two of the most common venomous snakes in eastern and central United States with a range extending from the eastern coastline to southwestern Texas. Five subspecies of *A. contortrix* and three subspecies of *A. piscivorus* have been described based on morphological studies, largely color pattern. In this study we investigate phylogeographic relationships within each species using both mitochondrial and nuclear data. Recognition of the described subspecies seems to overestimate lineage diversity in both species. Preliminary molecular data identifies three putative lineages of *A. contortrix*, and only two of *A. piscivorus*. This study aims to i) identify evolutionary lineages within each species group, ii) investigate species boundaries and investigate possible gene flow across

species boundaries in order to better define putative intergrade zones, iii) examine ecological niches occupied by each distinct evolutionary lineage, and iv) infer ancestral area and divergence times in order to correlate species divergence with ecological events.

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Mechanisms of chytridiomycosis: If coquis have chytrids, why are they still alive?

While three species have disappeared in Puerto Rico since 1976, populations of other species have been extirpated only from certain areas, and others have recuperated or do not show impact at all. Thus, we questioned what type of mechanisms may be acting to reflect such specific taxonomic and population effects in a small geographical scale. We have documented the occurrence of *Batrachochytrium dendrobatidis* (*Bd*) among declining amphibians in the mountains of eastern Puerto Rico since 1976. To assess the spread of this fungus to other areas we sampled lowland and highland frogs in localities island-wide. We found *Bd* in various species of *Eleutherodactylus* and on *Leptodactylus albilabris*, only in the highlands. Incidence of chytrids with respect to seasonality, ontogeny and ecology of *E. coqui* were investigated showing interesting patterns with respect to the first two variables. Data suggests that a cyclic dry/cool-wet/warm climate linked mechanism is driving a synergistic interaction between chytrids and frogs that allows this pathogen to persist without exterminating its host. While this interaction may maintain ecologically hardy species like *E. coqui*, it can represent a threat for more vulnerable species. Individuals that escape or recuperate from high chytrid infections, carry the fungus at low incidences during the warm/wet season when conditions are less optimal for *Bd* growth. These frogs serve as reservoirs for the prevalence and spread of the disease. Ontogenetic diagnosis of chytrids on *E. coqui* revealed infections at all stages from eggs to adults, with significantly higher incidence among juveniles. This suggests that parental care in direct developing terrestrial species, can serve as a mechanism to spread *Bd* spores from infected parents to their offspring. Additional studies are underway to investigate associations between fine-scale microclimate data and the response of *Eleutherodactylus* frogs to chytrid infection.

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### Comparative osteology of the *Etheostoma variatum* group

The fishes of the *Etheostoma variatum* group have been intensely studied over the past two decades. The group was hypothesized to be one of three distinct groups of fishes within the subgenus *Etheostoma* (Richards 1966). Recent genetic analyses using genetic markers places the *E. variatum* group as its own distinct clade (Page and Cordes 1983, Switzer 2004). A thorough examination of 28 osteological characters, primarily those involving the cranium and axial skeleton, verify that this clade is morphologically distinct from the other clades of the subgenus *Etheostoma*. A phylogenetic reconstruction using PAUP 4.0b10 presented a tree very similar to the tree presented in Switzer 2004. The species examined were: *E. variatum*, *E. kanawhae*, *E. osburni*, *E. niangua*, *E. erizonum*, *E. euzonum* "Red River", *E. euzonum* "Strawberry River", *E. tetrazonum* "Osage River", *E. tetrazonum* "Gasconade River", *E. sagitta*, and *E. spilotum*. The outgroup taxa examined include: *E. gracile*, *E. spectabile*, and *E. blennioides*. Detailed illustrations of the cranial osteology of the species in the group are displayed, as well as the key differences between those within the group and the outgroup taxa.

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### The reproductive ecology of two shiner species, *Notropis asperifrons* and *N. stilbius*, in Alabama

Important details of the reproductive ecology of many freshwater fishes of the species-rich southeastern USA are still poorly known. Two such species are the burrhead shiner, *Notropis asperifrons*, and the silverstripe shiner, *N. stilbius*. Both are endemic to the Mobile Basin. Both are found in Borden Creek in the upper Black Warrior system in the Sipsey Wilderness of the Bankhead National Forest in Alabama. To determine timing and patterns of reproductive effort, collections were made of as many as 20 individuals of each species at roughly four week intervals from March to September. Individuals were fixed in buffered formaldehyde before being identified to sex. Gonadal tissues were removed and weighed so that gonadal somatic index, GSI, could be determined as an indicator of reproductive condition. Gonadal tissue from a smaller number (4-12) of individuals from each collection date, species and sex were dehydrated and stained for histological examination for a more precise assessment of reproductive condition, especially of females. Female GSI data averages for each collection indicate that burrheads peak in reproductive activity in April (16.3, N=5), while silverstripes peak in May (12.2, N=10). Both species still had

elevated female GSI values on July 3 (burrheads 10.9, N=4, and silverstripes 9.9, N=10) but both had a sharp decline on July 31 (burrheads 5.6, N=5, and silverstripes 4.8, N=9) with further steep drops in August and September. Histological examination of ovarian tissues to determine developmental status of oocytes indicates both species are multiple spawners, typical of North American notropines.

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Experimental analysis of RFID antennas for use in herpetological studies using PIT tagged salamanders (*Ambystoma tigrinum*)

Two types of proprietary RFID antennas were tested for maximum read distance in open and soil covered treatments. Maximum read distance is defined as the furthest distance away from a specimen that the antenna was able to read a PIT tag. Maximum read distance was determined by lowering the antennas in a level, straight line, above the specimen until the tag was identified or until the surface of the soil was reached (failure to read a tag was scored as a zero). Antennas tested were the Destron 2001 F-ISO Circular antenna and the Biomark Triangular Field antenna using attenuation box antn-04. Antennas were supplied on loan for the experiment from Biomark Inc. PIT implanted salamanders were placed in a cloth bag to limit movement and then covered with differing levels of soil. Antennas were analyzed for maximum read distance using differing levels of soil coverage in all treatments. Treatments were 1) antenna type and 2) depth of soil covering salamander. The following amounts of soil were used in the treatments; 2.2 cm (1inch), 6.6 cm (4 inches), 13.2 cm (6 inches), and 15.4 cm (8 inches) of loose soil. Data were analyzed using a two way ANOVA. Statistically significant differences (p value < .001) were seen between antenna types, maximum read distance at soil depth profiles and among soil depth profiles. The circular antenna read at a greater distance at all treatments except the treatment without soil. Additionally there was a significant decrease in maximum read distance for both antennas at soil depths greater than 6.6 cm and a significant interaction effect beyond this depth profile.

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Colonization of unmaintained swimming pools by mosquito larvae and their predators following Hurricane Katrina

Thousands of flooded swimming pools were abandoned in greater New Orleans following Hurricane Katrina, creating novel breeding opportunities for mosquito larvae in this ravaged urban landscape. We conducted a randomized survey of 90 swimming pools in January 2006 to evaluate the extent of colonization by mosquito larvae and their predators in the Lakeview and Filmore areas of New Orleans. Most of these pools (71%) had not been drained, cleaned, or treated for mosquitoes. For the 64 unmaintained pools, 62% contained mosquito larvae, 92% contained predatory invertebrates, and 47% contained fishes. Adults of mosquito larvae collected from unmaintained swimming pools are common vectors of West Nile virus and Western Equine Encephalitis virus. Dragonfly larvae were the most common invertebrate predators. Western Mosquitofish (76%), sailfin mollies (9%), Least Killifish (6%), and sheepshead minnows (5%) were numerically dominant. Rainwater Killifish, Diamond Killifish, Bayou Killifish, golden topminnows, naked gobies, and introduced Rio Grande cichlids were also collected. No aquarium species were collected. The fish assemblage found in swimming pools was similar to that found in drainage canals that flooded the Lakeview area. Abundance and diversity of fishes were both negatively correlated with distance from levee breach. Distance from large urban ponds also influenced fish diversity in pools. Fishes, especially Western Mosquitofish, appeared to have strong negative effects on mosquito larvae and larger predatory invertebrates. Path analysis indicated that fishes exert a strong trophic effect on dragonflies and mosquito larvae in structurally simple swimming pools. Introduction of local populations of Western mosquitofish may be the most cost effective method of suppressing mosquito breeding in unmaintained swimming pools during restoration of New Orleans.

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Is there a maximum age which can be determined from shark vertebrae?

The age composition of porbeagle sharks (*Lamna nasus*) in the Northwest Atlantic has been corroborated and validated using a broad range of rigorous techniques, making it one of the most reliably-aged shark species in the world. However, when vertebral sections from New Zealand porbeagles were examined microscopically and under X radiography, the presence of many fine increments near the margin of very old sharks raised concerns that band deposition may not have been annual. Bomb radiocarbon dating supported the ages assigned to New Zealand porbeagles up to about 20 years of age; however, for older sharks, the radiocarbon chronologies were delayed by periods of up to 34 years, suggesting substantial age underestimation. Alternative explanations for the observed radiocarbon patterns in vertebrae were implausible; surface marine radiocarbon in the vicinity of New Zealand was comparable to that found elsewhere in the world, and porbeagle feed on short-lived surface prey that reflect the radiocarbon of surface waters. These results imply that

the older New Zealand porbeagles were under-aged from band counts by as much as 50%, and could reach an age of 75 years. Although it seems likely that vertebral band counts provide accurate age estimates under normal conditions, it may be that very slow growing old sharks push the method too far.

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Challenges facing the tree of frogs

The explosion of datasets relevant to frog relationships has introduced new challenges for the elucidation of the phylogeny of frogs. Many nodes have been easily resolved, requiring few data; however, many nodes will resist discovery. Importantly, several related conceptual and analytical issues require attention. Missing data: the amalgamation of diverse datasets leads to gaps in the concatenated data matrix. From empirical studies, it has been argued that such holes do not reduce the accuracy of phylogeny estimation. Choice of genes: sampling is often haphazard, with little attention to the relative quality of genes. Probabilistic models: the development and implementation of models for morphology has lagged far behind that for nucleotide data. Dataset size: the increasing size of datasets challenges available estimation procedures. Taxonomy: Although monophyly is a generally accepted goal, the path to a taxonomy of monophyletic groups is not clear. Solutions to some of these issues as they relate to frog phylogeny will be discussed. This work is funded by a NSF grant to the AmphibiaTree project.

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The effect of radiotelemetry on the growth of free-ranging Mohave rattlesnakes (*Crotalus scutulatus scutulatus*)

This study compares the growth rates of 13 free-ranging Mohave rattlesnakes (*Crotalus s. scutulatus*) with intracoelomically-implanted radio transmitters, monitored for 10,003 snake/days (mean duration = 769 d, range 365-1074,  $\pm 70.3$  SE) to growth rates of 16 non-telemetered animals captured and recaptured by chance at the same study site during the same time period, resulting in growth data for 6449 snake/days (mean duration = 403 d, range 194-977,  $\pm 60.3$  SE). Precise snout-vent lengths (SVL) were obtained from all specimens under general anesthesia. The telemetered group was restricted to animals with body mass  $\geq 180$  g, yielding a mean SVL of 762 mm (range 702-838,  $\pm 12.4$  SE), while the unrestricted non-telemetered group produced a mean SVL of 664 mm (range 467-838,  $\pm 22.4$  SE). Although the mean annual increase in SVL was greater for non-telemetered than for telemetered rattlesnakes (23.3 mm  $\pm 7.2$  SE, and 7.3 mm  $\pm 2.1$  SE, respectively; independent *t*-test

$P = 0.047$ ), evaluation of growth data with ANCOVA using radiotelemetry (Y/N) as the fixed factor and SVL as a covariate indicates a strong relationship between snake size (SVL) and growth rate ( $F_{1,26} = 21.317$ ;  $P < 0.001$ ), while the relationship between being telemetered and growth rate was insignificant ( $F_{1,26} = 0.247$ ;  $P = 0.623$ ).

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### Patterns of movement and habitat utilization of female leopard sharks in Elkhorn Slough, California

The leopard shark (*Triakis semifasciata*) is one of the most abundant nearshore sharks in California and is commonly found in bays and estuaries. Elkhorn Slough is a shallow tidal embayment at the edge of Monterey Bay that is extensively utilized by leopard sharks of all ages, for which it is believed to function as a nursery ground. Since much of the life history of leopard sharks occurs in the slough, understanding how sharks utilize this habitat is important. Patterns of movement and habitat use of female leopard sharks in Elkhorn Slough were examined using acoustic tags and a combination of manual tracking and passive monitoring techniques between May 2003 and February 2005. Ten leopard sharks (91-132 cm TL) were tagged and manually tracked for 20-71.5 hours. An additional 13 leopard sharks (78-140 cm TL) were tagged and monitored for 4-443 days using an array of acoustic receivers. Analyses done to date indicate that the Elkhorn Slough National Estuarine Research Reserve marsh restoration site (ESNERR) is important for leopard sharks and may serve as a nursery ground for them. Shark movements and habitat use were tidally influenced, and in terms of large-scale movements, they generally moved with the tides. In the ESNERR they moved up onto intertidal mudflats at higher tides and were restricted to deeper channels during low tides. While in the main channel of Elkhorn Slough they exhibited a highly periodic pattern of movement, during which they were in the upper slough during higher tidal levels and would move up and down the length of the slough during periods of large tidal change. There also was a seasonal pattern of general habitat use, where sharks spent most of their time in the ESNERR during the spring and summer, and more time in the main channel during the fall.

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### Monitoring the recovery of Smalltooth Sawfish using standardized indices of relative abundance

The U.S. population of Smalltooth Sawfish, *Pristis pectinata*, is currently listed as endangered under the Endangered Species Act. An important component of monitoring the recovery of this species is establishing long-term baseline trends in abundance. In the absence of scientific survey data, assessing and monitoring the status of some marine species has required the utilization of fishery-dependent data. However, bias is associated with these data because fishers commonly change methods and consequently time series developed from these data require statistical modeling to correct for factors unrelated to abundance. The current center of abundance for smalltooth sawfish in the United States is in the Ten Thousand Islands and Florida Bay region of the Everglades National Park and detailed catch and effort data are available from this region from 1972-2004. The data are collected by Everglades National Park during voluntary dockside interviews of sport fishermen. Interviewers record effort, landings, and releases of all species caught. Using this data, a standardized index of abundance was created for smalltooth sawfish using the delta-lognormal method by combining two generalized linear models. Smalltooth sawfish were not reported until 1989. From 1989, the index shows a small increase in abundance at an average rate of about 3 to 5 percent per year. These results indicate that the population of smalltooth sawfish in the Everglades may have at least stabilized and may be slightly increasing. However, additional data and analyses from multiple sources are required before definitive conclusions on the recovery of smalltooth sawfish can be established.

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### Close correspondence between changes in trophic morphology and community composition in a group of darter fishes (Percidae)

Morphological diversity is an important metric of biodiversity. However, the factors that affect its origin and maintenance are poorly understood. Using rate of change in morphology as a phylogenetically corrected measure of diversity, we examined the relationship between community composition, specifically the number of close

relatives in a community, and changes in trophic morphology within the lineage of darter fishes; considerable theoretical and empirical evidence suggests that coexistence with ecologically similar species (i.e. close relatives) is often correlated with morphological change. We first gathered morphological data from 68 species in two groups of darters (39 species of *Percina* and 29 species of snubnose darters) and used the morphological data in combination with a phylogenetic tree based on cytochrome *b* sequence data with time-calibrated branch lengths to calculate the rate of change in trophic morphology for each group. We found that trophic morphology evolves at different rates in the two groups; the rate of change is 8.5 times greater in *Percina* than in the snubnose darters. We then examined the relationship between standardized contrasts in trophic morphology and reconstructed measures of community composition and found that changes in trophic morphology are strongly correlated with changes in community composition in *Percina* but not in the snubnose darters; large changes in trophic morphology are associated with increases in the number of close relatives that co-occur in a community. These results suggest both that the rate of morphological change is not constant within the darter lineage and that the effect of community composition on the evolution of morphological diversity varies between groups.

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### Potential effects of climate change on amphibian species diversity

Species are responding idiosyncratically to climate change by moving into once colder environments. Future range projections under plausible future climate scenarios suggest that these movements will result in the extinction of a sizeable fraction of the earth's biota. However, future range models are accompanied by many sources of uncertainty, some quantifiable, others not. Here we critically examine the potential effects of future climate change on amphibian species native to the Atlantic Rainforest in Brazil, and compare them to predicted shifts in the distribution of species endemic to other Brazilian ecosystems such as Amazonia, the Cerrado, and the Caatinga. To that end, we use expert-drawn maps of ca. 700 Brazilian amphibian species recently made available through the Global Amphibian Assessment initiative. We first consider whether the distribution models accurately predict persistence of taxa known to have been present during the Pleistocene. We then quantify area associations between current and past modeled distributions to test whether the observed correspondence is approximately one-to-one, as expected for comparisons across a wide range of species. Finally, where possible we assess the degree to which the reconstructed Pleistocene distributions are supported by intraspecific molecular data. Species distributions are then modeled under 2xCO<sub>2</sub> for existing levels of habitat availability and again given future estimated rates of habitat loss. Our approach identifies certain species for which predicted responses to climate change appear robust. We conclude with a discussion of the putative factors favoring

accurate projections under past and future climates.

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### Acoustic telemetry studies of common thresher shark, *Alopias vulpinus*, in the Southern California Bight

The largest commercial shark fishery in California waters is for the common thresher shark, *Alopias vulpinus*. We used acoustic telemetry to study the fine-scale movement patterns and habitat preferences of the common thresher in the Southern California Bight. One juvenile (fork length, FL: 84 cm) and eight subadult or adult thresher (FL: 122 to 203 cm) sharks were tagged with temperature and depth sensing acoustic transmitters and tracked for up to 49 h. Temperature-depth profiles were made every 2-3 h to characterize the thermal structure of the water column. Position and depth data were plotted in GIS and analyzed in relation to oceanographic data and time of day. Larger threshers utilized areas offshore of the continental shelf, while the juvenile shark remained in shallow waters over the continental shelf. All sharks displayed highly directed movements over entire tracks or extended portions of tracks, although there was no consistent direction of travel among the different sharks. Horizontal rate of movement (ROM) of the eight subadult or adult sharks averaged  $2.15 \pm 0.46$  km h<sup>-1</sup> (mean  $\pm$  SD), and was significantly higher than ROM of the juvenile shark ( $1.45 \pm 0.31$  km h<sup>-1</sup>). ROM peaked at dawn ( $2.61 \pm 0.36$  km h<sup>-1</sup>), and decreased until sunset, as did linearity of shark movements. Maximum ROM for all sharks was 4.42 km h<sup>-1</sup>. No relationship was found between ROM and FL for the larger sharks. Diurnal movements of several sharks were characterized by repeated vertical excursions below the thermocline into waters less than 10° C (maximum dive depth of 217 m). Nocturnally, local thermocline depth appears to have a strong limiting effect on the vertical distribution of common thresher sharks, and thus affects their susceptibility to the drift gillnet fishery.

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Diets of *Sargassum*-associated fishes collected during summer off Cape Hatteras, North Carolina

In the western North Atlantic, pelagic *Sargassum* forms a dynamic floating habitat that supports a diverse assemblage of fishes. As part of a water column trophodynamics study, the diets of dominant *Sargassum*-associated fishes (mostly juveniles), *Stephanolepis hispidus* (8-40 mm SL), *Caranx crysos* (9-70 mm SL), *Cheilopogon melanurus* (22-248 mm SL), *Balistes capriscus* (9-27 mm SL), *Seriola* spp. (12-96 mm SL), *Parexocoetus brachypterus* (55-117 mm SL), *Coryphaena hippurus* (9-605 mm SL) and *Abudefduf saxatilis* (9-20 mm SL), were analyzed. In addition, the diet of the endemic species, *Histrio histrio* (15-41 mm SL), was examined. Fishes were collected in the upper meter of the water column by neuston net, dip net and hook and line during summers of 1999-2001. Stomach contents were identified to the lowest practical taxa, and percent volume and frequency were calculated for each food item. For all species, 88% of the stomachs analyzed contained food items. *S. hispidus*, *C. crysos* and *A. saxatilis* almost exclusively fed on copepods (4 spp.). Juvenile *C. melanurus* fed primarily on copepods (2 spp.) and chaetognaths, while the majority of food items found in the stomachs of adult *C. melanurus* were pteropods, crustaceans and fish. *B. capriscus* fed on crustaceans and copepods. Fish (2 spp.), copepods (3 spp.) and crustaceans (2 spp.) were the dominant food items in the stomachs of *Seriola* spp. Crustaceans, cephalopods and hyperiid amphipods were dominant food items in *P. brachypterus* stomachs. Food items in stomachs of juvenile *C. hippurus* were fish (4 spp.) and copepods, while adult *C. hippurus* fed on fish (8 spp.) and squid. *Sargassum* was found in the stomachs of 62% of all dolphinfish. *H. histrio* fed on fish (2 spp.), shrimp (2 spp.) and copepods. Parasites were observed in 35% of all stomachs analyzed and were not included as food items. The *Sargassum* habitat supports rich sources of energy for many juvenile fishes in an otherwise nutrient-poor environment.

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Red-eared sliders (*Trachemys scripta elegans*) as long-term indicators of environmental contamination

The timing and mass release associated with contamination events are often unknown, which limits the ability to evaluate ecological risk. Long-lived biota having

distinguishable features associated with periodic growth, such as turtles, can be useful biomonitors for reconstructing contaminant exposure histories. Additionally, such biomonitors can be used in long-term environmental surveillance research as well as to evaluate the efficacy of remediation activities. Turtles are attractive indicator species because they are extremely long-lived organisms, appear to be relatively tolerant to a wide range of pollutants, and their shell is comprised of bone (apatite), which is a well-known target organ for various transition and heavier elements. They also display discernible growth rings in their scutes, which provide a chronological record similar to dendroanalysis. The purpose of this study was to test the ability to reconstruct a historical record of contaminant exposure by measuring metal concentrations in periodic growth rings of turtle scute and bone sections. Five hundred hatchling red-eared sliders (*Trachemys scripta elegans*) were gavaged with nickel citrate at concentrations of 0 (control), 20mgL<sup>-1</sup>, 65mgL<sup>-1</sup>, and 300mg Ni L<sup>-1</sup> during active growth on a bi-monthly basis since July 2003. Marginal and plastron scutes and bone sections from individuals in control, 65mgL<sup>-1</sup>, and 300mgL<sup>-1</sup> groups have been analyzed using a synchrotron x-ray fluorescence (SXRF) microprobe at the National Synchrotron Light Source (Brookhaven National Laboratory, Upton, NY). Nickel banding patterns correlating to growth rings were apparent in carapace scute thin sections, and a gradient of Ni in accordance with dose was observed. Fluctuating asymmetry and DNA strand breakage in tissues of control and exposed turtles is currently being evaluated. The results demonstrate the potential utility of turtles as sentinel species for use as a biomonitor/bioindicator for a range of applications.

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#### **CASHNER, MOLLIE F.**

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#### Explorations in nest association: Using restriction fragment length polymorphisms (RFLP) to identify cyprinid eggs

Nest association, the reproductive strategy of spawning in the prepared substrate of another species' spawning site, is a visually stunning, yet poorly understood reproductive strategy of many North American minnows. Up to six cyprinid species at a time have been observed aggregating over a single site. Although participants in these aggregations exhibit spawning coloration and behavior, spawning success and frequency are unknown for most. This study addresses two questions related to nest association: (1) do all species observed over nests spawn at the nest site and (2) is the number of nest associate eggs found in a particular nest proportional to the number of nest associates observed over a nest (i. e. can the hosts eggs be 'swamped' out by the eggs of associates, or do they benefit from a dumping effect of associate eggs)? I have developed a technique using restriction fragment length polymorphism (RFLP) patterns to identify cyprinid eggs collected from spawning aggregation substrates. Inter- and intra-specific RFLP patterns have been identified for nine cyprinids (three of which are known nest associates) in the Pascagoula River drainage: *Notropis baileyi*, *N. texanus*, *N. longirostris*, *Nocomis leptcephalus*, *Luxilus chrysocephalus*, *Lythrurus roseipinnis*, *Ericymba buccata*, *Hybopsis winchelli*, and *Cyprinella venusta*. Pattern

variations have been confirmed with direct sequencing. These RFLP patterns will be used to identify unknown cyprinid eggs collected from *Nocomis leptcephalus* nests, and to determine the proportion of eggs contributed by each associate species.

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A report of a distinct form of *Campostoma anomalum* from the uplands of Oklahoma and Arkansas

For well over 20 years RCC and WJM have made observations of a red-finned form of *Campostoma anomalum* from the Red and Ouachita rivers in the Ouachita Uplands in southeastern Oklahoma and west-central Arkansas. There are several distinctive features about the fins that we regard as unique among the various species and populations of stonerollers familiar to us. These include the distribution of red coloration in both paired and median fins, the occurrence of highly colored fins in both males and females as well as in juveniles, and the persistence of fin color beyond the breeding season. We recently discovered that the limits of the red-finned form extend significantly greater than just the limited region of Ouachita and Red river uplands. We provide a well-defined geographic range for the form, report on chromatic variation in the fins and document that contiguous *Campostoma* populations outside the described range lack such fin color characteristics. We will also present molecular evidence that red-finned stonerollers represent a monophyletic group. The red-finned stoneroller is likely referable to a form previously described by Girard (1858) from a branch of Sans Bois Creek.

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The directional hearing abilities of elasmobranchs

The hearing abilities of elasmobranchs have long been postulated as being one of their more important and acute sensory modalities. This has recently been brought into question as laboratory experiments have produced results that are contrary to field attraction experiments. Recent data suggest that elasmobranchs can detect a relatively narrow, low frequency range with thresholds that are not as sensitive as many bony fishes. However, an important aspect of audition which has been generally ignored is directional hearing sensitivity. Previous experiments have focused primarily on behavioral responses with the fishes being trained to swim towards a sound source for a reward. We built a shaker system which can stimulate

the sharks' auditory system from any direction in three dimensions. The sensitivity to linear acceleration which mimics acoustic particle acceleration was measured using auditory evoked potential measurements from the brain of the brown banded bamboo shark, *Chiloscyllium punctatum*. Thresholds of detection were obtained from several directions and multiple frequencies to create directional audiograms for determining if sharks primarily detect sound from a specific direction as has been proposed or if they detect sounds from all directions equally.

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**Changes in baseline growth and maturation parameters of Northwest Atlantic porbeagle shark, *Lamna nasus*, following heavy exploitation**

We tested for density-dependent changes in growth and maturation of northwest Atlantic porbeagle shark (*Lamna nasus*) after intense fishing pressure. Vertebral samples and reproductive data collected from the virgin (1961-1966) and heavily exploited (1993-2004) populations were analysed in order to test for differences in growth and age/size at maturity between the time periods. Porbeagle grew faster and matured earlier after the population had been reduced by 75-80% from fishing. Likelihood ratio tests detected significant differences in reparameterized von Bertalanffy growth models and all of its parameters between the sampling periods. Beyond an age of 7 years, mean length-at-age of recently captured sharks was greater than that of sharks captured during the 1960s. Between 1961-1963 and 1999-2001, size at maturity in males decreased from 179 to 174 cm FL, while size at maturity in females remained unchanged (216 cm FL). This, combined with increased growth rate, led to a decline in age at maturity from 8 to 7 years in males, and from 19 to 14 years in females, since the early 1960s. An analysis of porbeagle temperature associations indicated that sharks occupied similar temperature conditions during the 1960s and 1990s, thereby ruling out the possibility of temperature-induced changes in porbeagle growth. This is the first study to document changes in baseline life-history parameters in an elasmobranch population following exploitation. The observed increase in growth rate and decrease in age at maturity following exploitation support the hypothesis of a compensatory density-dependent growth response, although reductions in interspecific competition could not be dismissed as an alternative explanation.

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## **CASTELLO, LEANDRO**

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### Lateral migration of pirarucu, *Arapaima gigas*, in a floodplain of the Central Amazon

The migration of pirarucu (*Arapaima gigas*), a giant piscivore and obligate air-breathing fish species endemic to the Amazon, requires understanding to allow for sound assessment and management of overexploited populations. To this end, this study used counts done at the moment of aerial breathing to deduce movements of pirarucu in a local varzea floodplain. In 15 months, the pirarucu migrated among the eight sampled habitats and occupied generally shallow, slow flowing areas. Movements between habitats were strongly influenced by water level variations. During rising and high water levels, the pirarucu inhabited the flooded forest, where usually favorable conditions to feeding, growth, and reproduction are available. During lowering water levels, the pirarucu migrated into communicating channels and, eventually, into the lakes, where it remained during low water levels. There, the generally low oxygen levels tend to intoxicate most fishes, but not the pirarucu, which with its air breathing behavior and large size can predate actively. Pirarucu population densities in any one habitat are thus highly variable. Given that in some regions population assessments based on counts of pirarucu are a requirement for legal harvesting, scientist and managers should consider the dynamism of migratory movements and its intrinsic relation to intra- and inter-annual variations in flood cycles.

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## **\*CASTEN, LEMUEL R.; JOHNSTON, CAROL E.**

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### Life history plasticity across disturbance gradients in Alabama streams

Four populations of the Blacktail Shiner, *Cyprinella venusta* were studied to determine life history parameter variations across disturbance gradients in Alabama streams. Consistent with life history theory, fishes in stable environment were significantly larger (mean = 78.1 mm) than fishes from degraded site (mean = 70.9 mm) and fishes from the degraded site have the smallest size at maturity (mean = 38.2 mm), and propagule size (mean = 1.04 mm). Clutch sizes varied among populations and ranged from 61-1515 eggs (SL-adjusted mean = 295). Egg diameters were not related to SL among populations. There were no significant differences in mature egg diameters, however ripening egg diameters differed among populations and ranged from 0.93-1.31 mm (mean = 1.06 mm). There was no difference in gonad mass in females for all spawning months; however, there were differences in gonad mass in males in July. GSI peaked in July for both male and female. Reproductive males were still present in September for three populations but all females from all populations have become

latent by September indicating that spawning season has ended. The results of this study suggest that *Cyprinella venusta* has the ability to alter life history parameters in harsh environments and may be a factor why it persists in habitats where other species are declining.

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Observations on the reproductive biology of *Raja inornata* (Jordan and Gilbert, 1881), *R. velezi* (Chirichigno, 1973), and *R. rhina* (Jordan and Gilbert, 1880) in northern Gulf of California

A total of 520 skates of three species (*Raja inornata*, *R. velezi* and *R. rhina*) were collected from the commercial bottom trawl fishery operating off Puerto Penasco in the Northern Gulf of California, between March 2003 and April 2004. *R. inornata* had a female:male ratio of 1.2:1 (n=376), where the largest male and female measured 585 and 613 mm in total length (TL), respectively. The relationship between total body mass and TL was significantly different between sexes. The size at which 50% of males were sexually mature was 443 mm TL (75.7% of the maximum size), whereas 50% of females were mature at 514 mm TL (83.8% of the maximum size). The presence of females carrying egg-cases in different stages of development through the year (n=37), suggested a continuous reproductive cycle. Also, male and females were caught in different maturity stages through the range of trawled depths (68-272 m) suggesting a lack of spatial segregation by size and sex in the area. *R. velezi* had a sex ratio of 1.15:1 (n=73), where the largest male and female measured 910 mm and 1000 mm TL, respectively. The smallest mature male examined had a TL of 650 mm, whereas the smallest mature female measured 790 mm TL. *R. rhina* presented a sex ratio of 1.09:1 (n=71), with largest male and female size of 800 mm and 950 mm TL, respectively. The smallest mature male examined had a TL of 690 mm, whereas the smallest mature female measured 790 mm. Females of *R. velezi* and *R. rhina* attained larger body size and weight than males. And in both species the relationship between total body mass and TL was not significantly different between sexes. The amount of reproductive data collected for these two last species did not allow the outline the reproductive cycle duration.

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### Untangling 20 million years of coralsnake evolution and diversity

We have examined the diversity of coralsnakes and found a tremendous amount of taxonomic work necessary within the group, both in Asian, as well as New World taxa. In North America and Central America species seem to have been over-described, and in South America, under-described. At the generic level, coralsnakes are surely under-described and further subdivision at this level is required. We have started from the base of coralsnake phylogeny by asking: what a coralsnake is, how have they dispersed into the New World, and we have closely examined the tips of the coralsnake phylogeny to establish species boundaries. We find color pattern (possibly due to mimicry) to be very taxonomically misleading and confounding, and color patterns appear to relate more strongly with geography than with species boundaries. In order to detect boundaries and define species, we have employed DNA sequence data (both nuclear and mitochondrial), hemipenial characters, and intense studies of geographic ranges based on museum records. As an example we present our findings on the Mexican-triadal forms, a group of snakes in which we find are not closely related to one another, and portray a general pattern of diversity underrepresented by current taxonomy. We also present evidence for a similar pattern of under-description in the case of other Middle American species complexes including the *fulvius*, *nigrocinctus*, and *diastema* groups.

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### CATENAZZI, ALESSANDRO

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### Topographic effects on marine subsidies for gecko coastal desert populations

I analyzed how the topography of the coastal boundary influenced the distribution and abundance of a major nocturnal consumer in a desert ecosystem that receives significant amounts of marine subsidies. In the hyper-arid desert of the Peruvian coast, geckos are much more abundant along shore than they are in adjacent inland areas. These high abundances are supported by the input of marine resMyces, such as algal mats washed ashore by tidal action. I explored the idea that variation in coastal topography could mediate the effects of marine subsidies on gecko populations. I designed a natural experiment to examine whether the presence of cliffs separating the intertidal from the desert could influence the abundance and distribution of geckos. Spatial subsidies can increase the abundance of consumers by increasing survival and fecundity of individuals, or by promoting their aggregation along the edge of more productive habitats. My data show that geckos are significantly more abundant in places where no cliffs separate the desert from the

intertidal (open beaches) than they are in places with cliffs. Dietary analyses indicate that individuals consume more food along open beaches than along beaches bordered with cliffs. Geckos tend to aggregate along shore, and this aggregation is stronger for geckos along open beaches. Higher recruitment along open beaches suggests that marine subsidies could also increase fecundity in the coastal populations. I suggest that coastal topography, rather than ecological characteristics of the desert habitat, can explain long-term patterns of abundance and distribution for these geckos.

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Seasonal and geographic eurythermy of *Microlophus peruvianus*, a coastal Peruvian lizard

We contrasted the summer and winter field body temperatures of the tropidurid lizard *Microlophus peruvianus* at the Paracas Peninsula in southern Peru. We also compared our winter data to those gathered by Huey (1974) at the Illescas Peninsula in northern Peru, to test the hypothesis that southern lizards would tolerate lower temperatures than northern lizards. Cloud cover is more persistent in Paracas than it is in Illescas. During the austral winter, lizards at Paracas reduced surface activity to midday hours and had body temperatures below the mean set-point temperature (as measured in a photo-thermal gradient). Lizards from southern Peru were active over a wider range of temperatures than were lizards from Illescas. Mean body temperature of field-active lizards in the cloudy Paracas site was  $33.0 \pm 0.44$  C, significantly lower than the mean field body temperature at the sunnier Illescas site ( $36.3 \pm 0.26$  C,  $t=-6.19$ ,  $P < 0.001$ ). Although thermal preferences tend to be conserved among related lizard species, we found considerable variation in body temperatures and activity patterns of two populations of this tropical desert lizard.

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Osteological review of the ictalurid catfish skeleton with emphasis on *Noturus*

A comparative study of the ictalurid skeleton was undertaken in order to look for systematic characters that are of use at two levels (intergeneric and interspecific). A new fossil species of Miocene age was examined for help in polarizing character states. Both dry skeletal and cleared and stained specimens were used for each

Recent taxon examined. At the interspecific level emphasis was placed on the more speciose madtom group, *Noturus*. In general each ictalurid taxon could be identified by a set of osteological characters which are most helpful in interpreting ictalurid archaeological and fossil remains. Some of the *Noturus* characters studied have transitional states that can be polarized. These were used in a cladistic analysis. Skeletal characters form an important part of Ralph Taylor's monograph on *Noturus* taxonomy. The madtom skeleton has been largely neglected since his pioneering study. Osteology is particularly useful in describing some of the cryptic madtom taxa.

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**CECALA, KRISTEN K.**

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**A comparison of the effectiveness of MS-222 (tricaine methane sulfonate) and Orajel® (benzocaine) as amphibian anesthesia**

Traditionally, tricaine methane sulfonate (MS-222) has been used to anesthetize amphibians for a variety of procedures including surgery, marking, and photography. Recently, a human analgesic, Orajel®, has been recommended as a convenient and effective alternative. The effectiveness of each anesthetic has been tested, but no study has compared their effectiveness among amphibian species. We evaluated the time required for induction, time of anesthetization, and recovery time for *Desmognathus fuscus* and *Acris crepitans* using recommended doses of each anesthetic. Orajel® required significantly less time for induction (*A. crepitans*  $p < 0.001$ ; *D. fuscus*  $p < 0.001$ ) and resulted in a longer anesthetization period than MS-222 (*A. crepitans*  $p < 0.001$ ; *D. fuscus*  $p < 0.001$ ). Recovery time for each anesthesia did not differ significantly for each anesthetic (*A. crepitans*  $p = 0.82$ ; *D. fuscus*  $p = 0.57$ ). All animals survived testing with each anesthesia. Our study demonstrates that at recommended doses, Orajel® is more effective and appears to have minimal mortality risk. The effectiveness of MS-222 may increase at higher concentrations, but the risk of mortality would likely increase.

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**\*CHABARRIA, RYAN E.; CROTHER, BRIAN I.; WHITE, MARY E.**

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**Can DNA be extracted from preserved specimens?**

The use of molecular markers has become prominent in phylogenetic research; however the availability of samples is a problem that biologists frequently encounter. Museums contain a vast amount of phylogenetic information within their formalin fixed collections. Extracting DNA from these specimens has proven to be difficult, but there have been many methods of DNA extraction from formalin fixed specimens published. Traditional extraction methods do not consistently yield DNA from these

samples. This study attempts to determine a consistent method of extracting DNA from formalin fixed specimens, which would open up many doors in phylogenetic research. Along with finding a consistent method of extraction, this study will be testing the effects of preservation methods and the age of the specimen on the ability to extract DNA. Many of the proposed methods do not show that age of the specimen is an issue. However we believe that the age and the quality of preservation are factors in our ability to extract DNA from formalin fixed specimens.

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**CHABOT, CHRIS L.**

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Population genetics of the Tope (*Galeorhinus galeus*) in response to California fishery pressure

The tope (*Galeorhinus galeus*) has been the subject of intense fishery pressure over the last 74 years (Ripley 1946, FAO.org). Millions of sharks were harvested during the 1940s primarily for their vitamin A rich livers (Ripley 1946, Leet et al. 2001). This intense exploitation collapsed breeding areas within the San Francisco and Tomales bays (Leet et al. 2001). Currently all sharks face a new global threat, shark finning. Unfortunately, only well-qualified estimations exist as to how many sharks inhabit the world's oceans. Without exact population data, the impact of overfishing on shark species can only be assumed. Because empirical estimation of true population sizes of pelagic shark species is unrealistic, a method of determining shark population health is sorely needed. The tope provides an excellent model in that this species of shark was once historically overfished (Leet et al 2001). By analyzing and comparing the DNA of present day topes with the DNA of preserved specimens dating back to the early 1900's, evidence of inbreeding and the possible existence of a population bottleneck may be established. This information would be invaluable for the establishment of new conservation measures aimed at easing the current fishing pressure on topes, as well as other species of shark around the world.

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**CHAKRABARTY, PROSANTA**

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Deconstructing 'Cichlasoma': Phylogenetic analyses of Middle American cichlids

Cichlids from Middle American remain poorly studied phylogenetically despite being a major radiation with diverse behaviors, morphologies, and notable biogeographic histories. Taxonomy of this group was thrown into disarray when the catch-all Neotropical cichlid genus *Cichlasoma* was restricted to a dozen South American species; leaving nearly all the hundred Middle American cichlids without generic assignments. I present a combined molecular and morphological analysis of these fishes and discuss their phylogeny and biogeography. Without these

assignments and recognition of major clades, evolutionary studies on these fishes are hindered.

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**CHAMBERLAIN, SARAH J.; \*SCHNEIDER, LEAH; SUDKAMP, MITCHELL; TANG, KEVIN L.; WOOD, ROBERT M.; MAYDEN, RICHARD L.**

*Department of Biology, Saint Louis University, 3507 Laclede Avenue, Macelwane 128, Saint Louis, MO, 63103, USA*

### The Cypriniformes Tree of Life (CToL) Initiative: A progress report on the phylogeny of the order Cypriniformes

Cypriniformes comprise a diverse, widespread order of fishes with five families, roughly 280 genera, and more than 3000 species. These fishes are found in a wide variety of freshwater habitats in Africa, Asia, Europe, and North America. The order forms the world's most diverse lineage of freshwater fishes and includes many economically and scientifically important species (e.g., the zebrafish, *Danio rerio*, is a model organism in evolutionary and developmental studies; many species are important food sources around the world). The Cypriniformes Tree of Life project was initiated in order to discover the phylogenetic relationships among these fishes. At the completion of the project, one thousand representative species within the order will be sequenced and analyzed. This knowledge will further the fields of systematics and evolutionary biology as well as provide a valuable resource to other disciplines of biology and the general public. Currently, approximately two hundred taxa have been sequenced for the mitochondrial genes ND4 and ND5 and the nuclear genes RAG1 and Rhodopsin. These data were used to construct a tree using parsimony, maximum likelihood, and Bayesian methods. The phylogenetic relationships recovered by these analyses will be presented, with discussion of the monophyly of the diverse lineages within Cypriniformes.

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**\*CHANG, ANN T.; SHAFFER, H. BRADLEY**

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### Phylogeography of *Spea hammondi*: Multi-gene discordance shows evidence of North-South population split and interspecific hybridization

Recently, the applications of comparative phylogeography in identifying important regions of conservation and evolution have been gaining attention. Many comparative phylogeography studies take place in California because it contains numerous endemic species and is topographically and ecologically complex. Two common themes in California are a deep phylogeographic split north and south of the Transverse ranges (resulting in differentiated clades in southern and northern California), and an East-West split between populations from the coast and Sierra

Nevada. A recent systematic study of pelobatid frogs based on mtDNA suggested that the California endemic, *Spea hammondi* is non-monophyletic, with Southern Californian *S. hammondi* being more closely related to *Spea intermontanus* and *Spea bombifrons* than to Northern Californian *S. hammondi*. To further investigate this result, we extracted DNA from 56 *Spea* individuals, (47 *S. hammondi*, one *S. bombifrons*, four *S. intermontanus*, and two *S. multiplicatus*), including range-wide sampling of *S. hammondi*. We sequenced all individuals for the mitochondrial gene ND2 and a subset of our samples for the nuclear genes Rag1 and NCX - Sodium Calcium exchanger. Consistent with previously published results, our mtDNA supports the paraphyly of *S. hammondi*. However, our two nuclear genes support the monophyly of *S. hammondi*. While the mitochondrial and nuclear genes conflict with regards to *S. hammondi* monophyly, they both indicate a deep North-South split along the Transverse ranges. There was no evidence of an East-West split. Our results indicate divergence between Northern Californian and Southern Californian *S. hammondi* and are consistent with mitochondrial, but not nuclear introgression between Southern Californian *S. hammondi* and *S. intermontanus* or *S. bombifrons*. Lastly, because the *S. hammondi* data set lacks an East-West split, combining it with other population biology data sets from California may help identify the ecological or geographic barriers that cause population divergence between the Coast and Sierra ranges.

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## Origin and evolution of the New Zealand skink fauna

New Zealand boasts one of the world's most diverse temperate assemblages of herpetofauna (80+ species), particularly given its latitude and relatively small landmass. The endemic skink radiation in New Zealand comprises two genera (*Oligosoma* and *Cyclodina*) and as many as 40-50 species. Skinks are believed to have arrived in New Zealand via oceanic rafting or landbridges in the Oligocene, and radiated rapidly in response to changes in the landscape and climate over the past 25-30 million years. However, several species might have evolved as recently as the Holocene through isolation on offshore islands after the last glacial maximum. In order to test a series of hypotheses about the mode of skink evolution in New Zealand, we have constructed a robust phylogeny for all species of New Zealand skinks based on sequences from multiple mitochondrial (3400bp; ND2, ND4, Cytb, 16SrRNA, 12SrRNA) and nuclear genes (1900bp; Rag-1, B-Fibrinogen 7th Intron, Myh-2). Samples from the Lord Howe Island skink ('*Oligosoma*' *lichenigera*) and New Caledonian and Australian representatives of the *Eugongylus* skink lineage were included as outgroups. The resulting phylogeny has resolved several long-standing taxonomic issues within the New Zealand skink fauna, and clarified the phylogenetic relationships between most species. The tree topology indicates that the skinks radiated rapidly across New Zealand following their initial colonisation, although

there is evidence for multiple periods of speciation during the evolutionary history of the New Zealand skink fauna.

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### Polychromatism of the freshwater stingray *Potamotrygon leopoldi* (Chondrichthyes: Potamotrygonidae)

Freshwater stingray dorsal color patterns have been widely used as important criteria in species identification. The intra-specific dorsal color variability (polychromatism) that occurs within this family almost always results in misidentifications or in the use of different designations for a same species. *P. leopoldi* is an endemic species of the Xingu River basin that was described as dorsally dark black with yellow spots that become irregular at the disc center (half-moon or kidney shaped). Female and male specimens (n = 166) were collected in the mid Xingu River region in the years 2003 through 2005. All stingrays were photographed dorsally and ventrally immediately after capture. A dorsal color pattern characterization study was carried out considering the shape, distribution and presence / absence of defined figures. Ventral color variations were also registered. Different color patterns were observed among neonates, juveniles, sub-adults and adult specimens. Most color patterns had not been previously registered for this species. Neonate and juvenile specimens are easily misidentified as *P. henlei* and *P. motoro*, even by the ornamental fish trade. Some of the sub-adult and adult color patterns are similar to *P. henlei*, an endemic species of a neighboring river basin (Tocantins-Araguaia basin). Conclusively, this species presents a higher polychromatism than once thought. It is recommended that color characteristics should be used with care and not solely when identifying potamotrygonid freshwater stingrays.

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### Reproductive biology of the freshwater stingray *Potamotrygon leopoldi* (Chondrichthyes: Potamotrygonidae)

Potamotrygonids are completely adapted to live in freshwater and *Potamotrygon leopoldi* is restricted to the Xingu River basin. Freshwater stingrays present a reproductive mode known as matrotrophic viviparity with development of trophonemata or matrotrophic histotrophy. Specimens (n = 154) were collected in the mid Xingu River region in the years 2003 through 2005. Females (n = 77) and males (n = 77) were dissected and had their main reproductive characteristics studied in the field and laboratory. The following sequence of events was observed: gonadal maturation, copulation, pregnancy, birth and resting. Hepatosomatic index (HSI) values varied from 1.12 - 6.33 for males and 1.23 - 5.86 for females. Gonadosomatic index (GSI) values varied from 0.05 - 3.31 for males and 0.08 - 0.98 for females. HSI and GSI varied according to river level. Gonadal maturation lasts for about 4 months, pregnancy around 5 to 6 months, copulation takes place during the flood season and births begin as the water level goes down. Adult females presented an average ovarian fecundity of 9.7 and uterine fecundity of 4.8. Clasper size and number of embryos were positively correlated to disc width. Embryos (n = 200) were assigned to five different development stages. The results indicate that the reproductive cycle of *P. leopoldi* is closely related to the hydrologic cycle of the Xingu River and any changes in this system, such as damming, potentially will affect this species reproduction (partially supported by CAPES, WWF - Brazil and ACEPOAT / ACEPOPA).

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### **CHATFIELD, MATTHEW**

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### Hybrid zone dynamics between two species of salamanders in the genus *Plethodon*

Hybrid zones are active areas of research into the causes of speciation and maintenance of species boundaries. This study examines the pattern of introgression of a quantitative trait under putative positive selection through comparison with mitochondrial and nuclear genetic markers. *Plethodon jordani* and *P. metcalfi* (Plethodontidae) form a narrow hybrid zone in the Southern Appalachians of North

Carolina. *Plethodon jordani* possesses aposematically colored red cheek patches while *P. metcalfi* has uniformly gray cheeks. Using cline theory, introgression of red cheek pigmentation through the hybrid zone across two transects is assessed. These patterns are then compared to a suite of genetic markers. Data collected to date show differences in cline position between red cheek pigmentation and mitochondrial DNA. These data can be interpreted in one of two ways, either (1) red cheek pigmentation is differentially introgressing into the *P. metcalfi* population or (2) that *P. metcalfi* mtDNA is introgressing into the *P. jordani* population. Additional data from nuclear markers is required to distinguish between these alternatives.

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### A phylogenomic perspective on the new era of ichthyology

Ichthyology is one of the oldest disciplines in Biology and is also the second discipline (after Entomology) to make use of phylogenetic concepts in its classification. This dates back to the pioneering work of Greenwood and colleagues in 1966. This revolutionary approach, together with relevant techniques of morphological character analysis developed during the same period enabled spectacular progress in the systematic ichthyology of the 20th century. Most recently, rapidly increasing genomic information and developmental data, particularly on several existing (zebrafish, medaka and pufferfishes) and emerging (cichlids and sticklebacks) fish models provide not only new comparative data for medical sciences but are also enabling a new perspective in research directly impacting approximately one half of vertebrate species. Collectively these taxa have experienced several episodes of evolutionary radiation generating a large number of distinct and diverse species/populations with profound changes in morphological, ecological and behavioral characteristics. The question of how the members in such a diverse group are related to one another and how such tremendous diversity is generated in the context of genomic evolution is a particularly interesting question that is only beginning to be addressed. The goal of this poster is to review the utility of data stemming from phylogenomic analyses on the construction of a reliable phylogenetic tree of ray-finned fishes and to gain understanding into the evolutionary processes underlying the morphological, ecological and genetic diversification of fishes. This will be achieved by reference to postulated gene duplication events, taxon-specific gene content of genomes, and potential modification of control regions between paralogous/orthologous genes.

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### Population ecology of the Spotted Seahorse, *Hippocampus kuda* Bleeker

A total of 102 females and 103 males were tagged from April 2002 to March 2004, with no significant bias in the sex ratio. The average sightings of seahorses were lower in the wet season (July-August and November-December). The population size of *H. kuda* in the study area was estimated at 438 individuals using the Jolly-Seber method. The mean total length in males and females were similar. Length frequency distribution exhibit a normal, unimodal curve and the modal length for males and females was 15.0 cm. Sexual maturity was reached at 14.0 cm in both sexes. Weight-length relationship was exponential ( $W=0.0038L^{2.97}$ ) and characterized by an isometric growth type. Reproduction was year-round but peak reproductive season could not be determined. The maximum residency period of seahorses was 103 days with no significant difference in the residency periods between males and females. There was probable migration especially during the wet season. The mean home range size was 32.35 m<sup>2</sup> and the home range shapes were somewhat elongated. The home range size of males (mean: 39.25 m<sup>2</sup>) and females (mean: 25.46 m<sup>2</sup>) did not differ significantly.

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**CHRIPCZUK, JONATHAN; \*MARET, TIMOTHY J.**

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### Effects of *Notonecta irrorata* (Hemiptera: Notonectidae) on behavior and survival of larval amphibians from temporary ponds

Numerous studies have examined the role of odonate and vertebrate predators on the behavior, growth, morphology, and survival of larval amphibians. In temporary ponds in south-central Pennsylvania, backswimmers (*Notonecta*) are more widespread than odonate or vertebrate predators, yet little is known about the predatory effects of backswimmers on larval amphibians. We conducted laboratory and mesocosm studies using the backswimmer *Notonecta irrorata*, wood frog tadpoles, *Rana sylvatica*, and larval spotted salamanders, *Ambystoma maculatum*, to answer the following questions: (1) Does *N. irrorata* present a predatory threat to larval amphibians? (2) Do larval amphibians modify their behavior in the presence of *N. irrorata*? (3) Since backswimmers are active predators that pursue prey from the water surface and odonates are ambush predators that inhabit the benthos, will the combined predation effects by *N. irrorata* and odonates (*Libellulidae*) be greater than additive? In the laboratory study, *N. irrorata* reduced the survival of *R. sylvatica* but not of *A. maculatum*. The laboratory study further showed *N. irrorata* presence affected the amount of movement by *A. maculatum*, the amount of time spent hiding by *R. sylvatica* and the depth in the water column maintained by both species. In the mesocosms, *N. irrorata* posed a greater predatory threat to larval amphibians than did

Libellulidae. A non-additive effect of predation by *N. irrorata* and Libellulidae was not found in either portion of the study. This study appears to be the first to quantify Notonecta predation on larval amphibians. Furthermore, it demonstrates that *R. sylvatica* and *A. maculatum* alter their behavior in the presence of *N. irrorata*.

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**CHRISTEL, CAROL; DENARDO, DALE; BOBACK, SCOTT M.; \*SECOR, STEPHEN**

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The desert's little dinosaurs: Postfeeding metabolic and intestinal responses of Gila monsters

Gila monsters, one of two venomous lizard species in the world, actively forage in their desert environment for eggs of ground-nesting birds and litters of neonate rodents and rabbits. Known to feed relatively infrequently on large meals (up to 35% of body mass), we explored the magnitude that Gila monsters increase metabolic rate with feeding and the degree by which they regulate intestinal performance. In response to rodent meals equaling 5%, 10%, and 15% of body mass, lizards experienced 3.6-, 4.8-, and 5.1-fold increases in metabolic rates and maintained significantly elevated rates of metabolism for 4, 6, and 7 days, respectively. Egg meals equaling 10% of body mass generated a 4-fold increase in metabolism with elevated rates maintained for 5 days. Within 24 hours following the consumption of rodent meals equaling 10% of their body mass, the small intestines of Gila monsters had increased by 50% in mass and 50% in nutrient (amino acids and glucose) transport rates. These increases in intestinal mass and function were maintained until at least day 3 of digestion. As a product of the increase in intestinal mass and nutrient transport rates, the total capacity of the small intestine to transport nutrients had significantly increased on average by 150% after feeding. Although Gila monsters experience a significant postprandial increase in intestinal performance, the magnitude of this response is noticeably less than those experienced by infrequently feeding snakes. This difference is largely due to Gila monsters not regulating intestinal nutrient transport as widely as infrequently feeding snakes.

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**CIACCIO, JENNIFER**

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Increase in predatory efficiency of hatchling whitespotted bamboosharks, *Chiloscyllium plagiosum*

Foraging presents a significant challenge for neonatal predators. Adequate predatory skills must initially be present or must quickly develop. Additionally, predatory efficiency may change over time. Physical maturation may cause changes in efficiency due to improved neuromuscular coordination, increased sensory abilities,

or morphological changes. Experience may allow predators to increase efficiency by honing existing skills and developing new ones. Predatorily naive whitespotted bamboosharks, *Chiloscyllium plagiosum*, of two age groups (2 days old or 21 days old) were video-recorded foraging on live polychaete worms. The first fifteen prey captures of each shark were analysed for predatory efficiency - the duration of the predatory sequence from initiation of trial to complete ingestion of prey. Predatory efficiency was then subdivided into three measures: latency to attack the prey, duration of attack (between first contact with prey and initial ingestion) and duration of prey processing (between initial ingestion and final swallowing). The changes in these measures over time were compared between the two groups of sharks.

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**A distributional atlas of West Virginia fishes: A progress report**

During the past five years, we have synthesized and compiled data on historic and recent fish collections in West Virginia into a georeferenced database. The West Virginia fish database will be used to produce a spatial and temporal atlas of fish distributions, and currently includes 8,100 site records from fish collections during 1853 to 2005. Species distribution data will be depicted by time periods which reflect the substantial contributions and efforts of Ebenezer Andrews, Spencer Baird, Charles Bollman, William Hay, E.L. Goldsborough, Carl and Laura Hubbs, Milton Trautman, A.H. Wright, John Addair, Ed Raney, L.W. Wilson, E.A. Seaman, P.E. Swasey, H. Van Meter, Anthony Bodola, Frank Schwartz, Ron Preston, Bob Denoncourt, Charles Hocutt, Jay Stauffer, Rich Raesly, West Virginia Division of Natural Resources personnel, as well as collections from the authors. Over 2000 of the 8,100 site records are represented at museums, and we have verified species identifications of most of the individual lots of these records at Cornell University, University of Michigan Museum of Zoology, American Museum of Natural History, North Carolina State Museum, United States National Museum, and Ohio State University Museum. Additionally, we will include dichotomous keys (with illustrations) for identification of families, genera, and species. The general format, highlights, and illustrations of this upcoming book are presented.

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### Population declines in Ecuadorian glassfrogs (Centrolenidae)

Amphibians around the world are suffering declines. We have systematized all information available for the Glassfrogs (family Centrolenidae) from Ecuador and have found that several species show declines similar to those reported for *Atelopus* toads. Most Andean species of Glassfrogs from Ecuador show signs of severe decline, either in their number of localities or their abundance; while lowland species have not decline, and are still fairly widespread in adequate areas. At least five species of Glassfrogs have completely disappeared from their historical localities, and seven species have extensively reduced their distribution ranges and are found only in scattered localities. At least four Andean species are still undescribed and probably also on the verge of extinction. Possible causes for these declines/extinctions include climatic anomalies, diseases, water pollution, and severe habitat destruction. The effect of temperature and humidity change and/or the infection by chytrid fungus on Glassfrogs needs to be tested experimentally.

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### Nutritional exchange in the Clownfish/host anemone symbiosis: Stable isotope analysis demonstrates it is a tripartite exchange

Clownfish are obligate associates of sea anemones and this symbiosis has been well-characterized from the fish' point of view. Many authors have suggested that resident clownfish provide benefits to their host anemones as well (e.g. protection mutualism, enhanced growth and reproduction) yet few workers have demonstrated this experimentally. We hypothesized that clownfish (*Amphiprion clarkii* and *A. perideraion*) capture nutrients from the water column and supply them to their host anemone (*Heteractis crispa*). We used stable isotope markers ( $^{15}\text{N}$  and  $^{13}\text{C}$ ) to trace nutrients in formulated food provided to resident fish, host anemones, and intracellular symbiotic algae to characterize nutrient translocation in several directions. In the laboratory, either resident fish or their host anemone were fed isotope-labeled pellets and then fish tissue (gills, intestine, liver, muscle) and anemone tissue (whole, animal fraction, algal fraction) were analyzed for presence of

the markers. In order to determine if carbon fixed by intracellular symbionts was translocated to the anemone and/or the clownfish, we exposed anemones to  $^{13}\text{C}$ -labeled bicarbonate. Mass spectrometry analysis indicated that fish fed the labeled food had significantly higher levels of both  $^{15}\text{N}$  and  $^{13}\text{C}$  than did control fish; both these nutrients concentrated significantly in the intestine and liver. Isotope levels in whole, animal, and algal fractions supported the hypothesis that fish provide  $^{15}\text{N}$  and  $^{13}\text{C}$  to all fractions of the host anemone. Fish housed with anemones that received the food pellets also had significantly elevated levels of the markers, demonstrating that nutrient exchange is bi-directional. While  $^{13}\text{C}$  levels in the bicarbonate-exposed anemones were significantly elevated in the anemones, there was no support for the hypothesis that carbon fixed by these intracellular algal symbionts was translocated to the fish. It should be noted that while  $^{13}\text{C}$  levels in the resident fish were not significantly different from fish in control treatments, there was a suggestion of elevated  $^{13}\text{C}$ . The duration of the exposure (5 d) may have precluded significant translocation of carbon to the fish.

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#### Preliminary data from mark-recapture of the freshwater turtle population at Reelfoot Lake, Tennessee

Historically, Reelfoot Lake is well-known for its freshwater turtle diversity and density. In 2005 (April - October), we conducted a mark-recapture study using baited hoop nets in three of the lake's four basins. We had 2001.5 trap days and 1729 turtle captures (227 recaptures), dominated by three species: *Sternotherus odoratus* (n = 769), *Chrysemys picta* (n = 490), and *Trachemys scripta* (n = 389). Five other turtle species were captured but in lesser numbers. There were differences in overall captures with Blue and Middle Basin having similarly higher captures relative to Buck Basin. In addition, species differences existed among basins. *Sternotherus odoratus* was 2x more abundant in Blue Basin than in Middle Basin, with Buck Basin being intermediate. In Middle Basin, *C. picta* was 2x more abundant than Blue Basin, and 3x more abundant than Buck Basin. *Trachemys scripta* was the least abundant of the three primary species in Blue and Middle Basin. More (3x) young *T. scripta* were captured in Blue Basin than in the other two basins, however, variation among basins in body size was not evident in *S. odoratus* and *C. picta*. Catch per unit effort varied by species, basin, and season. Overall, considerable variation in species abundance and size composition existed among lake basins, possibly explained by differences in water depth, shoreline characteristics, and recreational use.

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### Historical distribution of lake sturgeon (*Acipenser fulvescens*) in the Lake Michigan basin

As part of an attempt to reconstruct the original distribution and relative abundance of lake sturgeon in tributaries to Lake Michigan, we surveyed old newspapers (mid-1800s to early 1900s) and other documents for accounts of sturgeon captured by sport and commercial fishers. We also reviewed the zooarcheological literature for records of sturgeon remains from prehistoric sites. We are especially interested in reports of sturgeon from sites to which they no longer have access because of the construction of dams that have blocked upstream spawning migrations. Over 200 records that can be plotted with some degree of accuracy were obtained. Resulting maps reveal a somewhat broader distribution than previously published maps based on museum specimens, but there were few unequivocal reports of sturgeon from reaches above dams in cases where they were not already known to have occurred in those reaches. This may be due in part to the fact that dams were constructed in many regions prior to the first printing of newspapers. Based on what has been published, the zooarcheological record seems more complete for the Michigan portion of the basin.

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### Phylogenetic patterns for gonad morphology, labile sexuality and species diversity in some gobiid fishes

Gonad morphology can provide informative characters in the search for homologies and associated phylogenetic relationships among gobioid taxa. These include ovary and testis architecture, relative placement and organization of various-staged sex cells, biochemical nature of gonadal-associated tissue secretions and structure and composition of accessory gonadal structures. In addition, sexual pattern as a character trait appears to show strong phylogenetic patterns in this group, and may underlie, in part, the successful adaptive radiation of some lineages. How gonadal and sexual features vary in their development and final form among gobioid clades will be discussed in order to support the proposition that reproductive features may offer important insights with regard to phylogenetic relationships among gobioid fishes.

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Seasonal basking patterns in two species of map turtles (Emydidae:  
*Graptemys*)

Within the Emydidae, previous studies have investigated seasonal and sexual differences in basking numbers in species of *Trachemys*, *Pseudemys*, *Chrysemys*, and *Graptemys*. A pattern often reported is that basking males tend to outnumber basking females, as observed in studies of *Graptemys oculifera* and *G. geographica*. Some investigators have suggested that seasonal sex bias in basking turtles may be associated with greater wariness of females, earlier maturation of males, or sexual differences in reproductive activity. The purpose of this study was to quantify seasonal variation in basking habits within two species of map turtles (*Graptemys pseudogeographica kohnii* and *G. ouachitensis sabinensis*) that occur in eastern Texas. Basking surveys were conducted twice per week from Jan 2005-Jan 2006 along a one-mile transect of the Sabine River in Smith County. During this period, 298 observations of male and 173 observations of female *G. p. kohnii* were recorded, while 2579 (male) and 1317 (female) observations of *G. o. sabinensis* were made. Peak periods of basking activity for both sexes of both species were in March and May with peaks of less magnitude occurring in Apr and Nov. Lower numbers recorded during April may have been associated with weather conditions on individual sampling days. As expected, the fewest basking turtles were recorded during Dec and Jan. Within *G. o. sabinensis*, significantly more males than females were recorded basking throughout the year, however in *G. p. kohnii* significantly more males were recorded only during spring and fall. Future investigations are planned to determine whether these observations reflect only male-biased sex ratios in the populations or if indeed males bask more frequently than females.

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A molecular genetic marker for the taxonomic identification of kingfishes,  
*Menticirrhus* spp. (Perciformes: Sciaenidae)

Kingfishes (*Menticirrhus* spp.) are harvested commercially and recreationally along much of the U.S. Atlantic coast. Three species are harvested in North Carolina: southern kingfish (*Menticirrhus americanus*), northern kingfish (*M. saxatilis*) and gulf kingfish (*M. littoralis*). Statewide landings of kingfishes declined from 1.2 million pounds in 1993 to less than 200,000 pounds in 1998. Because landings data for North Carolina are pooled across the three sympatrically occurring species, trends for individual species are difficult to ascertain. Effective management of kingfishes will

require species-level fisheries and biological data. Morphological variation among kingfishes is subtle. Although meristic counts and coloration can be diagnostic, these features are often damaged or obscured by harvesting practices. We developed an unambiguous molecular marker to distinguish among sympatric kingfishes. A 450-base pair fragment of the mitochondrial cytochrome b gene was amplified from reference specimens using PCR. Automated DNA sequencing of the fragment revealed substantial genetic variation among species with nucleotide sequence divergence estimates ranging from 9.5% (*M. americanus* vs. *M. saxatilis*) to 16% (*M. saxatilis* vs. *M. littoralis*). A restriction fragment length polymorphism (RFLP) assay was also developed from nucleotide sequence information and used to obtain species-level identifications of larval specimens previously keyed to only the genus level. Accurate taxonomic identifications using these markers can facilitate species-level investigations of recruitment, age and growth, reproduction and habitat ecology.

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A comparison of two emerging infectious diseases caused by chytrid fungus and ranaviruses in tropical and temperate habitats

Emerging infectious disease is among the hypothesized causes of global amphibian declines. Ranaviruses and the chytrid fungus, *Batrachochytrium dendrobatidis*, are two pathogens widely implicated as contributors to amphibian declines. We review similarities and differences in the effects of these pathogens on frog and salamander populations. A significant difference is that *Batrachochytrium dendrobatidis* is associated with population declines as well as species extinctions, while ranavirus infections are to date only associated with population declines typically followed by recovery. Ranaviral infections also seem more common in temperate as opposed to tropical communities, but significantly more surveys for ranaviruses are needed in tropical locations. Both pathogens are widely moved across the globe in the commercial trade of amphibians.

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Reproductive biology of *Rioraja agassizi* from coastal southwest Atlantic between northern Uruguay (34°S) to northern Argentina (42°S)

The Rio skate *Rioraja agassizi* is a common endemic skate from coastal Southwest Atlantic waters between southern Brazil to northern Argentina (42°S). The objectives of this study were to analyze the size at maturity and the monthly variation in the reproductive condition. A total of 407 individuals (185 females and 222 males) were captured by bottom trawl in the Southwest Atlantic coastal ecosystem between 34° and 42°S. The size of the smallest mature female was 495 mm and the largest immature female was 565 mm. Female size at 50% maturity (LT<sub>50</sub>) was 519.5 mm total length (78.01% of the maximum TL). The largest immature male measured 553 mm, and the smallest mature one 443 mm. The TL<sub>50</sub> of males was 475.4 mm (76.6% of the maximum TL), which was significantly different of the TL<sub>50</sub> of females. In males, significant differences throughout the year were founded in Hepatosomatic Index (HSI) but not in Gonadosomatic (GSI). The females had a partially defined annual reproductive cycle from July (winter) to March (summer) with peaks during November and December (late spring). This conclusion was based on the monthly variation of the GSI, oviducal gland width and largest ovarian follicles diameter. Egg-laying females were found between July and December and with atresic ovarian follicles in December and March. Egg-laying females were found between July and December and with atresic ovarian follicles in December and March.

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A delineation of the Eastern Shore of Virginia summer nursery habitat of juvenile sandbar sharks, *Carcharhinus plumbeus*

The identification and delineation of pupping and nursery areas of Atlantic sharks has been identified as an important information need for future management efforts. Recent studies have found the principal summer nursery areas of the western North Atlantic population of sandbar sharks occur in shallow coastal bays from New Jersey to South Carolina. The primary objective of this project was to spatially delineate the summer nursery for sandbar sharks that occurs in the coastal bays and lagoons of the Eastern Shore of Virginia. To accomplish this, twenty sites were chosen within an area that spanned approximately 700 km<sup>2</sup> from Magothy Bay to the south and Wachapreague Inlet to the north for repetitive sampling using longline gear. These

sampling locations were situated within four inlets from south to north: Sand Shoal Inlet, Great Machipongo Inlet, Quinby Inlet, and Wachapreague Inlet. The mean catch rate at each site during the peak nursery season varied from 5.6 to 22.2 sharks per 100 hooks. Despite the high catch rates throughout the study area, there was significantly higher abundance in Great Machipongo Inlet and there was a significant positive correlation between abundance and both distance from the inlet and bottom temperature. Neonates, small juveniles, and large juveniles were present throughout the sampling area, but there were significant differences in the relative abundance of each age class with inlet and with distance from the inlet. The catch rates of neonate and juvenile sandbar sharks within this area were comparable to those of the nearby Chesapeake Bay though a larger proportion of juveniles greater than 100 cm total length were caught within the Eastern Shore lagoons. This study indicates that the bays and lagoons of the Eastern Shore of Virginia function as important primary and secondary nursery grounds for this species and fit the criteria to be included in future management measures as a habitat area of particular concern (HAPC).

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Tracking juvenile sandbar sharks, *Carcharhinus plumbeus*, in the coastal bays and lagoons of the Eastern Shore of Virginia using a passive acoustic system

Previous manual tracking studies of neonate and juvenile sandbar sharks in the western North Atlantic Ocean have contributed valuable knowledge about the activity space and movements of these animals within their summer nursery areas. The use of a passive telemetry system within the coastal bays and lagoons of the Eastern Shore of Virginia has given us the ability to study longer time scale space use patterns of juvenile sandbar sharks. In addition the use of a passive telemetry system in combination with long battery life transmitters has allowed for the examination of annual survivorship and philopatry of juvenile sandbar sharks within this Virginia nursery area. An array of 15 passive acoustic receivers was deployed in 2003 in an approximately 7.5 km expanse of Millstone Creek in Wachapreague Inlet. This array was expanded to 21 receivers in 2004, and 19 receivers were deployed in 2005. During the summers of 2003 and 2004 transmitters were implanted in 64 juvenile sandbar sharks. The effect of environmental parameters on use of space by juvenile sandbar sharks at varying distances from the inlet and periodicity in the short-term movements of these animals was examined. In addition the attachment of juvenile sharks to the array area was studied using both acoustic data and tag return data. Minimum estimates of annual survivorship and philopatry of juvenile sandbar sharks to the array area were estimated using known fates of sharks in subsequent summers. At least 65% of the sharks tagged with transmitters in 2003 and 2004 survived to the subsequent summer. In addition a high degree of philopatry was

demonstrated with 37% of the sharks transmittered in 2003 and 65% of the sharks transmittered in 2004 returning to the array area, one summer after tagging.

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The systematic position of *Psilorhynchus* (Ostariophysi: Cyprinidae): Evidence from gill-arch characters

Members of the genus *Psilorhynchus* (Cyprinidae: Psilorhynchinae) are small cypriniform fishes with arched backs and flattened ventral surfaces which are restricted to fast flowing streams of the Ganga-Brahmaputra drainage of India and Eastern Nepal and the Ayeyarwady drainage of Northern Myanmar and adjacent China. The systematic placement of *Psilorhynchus* within existing cypriniform classification schemes has been controversial since its creation by McClelland in 1839. Over the last 150 years the genus has been assigned to, and removed from, the Cyprinidae, Balitoridae and Cobitidae at least once and has even been placed in its own family, the Psilorhynchidae. The current placement of *Psilorhynchus*, as a subfamily of Cyprinidae, is generally accepted. In this study the systematic significance of 31 characters derived from the gill-arches of cypriniform fishes is explored. Five characters of the gill-arches support the monophyly of the Order Cypriniformes. The families Gyrinocheilidae, Catostomidae and Balitoridae were each recovered as monophyletic but gill-arch characters alone are insufficient to characterize the families Cyprinidae and Cobitidae as currently recognized. The results presented here conflict with the current classification of the Order Cypriniformes where the Superfamily Cyprinoidea (cyprinids) is sister to the Cobitoidea (non-cyprinid cypriniforms). In the present study the families Cyprinidae+Cobitidae+Balitoridae form a monophyletic group separate from Catostomidae and Gyrinocheilidae. Members of the cyprinid subfamily Psilorhynchinae are more closely related to a clade composed of cobitids and balitorids than to other cyprinids. The systematic position of *Psilorhynchus* is discussed in light of this discovery.

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A wee croaker: Sexual dimorphism in the weberian apparatus of *Sundadanio axelrodi* (Ostariophysi: Cyprinidae)

*Sundadanio axelrodi* (Brittan) is a miniature (22.5mm total SL) cyprinid fish that inhabits peat swamp forests of Sumatra and Borneo. There are several anecdotal accounts of this small fish making a croaking noise when removed from water.

Examination of cleared and stained specimens, of both sexes, reveals that this tiny fish exhibits an array of sexually dimorphic characteristics of the jaws, pectoral girdle, pelvic girdle, Weberian apparatus, and the 5th rib. The outer arm of the os suspensorium of males is hypertrophied, as is the anteriorly displaced 5th rib, which articulates with an enlarged, anteriorly inclined parapophyses on the 5th vertebral centrum. The 5th rib of males is closely associated with the anterior chamber of the swimbladder. The outer arm of the os suspensorium of females is smaller than in males, as is the 5th rib, which is similar in size and shape to subsequent ribs. There is also a pronounced sexual dimorphism in the musculature associated with the 5th rib. Part of the hypaxial muscles forms a greatly hypertrophied bulbous muscle extending between the enlarged fifth rib and the os suspensorium. We speculate that the modification of elements of the Weberian apparatus and 5th rib in males of *S. axelrodi* are related to sound production. Based on the degree of sexual dimorphism present in *S. axelrodi* we hypothesize that this sound production is restricted to males of the species and that the bulbous muscle in males functions as a drumming muscle.

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**Impacts of a freshwater diversion on gene flow and genetic differentiation in fishes of the Mississippi River and Lake Pontchartrain Basins**

The Lake Pontchartrain Basin harbors a distinctive and every changing fish community. Due to environmental problems in the Lake Pontchartrain Basin, water will soon be diverted from the Mississippi River to the Lake Pontchartrain basin through an artificial canal in an effort to restore the wetlands in the western portion of the basin (Lake Maurepas). However, this environmental perturbation may also negatively impact the ichthyofauna of basin through homogenization of genetically distinctive stocks of fishes. We used high-resolution microsatellite markers to examine genetic differentiation between Lake Pontchartrain and Mississippi River basin fish populations of blue catfish (*Ictalurus furcatus*) and bluegill (*Lepomis macrochirus*) prior to the homogenization of these faunas. *Ictalurus furcatus* is a highly migratory, highly fecund species, whereas *Lepomis macrochirus* is less migratory and less fecund. We hypothesized that these differences in life histories would also impact the genetic structuring within and between the basins. Tissue samples were collected from five populations of each species across both basins. Five loci were amplified for two-hundred fifty blue catfish, and seven loci were amplified for two-hundred seven bluegill. Allele frequencies at each locus for each population were calculated and the data used to estimate the degree of genetic divergence among sampling locations by calculating fixation indices ( $F_{ST}$  values). Preliminary results suggest that there is a low level of genetic differentiation of blue catfish between basins ( $F_{ST}=0.0069$ ), which is consistent with high levels of gene flow. Bluegill reveal a higher level of genetic differentiation between basins ( $F_{ST}= 0.0147$ ), which is consistent with more genetic structuring between the basins. A Mantel test for matrix

correlation between genetic distance and geographic distance revealed significant genetic structuring within bluegill ( $r = -0.4336$ ,  $p = 0.006$ ), however no structure was detected within blue catfish populations ( $r = -0.0246$ ,  $p = 0.5540$ ). The implications of these results and the potential impacts of freshwater diversions will be discussed.

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### Chemical communication in the round goby

The success of the round goby may be due to its pheromonal communication between males and females during reproduction. We hypothesize that reproductive males (RM) release pheromones into the water that attract females to nests and deter males. Histological and biochemical studies showed that specialized glandular tissue in the male reproductive system produce androgen steroids, two of which (11-oxo-etiocholanolone (ETIO) and 11-oxo-ETIO-sulfate) are novel compounds in teleosts. Lab experiments showed that males do not respond (positively or negatively) to conspecific male odours (washings). In contrast, ripe females exposed to RM washings spent more time near the odour source, swam faster, and swam directly to the odour source when compared with responses to control water. When responses of females were tested against blends of synthesized steroids found in male round goby gonads, there was an overall significant difference between treatment and control, but no difference in response between reproductive and non-reproductive females. Different blends of steroids did not elicit significant differences in behavioural responses by females. Although females are attracted to the total blend of steroids, responses by females to male washings are more dramatic. Thus, the blend of identified steroids is likely missing an active ingredient.

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### Monitoring abundance of desert tortoises (*Gopherus agassizii*) in the Mojave Desert

The desert tortoise is listed as a threatened species in the Mojave Desert in the southwestern United States. The Recovery Plan mandates monitoring of populations as a prerequisite to any delisting actions. The US Fish and Wildlife Service, in cooperation with the University of Nevada and US Geological Survey, has conducted range-wide sampling of tortoises using line-distance methods since 2001. Data were analyzed using program DISTANCE, and results generally conform to the assumptions required by distance estimation. In the analyses, observations were truncated at 15 or 12m from the transect centerline and detection probabilities varied between 56 and 70%. Density estimation was stratified among 5 geographically separate Recovery Units. Estimates in individual Recovery Units varied between 0.9 and 11.6 adult tortoises/km<sup>2</sup>. Abundance was generally greater in the western Mojave Desert (California) than in the eastern Mojave (Nevada, Arizona, and the Beaver Dam Slope in Utah). Trends for a long-lived animal are difficult to interpret with only 5 yr of data, but the Eastern Colorado Desert Recovery Unit showed a large decrease in density between 2002 and 2003. A preliminary analysis suggests that year-to-year changes in density may be related to drought status.

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### A comparison of flooded forest and floating meadow fish assemblages in an upper Amazon floodplain

This paper presents a quantitative comparison of fish assemblage structure from flooded forests and floating meadows of macrophytes in the Peruvian Amazon and evaluates the degree to which these contiguous, connected habitats are characterized

by distinct fish faunas during the flooding season. Using matched sets of gill nets of different mesh sizes, fish species richness and composition, abundance, diel variation, and body-size distributions were compared between 10 flooded forest and 10 floating meadow sites. An overriding pattern of similarity emerged between these two habitats. Averaged across sampling sites, the mean abundance of fish, mean biomass, mean and maximum standard length, and mean mass did not differ significantly between flooded forest and floating meadows. However, the area of the flooded forest is much larger than that of floating meadows; thus, when scaled to total area, flooded forests have a much larger total fish biomass. Species abundances followed a strong negative exponential distribution in which three species accounted for 60-70% of the total abundance in both habitats. Despite these similarities multivariate analyses demonstrated subtle differences between the assemblages in flooded forest and adjacent floating meadows. In addition, species richness was higher in flooded forest, reflecting a high percentage of unique species. Higher abundance and species richness were observed in nocturnal samples of both habitats; however, among diurnal samples, more species were active in floating meadows.

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#### Stock assessment of dusky sharks (*Carcharhinus obscurus*) in the U.S. Atlantic and Gulf of Mexico

Dusky sharks off the U.S. East Coast were classified as a prohibited species in the 1999 NMFS FMP, but were never individually assessed. In 1997, they were designated by NMFS as a candidate species for listing under the ESA and are presently listed by the IUCN Red List of Threatened Species as vulnerable in the Northwest Atlantic and Gulf of Mexico. Despite uncertainty in the magnitude of the catches, all landings/catches showed declines since the early to mid 1990s. Decreasing average size trends suggest that the stock of dusky sharks off the U.S. Atlantic and Gulf of Mexico is heavily exploited. All data sources also indicated that the majority of animals caught were immature. Analysis of CPUE series standardized through GLM techniques also yielded decreasing trends. Analysis of biological information in a stochastic demographic framework resulted in very low values of population growth rate as would be expected from a species with very late age at first reproduction (20 years), high longevity (>40 years), and very limited reproductive potential. Accordingly, generation times were also very protracted (30 years) and the juvenile stage identified as the main contributor to population growth according to elasticity analysis. Multiple stock assessment methods were used to assess the status of dusky shark stocks. In the baseline analyses, three forms of surplus production models used predicted current depletions of over 80% of virgin

biomass, whereas depletions obtained with a catch-free model were 92% or more of virgin biomass. The age-structured model generally provided the least pessimistic results, but the majority of scenarios still estimated depletions of 62-80% with respect to virgin levels. In all, despite some recent signs of recovery, the various stock assessment methodologies used to estimate present (for 2003) stock status were all consistent in showing large depletions with respect to virgin levels.

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### Patterns of Squamata richness on the Brazilian Cerrado and its environmental determinants

The Cerrado, one of the world's biodiversity hotspots, is the second largest biome in South America, originally occupying 20% of Brazilian territory. In spite of this, much remains to be learned about the regions diversity patterns and species distribution. It has been shown for other ecosystems that species richness across a large scale may be related to environmental characteristics. The objective of this study is to investigate patterns of Squamata richness in the Brazilian Cerrado and determine if they are associated with specific environmental variables. Using museum data from the three most important collections for Cerrado Squamata (CHUNB, MZUSP and IB), we modeled the distribution of 107 Cerrado Squamata species using the software program DesktopGarp and environmental variables from the WorldClim project (<http://www.worldclim.org>). Then, we combined the predicted distributions of all 107 species to produce a map showing the species richness across the ecosystem. Finally, we used stepwise multiple regression to evaluate which environmental variables were important determinants of Squamata diversity. As a general pattern, richness increased towards the center of the ecosystem. In addition, certain areas in the northeast, southwest, and eastern part of the Cerrado appear especially rich. The variables associated most closely with richness were precipitation of the coldest quarter ( $F = 240.67, P < 0.001$ ), precipitation of the driest quarter ( $F = 74.74, P < 0.001$ ), and precipitation of the warmest quarter ( $F = 46.04, P < 0.001$ ). The Cerrado is well known by its marked seasonality with two well-defined seasons: one rainy and the other very dry and cold. Our results suggest that diversity in the Cerrado may be determined by conditions imposed by the dry, cold season. This result supports the environmental stress hypothesis, which states that richness may be limited by the fact that fewer species are physiologically equipped to tolerate harsh environments.

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### Genetic variance in the smooth green snake (*Opheodrys vernalis*) in South Dakota

The smooth green snake, *Opheodrys vernalis*, is a wide-ranging species found throughout much of the northeastern United States and southeastern Canada. Twenty-four isolated populations are found throughout the Midwest, northern Plains, and Rocky Mountains of the United States. It appears to have declined throughout much of its range and is now protected in Indiana, Missouri, Montana, North Carolina, Wyoming, and Utah. There are isolated populations in the Black Hills and Bear Lodge Mountains of western South Dakota and northeastern Wyoming, as well as a population on the northeastern plains of South Dakota. This species has been the subject of taxonomic debate, including controversies over generic classification and subspecific variation. We have sequenced the d-loop region of the mtDNA and used the Basic Local Alignment Search Tool at the NCBI website to examine similarity with other *Opheodrys* species. For this study we are examining genetic variation among the plains population in South Dakota and populations in the Black Hills and Bear Lodge Mountains. Additionally, we are comparing genetic variation in these populations with specimens collected in other parts of the species range. Sequence data obtained from PCR amplified D-loop, ND4, ND2 and cytochrome B regions of mitochondrial DNA will be used for genetic comparisons. Microsatellite markers are being developed for further studies.

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**COTTONE, AMANDA M.**

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### An investigation of food habits and reproductive biology in Psammophiinae (Colubridae)

Snakes of the monophyletic group Psammophiinae (Colubridae) are well represented, where they are abundant and widespread in southwestern Asia, Mediterranean Europe, and Africa. Empirical data on the biology of most African and Asian species are lacking. Studies to date reveal that most psammophiines feed largely on lizards and frogs (specializing on certain types in areas of sympatry); however, larger temperate species take mammalian prey more frequently. Investigations into the reproductive biology of this clade indicate that one tropical species exhibits strongly seasonal reproduction (similar to the closely related temperate species), yet requires only one season to reach sexual maturity. Additionally, monomorphism in regard to SVL/tail length is exclusive to this clade. Therefore, I examined the diet, reproductive attributes, and sexual size dimorphism of three species of psammophiines, *Psammophylax rhombeatus*, *Psammophis crucifer*,

and *Psammophis schokari*. In terms of diet and reproduction, *P. crucifer* and *P. rhombeatus* are consistent with other temperate psammophiines from the southern hemisphere. However, these species range from the temperate zones in the Western Cape in South Africa to more arid conditions of subtropical Namibia. Accordingly, significant geographic variation within these species occurs with respect to the timing of reproduction. *Psammophis schokari*, a northern hemisphere psammophiine, also displays geographic variation in these traits as a function of annual temperature and rainfall. The degree and direction of sexual size dimorphism among these species also varies and possible explanations based on an eco-geographical gradient are provided. Although ecology and sexual size dimorphism in psammophiines have significant phylogenetic components, the biology of these widespread members of the group suggests that localized climatic conditions are most predictive of these attributes.

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#### Differential cover object usage within a community of wetland snakes

Cover objects are important for many snake species as refugia, for thermoregulation and as hibernacula in temperate climates. This cover may be a limited resource, and could be competed for by snakes occupying the same habitat. For this study, we tested for patterns of cover object usage consistent with competition. Snakes were collected from an abandoned townsite in a western Iowa wetland which contained many cover objects that were utilized by four different snake species. For each snake we captured, we recorded snout-vent length, sex, and the surface area and type of the cover object. Smooth green snakes (*Opheodrys vernalis*) were found under significantly smaller cover objects than the three other snake species at the townsite (*Thamnophis sirtalis*, *Thamnophis radix*, *Elaphe vulpina*). There was no significant relationship between snout-vent length and cover object surface area, indicating that differences in cover object usage was not due to differences in body size among species. Additionally, no difference was found among snake species for type of cover object utilized. Interspecific competitive interactions with other snakes at the townsite may explain why smooth green snakes were found under smaller cover objects than the other three species. However, the patterns we found could also be indicative of some intrinsic ecological or physiological difference among species, independent of species interactions. Habitat separation by differences in cover object utilization may be widespread within snake communities, and in some instances may indicate interspecific competition.

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### Energy efficiency determinants for juvenile Burmese pythons (*Python molurus*)

The proportion of ingested energy that is absorbed by the gut (digestive efficiency), becomes available for metabolism (assimilation efficiency), and allocated for growth (production efficiency) varies with respect to meal type and in some cases with body temperature. We fed sibling juvenile Burmese pythons (*Python molurus*) rodent meals equaling 15%, 25%, and 35% of body mass and individuals from five different clutches 25% size rodent meals to determine the effects of meal size and relatedness on these three energy efficiencies. For each of 12 consecutive feeding trials, body mass was recorded and feces and urate of each snake was collected. Energy content of meals (mice and rats), feces, urate, and pythons were determined by bomb calorimetry. Apparent digestive efficiency was calculated as (energy consumed– fecal energy)/energy consumed, apparent assimilation efficiency as (energy consumed– fecal and urate energy)/energy consumed, and production efficiency as energy of body growth/energy consumed. For siblings fed three different size meals, growth rate increased with larger meals, but there was no effect of meal size for any of the calculated energy efficiencies. Among the three size meals, apparent digestive, apparent assimilation, and digestive efficiencies averaged 90.6%, 84.1%, and 39.7%, respectively. In contrast, there was significant differences for each of these energy efficiencies among the five different clutches that ingested meals 25% of body mass. Among these five clutches there was a significant negative correlation between mean standard metabolic rate (SMR) and production efficiency. Clutches that tended to have lower SMR were therefore able to allocate more of ingested energy into growth.

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### Roadside ditches: Ecological traps or viable habitats? A study using greater sirens (*Siren lacertina*)

With the continued reduction of wetlands habitat in the United States, the use of incidental and artificial habitats by wildlife may become increasingly important. Roadside ditches are prevalent in many areas and commonly used by a variety of wildlife. However, a number of characteristics may cause some ditches to function as "ecological traps", including frequent drying and saltwater intrusion in coastal areas. We examined the suitability of roadside ditches by comparing populations of greater sirens (*Siren lacertina*) in roadside ditches to those in natural wetlands on the Kennedy Space Center (KSC) in east-central Florida. Sirens were captured using commercial crayfish and wire-mesh minnow traps, and all animals over 10 g were pit-tagged. To assess habitat suitability, we compared reproduction, body condition, and survivorship of sirens between ditches and natural wetlands. Survivorship was estimated using program MARK and supplemented with radio telemetry of sirens in each habitat type. Results of these comparisons will be reported as well as

recommendations for managing the roadside ditches as suitable habitats for sirens and other amphibians.

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Phylogeography of the Flag Cabrilla, *Epinephelus labriformis* (Serranidae): Implications for the biogeography of the Tropical Eastern Pacific and the early stages of speciation in a marine shore fish

To examine the role of previously described biogeographic boundaries in shaping the phylogeography of two eastern Pacific sibling species, the flag cabrilla, *Epinephelus labriformis* (Jenyns 1840) and the Clipperton grouper, *E. clippertonensis* Allen and Robertson 1999 (Serranidae), sequence data from the mitochondrial cytochrome *b* gene were obtained from samples throughout the range of the species. Coalescence analysis, mismatch distributions, and an analysis of molecular variance (AMOVA) were used to infer population differentiation and demographic parameters. Overall, 49 haplotypes were found among 304 specimens, and there was significant structure corresponding to geographic locality (AMOVA  $ct = 0.198$ ;  $p < 0.001$ ,  $st = 0.207$ ,  $p < 0.001$ ;  $F_{st} = 0.169$ ,  $p < 0.001$ ,  $F_{ct} = 0.151$ ,  $p = 0.036$ ). This structure was only evident between island and mainland populations. Our results suggest that previously described barriers to dispersal along the mainland coasts of the TEP may not impinge upon the dispersal ability of marine species, such as these groupers, that have sufficient larval dispersal. In contrast, geneflow between mainland and island populations of the readily distinguishable morphospecies *E. labriformis* and *E. clippertonensis* is restricted. The low level of genetic differentiation between the two species indicates that changes in external color patterns may evolve more rapidly than do genetic markers commonly used to delimit species boundaries.

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A new species of the clingfish genus *Discotrema* (Gobiesocidae) from Papua New Guinea

A new species of the clingfish genus *Discotrema* Briggs is described from New Britain, Papua New Guinea. It differs from its presumed sister species, *D. crinophila*, in color pattern (absence of a middorsal stripe) and unique mitochondrial DNA sequences. Both species appear to be obligate crinoid commensals.

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Squamate phylogeny

A key interest of Joe Slowinski was inferring squamate phylogeny. Early in his career, in 1995, he coorganized a symposium on higher level snake phylogeny and much to the surprise of the organizers, there was little empirical data presented on the problem. Eleven years later we report on higher level squamate phylogeny with data sets of 600+ and 1000+ OTUs. A data mining program was used to obtain c-mos and cyt-b sequences from GENBANK. These sequences were aligned and subjected to parsimony and Bayesian inference methods to hypothesize higher level squamate phylogeny. Given recent hypotheses, our goal is to test the monophyly of the Iguania and the Scleroglossa and infer overall higher level phylogeny of squamates.

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Anatomy underlying the body form of swimming watersnakes, *Nerodia sipedon*

*Nerodia sipedon* increases the height:width ratio of the posterior half to two-thirds of the trunk when swimming. This change in trunk cross-sectional form correlates with the existence of well-formed ball-and-socket tuberculovertebral joints and flattened capitulovertebral joints. Each rib also has a high tubercle on the proximal-dorsal surface. The specific arrangements of joint surfaces, rib processes, and medial intercostal and vertebrocostal muscle attachments allows rotational movements of the ribs in a variety of directions. In *N. sipedon*, the anterior region of each vertebrocostal capsular ligament is hypertrophied as a highly elastic mechanical damper that returns the rib to its resting position regardless of the direction or degree

of displacement. We propose that body shape change during swimming involves anteroventral and medial movement of the ribs powered primarily by the tuberculocostalis, costovertebrocostalis, and dorsal transversus abdominis. Rib movements required to retain a laterally flattened body shape compress both the elastic damping ligament and the viscera and cause the ventral scales to bend outwardly. Hence, in *N. sipedon*, body deformation may require work that subtracts from energy devoted to driving the snake forward in the water. We suggest that this additional energetic demand was the primary selective force underlying evolutionary modifications in vertebrocostal joints, reduced rib curvature, reduced size of the tubercle, and reduced ventral scale width seen in permanently (most marine hydrophiine) aquatic snakes.

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The influence of geographic variation of species interactions on terrestrial salamanders of the genus *Plethodon*

Species interactions can influence spatial distributions at a fine local scale. In addition, species interactions can influence spatial patterns at broad scales by limiting range expansions and setting species range limits. Abiotic factors, such as climate and geography, may also cause geographic variation in territorial behavior across a species range. We use members of the *Plethodon glutinosus* salamander complex to address questions related to the impact of species interactions on congener shared range boundaries. If behavioral variation is present within a species then behavioral interactions between individuals from allopatric populations may differ from interactions with individuals from parapatric populations, especially if species interactions influence range limits between congeners. Specifically we address: (1) Is survival impacted by the presence of a potential competitor? and (2) Is interspecific and intraspecific competition more intense between individuals from parapatric populations versus allopatric populations? We conducted a reciprocal transplant between the slimy salamanders, *Plethodon glutinosus* and *Plethodon mississippi*, from Alabama and Virginia. Salamanders of both species lost less weight in Virginia versus Alabama ( $F_{2,122} = 57.870$ ,  $p=0.000$ ). No significant difference in the percentage of mass lost was detected between the species. The presence of a competitor did result in a higher percentage of mass lost ( $F_{2,122} = 4.552$ ,  $p=0.005$ ). The effects of competition were found to vary between the Alabama and Virginia sites ( $F_{2,122} = 3.570$ ,  $p=0.031$ ). The intensity of competition varied between interspecific competitors from allopatric populations versus competitors from parapatric populations ( $F_{2,122} = 4.552$ ,  $p=0.012$ ). Mass loss was higher for allopatric encounters than parapatric encounters suggesting that previous contact (historical or evolutionary) may result in lowered aggression. Ongoing laboratory studies will provide additional data to determine if species are more or less aggressive at range boundaries and how geographic variation in behavior can influence species distributions and range boundaries.

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Thermal tolerance and acclimation in the anurans, *Gastrophryne carolinensis* and *Pseudacris brachyphona*

Critical thermal maxima (CTM) were determined at acclimation temperatures (AT) of 20°C and 30°C for the anurans, *Gastrophryne carolinensis* and *Pseudacris brachyphona*, from Kentucky. *Gastrophryne carolinensis* had a significantly higher CTM at each AT than *P. brachyphona*. *Gastrophryne carolinensis* breeds during summer and is active mainly at warmer times, while *P. brachyphona* breeds during early spring, but calls most months of the year. Also, *P. brachyphona* has a more northerly geographic distribution and occurs at higher elevations. Thus, thermal tolerance and acclimation may be related to the breeding periods, activity, and geographic distribution of these species. The lower mean CTM of *P. brachyphona* reflects the lower thermal regime of this species which allows it to be active at lower temperatures.

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Daily movements and habitat use of immature bull sharks, *Carcharhinus leucas*, in the Indian River Lagoon System, Florida

Bull sharks (*Carcharhinus leucas*) are a component of the large coastal shark fishery, and are regularly captured by commercial longline fishermen off the southeastern United States. Effective management of this species requires accurate delineation and description of its critical nursery habitats. Though several coastal bull shark nursery areas have been identified, little is known of their daily activity patterns and habitat use within these areas. We acoustically tracked five young-of-the-year (60-71 cm FL) and five juvenile (79-94 cm FL) bull sharks in the Indian River Lagoon, a shark nursery along the Florida Atlantic coast. Active tracks were 2-24 hours in duration, yielding a combined total of approximately 144 hours of short-term movement and habitat use data. The daily activity spaces of these bull sharks were relatively small (< 5 km<sup>2</sup>), as compared to the reported activity spaces of other carcharhinids on their nursery grounds. Most of the sharks demonstrated some degree of site attachment to either freshwater creeks or power plant outfalls. During their tracks the sharks swam in depths of 0.2-3.6 m, temperatures of 18.5-34.2° C, salinities of 1.2-31.9 ppt, in dissolved oxygen concentrations of 1.8-8.2 mg/L, and in water clarity levels as low as 0.7 m. The most common activity pattern was swimming parallel to the shoreline, repeatedly patrolling the edges of shallow seagrass beds or deeper dropoffs. There was little evidence of diel changes in activity. This information will help us to better

define the habitats that are essential to the growth and development of these immature sharks in this region.

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### Population structure of shoal bass (*Micropterus cataractae*) in the Chattahoochee River System

The shoal bass (*Micropterus cataractae*) was described in 1999 as a member of the redeye bass group, and is endemic to the Apalachicola River drainage of Georgia, Alabama, and Florida. Hydroelectric dams on the Chattahoochee River near Atlanta are thought to be significant barriers to gene flow between populations of *M. cataractae*, which do not inhabit lacustrine habitats such as the reservoirs created by these two dams. In this study, four populations of *M. cataractae* in the Chattahoochee River System were examined: above Buford dam, Big Creek (a tributary between Buford and Morgan Falls dams), immediately below Morgan Falls dam, and further downstream at Cochran Shoals. Genetic samples of *M. cataractae* from each of the four populations were genotyped for 10 highly polymorphic microsatellite loci, and patterns of genetic diversity and differentiation were examined. The distribution of allele frequencies at each locus were significantly different for nearly every comparison, and permutation tests revealed significant values of  $F_{st}$  between neighboring populations. Additionally, permutation tests showed significant differences in the effective number of alleles, allelic richness, expected heterozygosity, and private alleles between populations. Overall, the population immediately below Morgan Falls dam was the most diverse population by all measures, while the population above Buford dam was the least diverse. The average population divergence (as measured by  $F_{st}$ ) was 0.03 across the Buford dam, which was built in 1958, but was 0.16 across the Morgan Falls dam, which was built in 1904. A comparison across a similar unimpeded river distance yielded an  $F_{st}$  value of 0.07, suggesting that hydroelectric dams have had a significant impact on the genetic structure of *M. cataractae* in the Chattahoochee River System.

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Frequency of multiple paternity in an unfished tropical population of sandbar sharks (*Carcharhinus plumbeus*)

The mating systems of elasmobranchs have received growing attention in the past few years due to worldwide overexploitation and vulnerability of shark populations. The sandbar shark (*Carcharhinus plumbeus*) is heavily harvested around the world, and constitutes 70% of the largest directed shark fishery in the United States. Although the degree of depletion in most areas is unknown, the population in the Northwest Atlantic was reduced by 80% during the 1980s. As a result of management, this population is currently recovering but remains at approximately 50% of its pre-exploitation levels. Hawaii hosts one of the few populations of sandbar sharks protected from commercial exploitation because of a ban on longline fishing in coastal waters. Strong cultural taboos against killing sharks and the lack of artisanal fisheries make Hawaii one of the only known unfished populations of sandbar sharks in the world. We examined the frequency of multiple paternity in this population through direct sampling of gravid females outside Kaneohe Bay on the Windward coast of Oahu. We genotyped 130 individuals (20 mothers with 3-8 pups each per litter) using 6 polymorphic microsatellite loci and found 12 of the 20 litters were sired by a single male. This sample closely matched the expected population level of multiple mating based on a Bayesian approach which estimates the frequency of multiple mating to be 43.8%, with a 95% confidence interval of 23-63%. Because of difficulty in sampling, few studies to date have examined mating systems in sharks. The Hawaiian population of sandbar sharks represents an important opportunity to gather data on the reproductive biology of a vulnerable shark species without the confounding effects of obvious sources of anthropogenic mortality.

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Snake predation on red-eyed treefrog eggs: feeding behavior and egg hatching induced by four colubrids

Four species of colubrids feed on arboreal egg clutches of red-eyed treefrogs, *Agalychnis callidryas*, and embryos hatch up to 30% early in response to snake attacks. Escape hatching behavior is cued by physical disturbance of clutches, and embryos distinguish among different vibrational patterns. We exposed hatching-competent embryos to snake attacks to assess their ability to escape from different species, and we videotaped snakes feeding on hatchable egg clutches to compare their feeding

behavior. We analyzed 38 attacks by six individual *Leptodeira annulata*, seven *Leptodeira septentrionalis*, six *Leptophis ahaetulla* and one *Imantodes inornatus*. Average attack duration was similar among species (7 min) and the four snake species used overlapping behavioral repertoires in feeding. All but *I. inornatus* initially lunged at clutches, while *I. inornatus* approached more slowly. *L. septentrionalis* and *L. ahaetulla* ingested eggs using mainly pterygoid walks, while *L. annulata* more often used inertial transport, in which the two sides of the jaw do not move independently. The *I. inornatus* used one or both of these behaviors, as well as series of rapid bites. All species pulled backward to tear mouthfuls of eggs off the leaf. The temporal patterns of attacks varied substantially among species. *Leptodeira annulata* and *I. inornatus* attacks were broken up into many (average 11), relatively short periods of contact, whereas *L. ahaetulla* and *L. septentrionalis* attacks included fewer (average 3), much longer contact periods. Thus the pattern of disturbance that embryos experience in attacks varies among species of snake. Despite this, escape rates were similar in attacks by different species of snakes on embryos of full hatching competence, averaging 79%. Escape rates differed only during the onset of hatching competence, two days before the peak of spontaneous hatching, when differences in diel activity patterns of snakes gave them access to eggs differing in hatching ability.

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The effect of long-term insulation on the structure of frog communities in two islands of the coast of Rio de Janeiro, Brazil

The relative movements of the sea level, that took place in the Upper Pleistocene, had two major consequences in the coast of Brazil. One was the redistribution of sands and redesign of beaches and overall reconfiguration of the coastline. The other was the insulation of coastal mountain peaks, forming coastal islands. Two events relating to sea level changes are of importance. A transgression initiated 17.500 ybp and two regressions at approximately 5.000 and 3.500 ybp. The frog faunas of the islands are a subset of the continental one and are the results of natural experiments of long-term insulation; assuming most of the frogs would not be able to cross the barrier represented by the ocean. In order to describe these effects, we surveyed frogs in the continent immediately in front of the islands and compared the data with that available for two islands and a few other areas in the State of Rio de Janeiro. In general, continental areas may hold up to 43 species of frogs in 6 families (Leptodactylidae, Hylidae, Bufonidae, Centrolenidae, Brachycephalidae, Microhylidae). The islands with 193 (Ilha Grande) and 43 (Marambaia) squared kilometers hold about half of the diversity found in the continent, with members of the same families. Only Marambaia holds an endemic species, *Leptodactylus marambaiae*. A toad, large tree frogs, and some litter frogs are not present in the islands. We assume that, in addition to the effects of area and stochastic local extinctions, habitat loss occurred during higher sea level stages are the main causes

behind species loss. In the case of Marambaia, the partial reconnection of the island to the continent through a sandbar may have resulted in faunal reintroduction from the continent, resulting in a similar number of species, but in different composition from Ilha Grande

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Predicting the geographic distribution of *Ambystoma mabeei* using ecological niche models

Much of the basic natural history of the salamander *Ambystoma mabeei* remains unknown. Its current distribution appears to be restricted to the Atlantic Coastal Plain, from southeastern Virginia south to the Savannah River. Listed as a threatened species in Virginia, its conservation status is currently undefined elsewhere. To gain a better understanding of the geographic distribution of *A. mabeei*, we examined a suite of climatic conditions associated with known localities, compiling locality data from all major U.S. museums and relevant literature into a GIS database. We then developed an ecological niche model to identify locations with climatic conditions that appear to be suitable for the presence of *A. mabeei*. Preliminary results suggest that the climatic variables used in our niche models are congruent with the species' established range, indicating these variables are good indicators of distribution. Our models also underscore annual mean temperature as a particularly important variable for predicting this salamander's distribution. Our study updates the known range of *A. mabeei* and provides a foundation with which to assess its conservation status within this revised distribution.

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Age and growth of the roughtail skate, *Bathyraja trachura*, (Gilbert, 1892) from the eastern North Pacific

To investigate the age and growth of *B. trachura*, specimens were obtained along the continental slope of the contiguous western United States from the Northwest Fisheries Science Center groundfish survey cruises and commercial fishing vessels. Samples were collected between June 2003 and May 2005. Vertebrae ( $r^2 = 0.94$ ) and caudal thorns ( $r^2 = 0.67$ ) grew proportionately with total length, suggesting that they are appropriate ageing structures for *B. trachura*. Age was estimated for 237 individuals using band counts of vertebral thin sections and for 100 individuals using band counts of caudal thorns. Bias and precision calculations (vertebrae, APE = 12%,

CV = 16%, D = 11; caudal thorns APE = 11% CV = 21%, D = 15) for both structures were similar. When band counts were compared between structures, there was a significant difference in age estimates ( $t = 3.00$ ,  $p < 0.01$ ). The maximum ages estimated from vertebrae (18 yrs, females; 20 yrs, males) were older than those estimated from caudal thorns (9 yrs, females; 9 yrs, males). Vertebral growth provided a better fit to total length; therefore vertebral age estimates were selected for growth analysis. Multiple growth functions were fitted to age at length and age at weight data. The 2-parameter Von Bertalanffy Growth function using age at length data provided the best fit (female,  $r^2 = 0.92$ , SEE = 5.22; males,  $r^2 = 0.89$ , SEE = 6.61). There is no statistical difference between the growth of males ( $L_{inf} = 95.95$  cm,  $k = 0.10$   $y^{-1}$ ) and growth of females ( $L_{inf} = 103.29$  cm,  $k = 0.08$   $y^{-1}$ ).

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### Preliminary assessment of life history characteristics of bowfin in southeastern Louisiana

As the last surviving member of Amiiformes, Bowfin *Amia calva* is an ancient non-Teleost fish. They are a top-level predator in the swamps and bayous of Louisiana that is harvested for meat and for roe (Cajun caviar) and are a valuable commodity within south Louisiana. Recreational and commercial fisheries for bowfin are regulated by minimum length regulations (406 mm Total length recreational limit and 559 mm Total length commercial limit). Although bowfin support commercial and recreational fisheries in south Louisiana, the life history of this species is poorly understood. An understanding of their life history characteristics such as age and growth, fecundity, and mortality is important for the refinement of population models for management of the species. Bowfin were collected bi-monthly from September 2005 to July 2006 using gill nets, trot-lines and hook-and-line from Bayou Chevreuil near Chackbay, Louisiana. This bayou was historically subjected to an annual floodpulse from the Mississippi River but is now only receiving inputs from precipitation. Age, growth, maturity, and fecundity data were collected from each individual. Because bowfin otoliths cannot be used for age determination, fish were aged using gular plates. We collected bowfin ranging from 3 to 8 years in age and lengths of 362 to 703 millimeters. Females were significantly larger and older ( $P=0.0001$ ) than were males. Annual egg production was exponentially related to length where larger females had greater reproductive potential ( $R^2=0.85$ ;  $P=0.0001$ ). Results of population modeling indicate that current length limits adequately protect bowfin stocks. Defining the life history of bowfin can insure protection of stocks of bowfin and aid in providing a sustainable bowfin fishery for users in Louisiana.

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### Molecular phylogeny of the subfamily Boinae

Snakes of the boid subfamily Boinae exhibit a disjunct distribution that includes the Neotropics (genera *Boa*, *Corallus*, *Epicrates*, and *Eunectes*), Madagascar (genera *Acrantophis* and *Sanzinia*), New Guinea, and several southwest Pacific islands (genus *Candoia*). This distribution is not unique to the Boines, as two other reptile groups, podocnemine turtles and oplurine iguanid lizards, exhibit a similar biogeography. Cladistic analyses based on morphological characters suggested that genera within each of these regions do not form monophyletic groups. Furthermore, these data suggest that the Neotropical *Boa constrictor* is more closely related to the geographically distant Madagascan genera, rather than with New World species. Conversely, recent molecular phylogenetic studies aligned *B. constrictor* with the Neotropical boines rather than with Madagascan taxa. These studies, however, still recognize some degree of paraphyly within the boines, which suggests that additional phylogenetic hypotheses be evaluated. The goal of this study was to re-evaluate the phylogeny of the subfamily Boinae using a mt- and nuclear DNA perspective. A more inclusive sample of representative taxa was incorporated to test the hypothesis that each geographic group forms a monophyletic clade. Results will be discussed.

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### Relationships within the Suborder Synodontoidei (Aulopiformes: Synodontoidei): A review

The order Aulopiformes contains approximately 38 extant genera of marine inshore, pelagic, and bathypelagic fishes. Within the Aulopiformes, the suborder Synodontoidei is comprised of seven extant genera, including the recently recognized *Paraulopus*, and the previously recognized *Aulopus*, *Pseudotrichonotus*, *Synodus*, *Trachinocephalus*, *Harpadon*, *Saurida* and a few fossil genera. Previous hypotheses of evolutionary relationships did not recognize *Paraulopus*, *Aulopus*, and *Pseudotrichonotus* as being closely related to synodontids, however, more recent studies involving large amounts of morphological data have recognized them as more closely related to synodontids than other Aulopiformes. Additionally, the genus *Paraulopus* has been recognized as basal within the Aulopiformes, conflicting with previous hypotheses recognizing *Aulopus* as the basal member of Synodontoidei and Aulopiformes. While relationships among genera within the suborder are

currently supported by a number of morphological data, interrelationships of species within the suborder are poorly understood. Currently there are no hypotheses regarding evolutionary histories at the species level within the suborder, and there have been no phylogenetic studies done at this level utilizing any kind of molecular data. Additionally, similar external morphological patterns and broad biogeographic distributions have caused confusion with species identification and multiple species descriptions. This presentation is intended to offer an extensive review on the history of the suborder and its members, and current plans for research into the evolutionary relationships and history of fossil and recent species within the suborder Synodontoidae.

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#### Morphological Investigation of a Putative Hybrid Zone between *Moxostoma macrolepidotum* and *Moxostoma pisolabrum* (Cypriniformes: Catostomidae) in the Kansas River Basin

The taxonomy of North American redhorses (Cypriniformes: Catostomidae), particularly the genus *Moxostoma*, has been widely studied and revised multiple times. Lack of conspicuous morphological differences among species in the genus *Moxostoma* has previously made the diagnosis of individual species problematic. Previous work had recognized three subspecies of the shorthead redhorse (*Moxostoma macrolepidotum*): *Moxostoma macrolepidotum breviceps*, which inhabits the Ohio River Basin; *Moxostoma macrolepidotum pisolabrum*, located west of the Mississippi River and south of the Missouri River in principally Ozarkian streams, as well as westward onto the plains in the Arkansas and Osage River basins; and *Moxostoma macrolepidotum macrolepidotum*, distributed across the Mississippi and Missouri River Basins, Great Lakes and St. Lawrence Basin, Hudson Bay Basin, and the Atlantic Slope from the Hudson Drainage southward to the Santee River Basin of South Carolina. Recent work elevated *Moxostoma pisolabrum* from the synonymy of *Moxostoma macrolepidotum* based on morphological data. The Kansas range of *Moxostoma pisolabrum* is principally Ozarkian, and includes the Osage (Marais de Cygnes) and Arkansas River basins of Kansas. The range of *Moxostoma macrolepidotum* in Kansas appears to be restricted to the Missouri River in Northeast Kansas. Previous studies have widely reported the presence of hybrids or intergrades between these formerly recognized subspecies, and there appears to be a hybrid zone located between their ranges in the Kansas River basin, where collected specimens have long been considered hybrid representatives. In order to establish whether specimens from the Kansas River basin are members of the supposed *Moxostoma macrolepidotum x pisolabrum* hybrid, morphometric and meristic data was gathered and analyzed from museum specimens, as well as recent specimens collected by the Kansas Department of Wildlife and Parks.

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**DAWSON, BETH**

## The effect of highway traffic noise on advertisement calls of male cricket frogs

Male frogs typically rely on acoustic signals to attract females. Individual frogs of many species often congregate at creeks and ponds at night to make these advertisement calls and mate with females. These multispecies choruses can be some of the loudest sounds in nature. Avoiding acoustic overlap may drive the evolution of acoustic signals that avoid spectral and temporal conflict. A new source of acoustic competition is traffic noise. Many creeks and ponds throughout the United States are in close proximity to highways and the noise produced by car and truck traffic could reduce the effective transmission of frog advertisement calls. This study looks at possible effects of traffic noise on cricket frogs (*Acris crepitans*) in central Texas creeks. Recordings were made of 17 male frogs at pairs of sites close to and far from highways, in three creeks south of Austin, Texas. Each recording was digitized and analyzed for temporal and spectral characteristics typical of this species. Statistical analysis shows that male cricket frogs at sites with traffic noise nearby call less and produce less complex calls (which are less attractive to females) than do males at quiet sites. Highway noise may mask the calls of nearby males, reducing each male's perception of chorus size. Playback tests are underway to study possible mechanisms behind this change in calling activity. If highway noise reduces frequency and attractiveness of calls, reproductive success at these sites may be compromised.

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## Movements and habitat utilization of the Prickly Shark, *Echinorhinus cookei*, in the Monterey Submarine Canyon

Spatial utilization and movement patterns are fundamental to understanding the life history of a species. The prickly shark, *Echinorhinus cookei*, is a poorly known large predator that commonly occurs at the head of the Monterey Submarine Canyon (MSC). It has a distribution throughout the Pacific Ocean and is characterized in the literature as a deep-water species (100 – 650 m). Several observations and catches have been made at the head of the MSC in water less than 60 m deep. These observations are in contrast with the generally accepted depth distribution of prickly sharks and lead to questions about their depth range and movement patterns. We used acoustic telemetry to determine the movements, habitat utilization patterns, and seasonal abundance of prickly sharks in the MSC. Acoustic transmitters were implanted in 10 female and 5 male prickly sharks from March – August 2005. Tagged sharks ranged in size from 1.7 – 2.5 m. Acoustic signals from tags were collected by a combination of active tracking from the surface and passive tracking via moored receivers. Male and female prickly sharks exhibited a pronounced diel movement

pattern. The pattern included an offshore movement along the axis of the canyon during the day and an onshore movement at night. To date, tagged sharks have had sustained residency at the head of the MSC in depths less 60 m, which is much shallower than the depth range reported in the literature. A 95 % kernel utilization distribution was calculated to determine home range size for each prickly shark.

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### Ontogeny of calcification of the tessellated skeleton

A key component of the high level of performance of the elasmobranch skeleton is its tessellation: in most elements, the soft hyaline cartilage core is tiled with an outer rind of calcification, comprised of abutting blocks called tesserae. However, not only are we ignorant of the calcification mechanism of shark cartilage, we do not know whether it is homologous in any respects to vertebrate mineralization pathways. We examined ultrastructural changes in calcification across ontogeny in the jaws of the round stingray, *Urobatis halleri* using electron microscopy and histological techniques. The uncalcified cartilage of early embryonic stages (35-65mm DW) is highly cellular, with hypertrophic chondrocytes occluding the matrix. Cell size and density shows a marked decrease in late embryos (< 65mm DW) when tesserae arise as thin plates (100  $\mu$ m wide, 50  $\mu$ m deep). At the calcification front, chondrocytes are flattened and arranged in series along their long axes; these strings of cells are engulfed by globular calcification and incorporated intact into forming tesserae, creating cell-rich laminae with small passages connecting adjacent entombed cells. Cell spaces (lacunae) at the margins of tesserae are apparently continuous with cells invested in the fibrous intertesseral joints connecting tiles. Chondrocyte size and density continue to decrease to the adult stage as tesserae widen and deepen by 2-3 and 3-5 times, respectively. These preliminary data reveal similarities and reinforce well-known differences between elasmobranch and mammalian calcification. As in endochondral ossification, elasmobranch chondrocyte size and density decrease with age, yet lack the end-stage hypertrophication and cell-death of the tetrapod pathway.

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A systematic overview of the Brazilian skate fauna (Chondrichthyes: Rajidae)

We present here an updated review of the systematics of skates occurring in the western South Atlantic off the coast of Brazil, based in part on newly collected material. The skates from this region represent just over 40% of its batoid fauna, and has grown considerably in recent years due to a Federal sampling program carried out on the Brazilian continental slope. We report 26 to 31 rajid species placed in 12 to 15 genera from this region, namely: *Cruriraja rugosa*, *Dipturus flavirostris*, *Dipturus teevani*, *Dipturus garricki*, *Dipturus leptocauda*, *Dipturus mennii*, *Dipturus* sp. 1, *Dipturus* sp. 2, *Rajella sadowskii*, *Rajella purpuriventralis*, *Rajella fuliginea*, *Breviraja spinosa*, *Malacoraja obscura*, *Gurgesiella atlantica*, *Gurgesiella dorsalifera*, *Atlantoraja cyclophora*, *Atlantoraja castelnaui*, *Atlantoraja platana*, *Rioraja agassizi*, *Bathyraja schroederi*, *Psammobatis bergi*, *Psammobatis extenta*, *Psammobatis lentiginosa*, *Psammobatis rutrum*, *Sympterygia acuta*, *Sympterygia bonapartii*, and three unidentified species which are still unassigned to genus. Additionally, a *Dactylobatus* and another *Dipturus* species have been reported locally in Brazil (material not examined by us). Some of the species and genera are reported here for the first time from this region, but a few of these were originally described from the western North Atlantic, Gulf of Mexico and Caribbean Sea. The species range vertically from shallow coastal waters to the lower continental slope. Taxonomic and biogeographic aspects of this skate fauna are also treated.

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Response of gopher tortoises to military training operations on Camp Shelby, MS

Automated radio telemetry equipment will be used to study the responses of gopher tortoises to military training operations on Camp Shelby, MS. This equipment can enable one person to monitor and document the activity and movement patterns of many animals continuously over an extended time, regardless of weather, light level or terrain. The basic approach is to record and analyze the radio signal received from a radio transmitter mounted on the study animal. Because of the directivity pattern of the transmitting antenna and the fact that variations in its juxtaposition to its surroundings change the radiated power, motion of the animal causes changes in the received signal. A recording of the temporal variation of the received signal contains considerable information about the movement of the animal. Interpretation of these

signals is amenable to automated analysis by computer algorithms. Automated data analysis computer algorithms classify signals as active or inactive, based on moving averages of changing signal amplitude. Activity data, in conjunction with meteorological data, are being recorded to provide detailed temporal information on when tortoises are active above and below ground on a yearly basis. Data from this research project should benefit the recovery and management of gopher tortoise populations through refinements in a number of research areas, e.g., response to human activities, vocalization behavior, social dominance, habitat use, movement patterns, etc.

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Natural history of the Eastern Box Turtle (*Terrapene carolina*) in an anthropogenically impacted area: LEAD, South Central Pennsylvania

Few long term formal studies have been carried out on populations of Eastern Box Turtles (*Terrapene carolina*) in Pennsylvania. The general perception, however, is that populations throughout the state are undergoing reductions caused by environmental stress. As part of a long term herpetological study, I have surveyed the box turtles in a mildly impacted area at Letterkenny Army Depot (LEAD), from 2003 to 2005. The goal of this study is to determine the natural history and demographic status of the resident population. Turtles were captured from May to August, using drift fence/bucket trap arrays and transects. A total 50 turtles were collected and marked, none of them juveniles. Males comprised 54 % of captures, while females were 46 %. This difference, however, does not represent a significant sex bias ( $\chi^2$ ,  $p = 0.36$ ). Average male carapace length (133.7 mm) was significantly longer than that of females (127.5 mm), (t-test,  $p = 0.028$ ), although the minor difference in the average body weight of males (439.4 g) and females (448.5 g) was not statistically significant (t-test,  $p = 0.71$ ). I detected injuries (missing feet, cracked carapaces, and eroded scutes) in 28 % of the captured turtles. A total of 48 turtles (96%) were encountered in high canopy temperate deciduous forest (nearly 70 % of the habitat available). During the three-year study only one turtle has been ever recaptured, indicating the likelihood of a fairly large turtle population. However, more intensive survey and long term monitoring will be necessary to ascertain the biological health of this population. Future research will focus on the fecundity and reproductive success of this species at LEAD. Long term studies like this are fundamental in promoting conservation and comprehensive understanding of the box turtle biology and status in Pennsylvania.

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*Callogobius* and the reality of the "Priolepis group"

*Callogobius* is a widespread genus of Indo-Pacific gobies characterized by raised ridges and flaps of neuromasts on the head. They typically show a cryptic coloration and are found in a variety of estuarine and shallow marine environments. Currently about 32 species are considered valid, but identification is often difficult, if not impossible, with available literature, and there are many undescribed species. The actual number of species is likely to be twice this number, making *Callogobius* one of the largest of goby genera. Based on characters of the axial skeleton, *Callogobius* has been assigned to the "Priolepis group" by Birdsong et al. (1988). The "Priolepis group" is generally diagnosed by having 10+16=26 vertebrae, a pterygiophore insertion pattern of 3-22110 and a single epural. One would expect to find the outgroup of *Callogobius* among the "Priolepis group" and some taxa have been suggested, such as *Gobiopsis* and *Mangarinus*, although preliminary analysis does not support these. The "Priolepis group" is large and unwieldy as presently defined, with over 55 included genera, and its monophyly will be reassessed using a greater diversity of characters, including those of the gill arches, suspensorium and cranium. Gobies display an incredible repertoire of morphological characters, yet many of these characters have been underexploited in systematic studies.

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**DENESHA, CRAIG**

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Thermal tolerance and acclimation response in gut passage time associated with northern range expansion by the invasive lizard, *Anolis sagrei*

The ability of an invasive species to expand its range depends, in part, on the ability to adjust to different thermal environments at the edges of the range. The Brown Anole, *Anolis sagrei*, was introduced into Florida decades ago, and is currently expanding its range northward. It is currently unknown whether the northern range limit of this subtropical species is currently limited by its thermal physiology. In this study I tested whether northern populations of *A. sagrei* have a greater thermal tolerance for cool temperatures than southern populations, even after acclimatization. Specifically, I tested whether lizards from northern Florida have a decreased gut passage time (GPT) for ingested food compared to lizards from a southern Florida population, even after acclimatization to the same temperatures (15 ° C, 20 ° C and 30 ° C). The results showed a significantly shorter GPT in the northern populations even after southern lizards had acclimatized to the same cool temperatures as the northern lizards. One possible explanation for these results is that northern populations of *A. sagrei* have evolved a greater thermal tolerance for cooler temperatures than their

southern source populations. If true, then this species may continue expanding northward beyond Florida and into cooler environments.

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Specializations in head and tail morphology: Case study of head- and tail-first burrowing *Pisodonophis boro*

The order Anguilliformes forms a natural group of eel-like species. Life styles of these species cover the entire spectrum from non-burrowing to burrowing tough wedging through small openings is assumed to be the plesiomorphic condition. This study focuses on burrowing anguilliform species in general, with *Pisodonophis boro* (Ophichthidae) as a case study. Ophichthidae are known in literature to burrow tail-first. However aquarium observations of living specimens of *Pisodonophis boro* reveal them to burrow both head-first and tail-first. Furthermore, these specimens are predators, using rotational feeding. A detailed osteological and myological examination of the head of *Pisodonophis boro* reveals striking morphological convergence with *Moringua edwardsi*, a specialized burrowing moringuid with predacious feeding habits. In *Pisodonophis boro* the adductor mandibulae complex is hypertrophied and the anterior fibres of the A2 are anteriorly directed; the shape of the skull is elongated, tapering towards the snout; the cranial bones are highly reinforced and their sutures show a high amount of overlap; the eyes are small; the coronoid process of the dentary is high and the quadrate and hyomandibula of the suspensorium form a strong entity, while the palatopterygoid is loosely connected to the hyomandibula; the opercular and suspensorial muscles are small. However, these features are more extreme in the head-first burrowing species *Moringua edwardsi* but appear to a lesser extent in the tail-first burrowing congrid species *Heteroconger hassi*. The differences in morphology can be considered as specializations for head-first burrowing behaviour as well as to differences in feeding. The osteology and myology of the tail shows striking similarities with the tail-first burrowing *H. hassi* and is highly different from that of the head-first burrowing *M. edwardsi*.

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Taxonomy and biogeography of the loricariid catfish *Peckoltia sabaji*

Containing over 700 valid species, the suckermouth armored catfish family Loricariidae is the largest catfish family and among the largest of all fish families. There are many problematic genera in the Loricariidae, and among the most problematic are the potentially polyphyletic *Hemiancistrus* and *Peckoltia*. One species

of *Peckoltia*, *P. sabaji*, sits between the main clades of the two genera and likely represents an undescribed genus. Since the description of the species, more collections have become available from much of the Orinoco basin, the lower Negro, the Madeira, and the Tapajós allowing a better examination of the species. We have morphometric evidence to suggest that the *P. sabaji* from the Orinoco is significantly different from the *P. sabaji* in the Amazon and Essequibo, and that the Orinoco population may be an undescribed species. This finding mirrors other species with similar patterns. For example, *Hypancistrus* and *Pseudolithoxus* have species found only in the Orinoco basin whereas sister species are found only in the Negro basin. These patterns have biogeographical implications within the Loricariids in the Guyana Shield. The Orinoco is seasonally connected to the Negro via the Río Casiquiare. The striking separation of species across this connection suggests that the Casiquiare is potentially a barrier to the movement of fishes through this corridor. Further investigations of species that occur on both sides of this connection between the Orinoco and Negro could provide insight to the role the Casiquiare has in structuring freshwater fish populations.

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#### All Catfish Species Inventory expedition to central Brazil

In July and August of 2005 a team of ichthyologists from Auburn University (USA), Museu de Zoologia de São Paulo, and Instituto de Pesquisas Amazônicas (Brazil) traveled into central Brazil in search of new species of catfishes for the NSF funded All Catfish Species Inventory. The Central Brazil Expedition collected fishes from the tributaries of the Tocantins and Araguaia Basins within the Central Brazilian Shield in the state of Goiás. Originating in the north of Brasília, we made collections at three stations in the headwaters of the rio Tocantins between the counties of Cocal and gua Fria. Heading northwest from the city of Goiás Velho we collected in the tributaries of the Araguaia until reaching the city of Aruanã on the Araguaia River. From the Aruanã we traveled northeast to the county of Nova Crixás. A total of fifteen stations were collected in the Araguaia Basin. This expedition yielded 1508 specimens, of which, 59 species, in 42 genera and nine families are in the Siluriformes. The largest collections within Siluriformes were within the family Loricariidae with 23 species in 18 genera, followed by Pimelodidae, Heptapteridae, Trichomycteridae, and Callichthyidae. Fourteen of the 59 total species may represent new species and are under further investigation. Potential new taxa under study include one species in an undescribed genus of Pseudopimelodidae with the remaining species in *Ancistrus*, *Hemiancistrus*, *Hypostomus*, *Rineloricaria*, *Neoplecostomus*, *Hypoptompoma*, *Harttia*, *Leporacanthicus*, *Auchenipterus*, *Corydoras*, *Anadoras*, *Stegophilus*. Other by catch material includes species from ten orders: Characiformes, Clupeiformes,

Cyprinodontiformes, Gymnotiformes, Myliobatiformes, Osteoglossiformes, Perciformes, Pleuronectiformes, Symbranchiformes, and Tetraodontiformes.

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An extreme case of convergent evolution on a low taxonomical level in clariids

Clariids represent an impressive range between fusiform and anguilliform morphs. Although this has been observed in other families of teleosts or amphibians and reptiles, it is rarely as extreme as within the Clariidae. Although originally the Clariidae were thought to have undergone an anagenetic evolution, more recent studies provide evidence that supports the hypothesis that anguilliformity evolved several times independently through a process of cladogenesis. Our combined morphological and molecular phylogenetic analyses suggest the derived nature of body elongation. The corresponding morphological changes that co occur with this elongation, e.g. increase of the number or size of vertebrae, skull length reduction, limblessness, reduction of the eyes, and/or increasing rigidity of the skull, can as such be regarded as an extreme case of convergent evolution at the genus level. Many of these morphological specialisations can be linked to the specialised life style of these anguilliform morphs.

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**DEVANEY, SHANNON C.**

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Molecular phylogenetics of dragonfishes (Stomiidae)

The family Stomiidae (dragonfishes and allies) composes close to 300 described species in 27 genera. These fishes are meso- and bathypelagic and representatives of the family are found in deep oceans throughout the world. Members of this family were formerly classified in six separate families, which are now designated as subfamilies within Stomiidae, although morphological analyses suggest that most subfamilies are not monophyletic. The interrelationships of the fishes in this family have never been addressed with molecular data. I present a phylogenetic analysis of the family Stomiidae based on nucleotide sequence data from the nuclear genes RAG1 and EF1, and the mitochondrial locus COI. This is part of a dissertation project involving the phylogeny of the order Stomiiformes as a whole. Similarities and

differences between hypotheses based on morphological and molecular data are addressed. Implications of this phylogeny for character evolution are also discussed.

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**Influence of reproductive mode in escape behavior in two sibling species lizards (*Sceloporus bicanthalis* and *S. aeneus*)**

Escape behavior and the locomotor speeds of two sibling species of lizards with different reproductive mode were studied (*Sceloporus bicanthalis*: viviparous; two populations at 4100 m and 3400 m, *S. aeneus*: oviparous; 3100 m) in the volcano Nevado de Toluca, central Mexico. The estimation of predations in the three studied sites was determined by the attacks to decoys (similar shape, color and size to lizards). The wariness behavior of males, non pregnant and pregnant females were measure by the approaching distances (from observer to lizard before run) and escape distances (the distance from the perch site to the refuge). The speed performance of lizards from each population was recorded at three different corporal temperatures in the laboratory. The highest incidence to decoy attacks occurred in the highest population of *S. bicanthalis* and the lower was in *S. aeneus* population. The speed of pregnant females was slower than the males and non pregnant females in viviparous populations, but no significant differences were found. The locomotor performance is proportional to body temperature in both species, at high corporal temperature the lizard is faster than when they present low body temperatures in the two reproductive conditions. Also, results show that the weight and volume due to pregnancy condition does not decreases locomotor performance in both species. Viviparous pregnant females were basking closer to refuge site, than the males and none pregnant females in contrast to the oviparous pregnant females which do not have differences in escape distances with males and non pregnant females. Also these results suggest that predator avoidance behavior depend on amount of predation pressures on each site in both sexes.

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When bigger is not better: Selection against large size, high condition, and fast growth in juvenile lemon sharks

A lemon shark nursery site at Bimini, Bahamas, was exhaustively sampled from 1995 to 2000. Morphological measures were obtained from approximately 200 individually-tagged juvenile sharks per year and their survival was recorded in subsequent years. To test the bigger is better and faster is better hypotheses of life-history theory, we determined whether body size, condition factor, or growth rate were related to survival. The mark-recapture program, MARK 5.1, was also used to validate our study site and population as one suitable for estimating the strength of selection. In young of the year sharks, selection on all measured traits was weak, but consistently suggested selection against large size, high condition, and fast growth. The pattern was similar but much stronger for age-1 juveniles. These results suggest that selective pressures at Bimini may be constraining the size and growth of juvenile sharks. These conclusions fit well with the observed low growth rate at this site.

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Movement patterns and the effect of tag type on the return rate of juvenile and adult raggedtooth sharks (*Carcharias taurus*) tagged off the east coast of South Africa

Movements of juvenile (< 1.8 m TL) and maturing and adult (> 1.8 m TL) raggedtooth sharks (*Carcharias taurus*) were determined by tag and recapture methods to outline spatial and seasonal distribution patterns. Between 1984 and 2004 a total of 1107 juvenile and 2369 maturing and adult raggedtooth sharks were tagged and released in a collaborative tagging exercise involving scientists and volunteer anglers from the Natal Sharks Board, the Oceanographic Research Institute and the Port Elizabeth Museum cooperative tagging programs. A total of 125 juvenile and 178 maturing and adult raggedtooth sharks were recaptured, representing recapture rates of 11.2% and 7.5% respectively. The average distance travelled by juvenile sharks was 18.7 km (95% C.I. = 10.8 to 26.6 km). Juvenile sharks displayed site fidelity to summer nursery areas. The location of winter nursery areas remains unknown. The average distance travelled by maturing and adult sharks was 342 km (95% C.I. =

275 to 409 km), however, one female shark was recaptured 1897 km from its original release site. The average rate at which pregnant sharks moved south from their gestation to pupping grounds was 2.6 km.day<sup>-1</sup> (95% C.I. = 2.04 to 3.16 km.day<sup>-1</sup>). Female sharks displayed a biennial reproductive migration pattern. Significant differences in recapture rates were evident between different tag types and tagging methods used to tag sharks.

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Behavior and variation in yellow ventral coloration in the Green Frog, *Rana clamitans*

Male green frogs (*Rana clamitans*) defend their territories using a combination of acoustic and visual displays. Visual displays are not well studied in this species, although it is possible that the yellow throats of calling males function as visual cues. We sampled green frogs (females and calling and non-calling males) from a permanent pond in the Tecumseh Natural Area of the Ohio State University at Lima, Allen County, Ohio. Frogs were collected at night during the months of June and July, 2005. We observed behavioral status and made recordings of advertisement calls for calling males. We measured the frogs for snout-vent length and weight, and we also took digital photographs of the ventral surface. The photographs were analyzed using Adobe Photoshop to collect data on area and color properties of the yellow ventral coloration. Only males expressed the yellow coloration, but the area and color properties varied between males. Calling males tend to have a greater area of yellow coloration than non-calling males, and the area is positively correlated with body condition. This suggests that it could function as a visual cue of fighting ability to other males or of fitness to females. Calling rate was not associated with ventral coloration. The yellow coloration seems to disappear in males outside the breeding season, and further work will examine its relationship to levels of circulating androgens.

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Thermal ecology and activity patterns of juvenile lemon sharks, *Negaprion brevirostris*, in a shallow water nursery

Ten juvenile lemon sharks (*Negaprion brevirostris*) captured between July of 2004 and April of 2005 were fitted with iButton temperature loggers and internal acoustic telemetry tags to simultaneously monitor diel movements and body temperatures.

Temperature loggers were also used to record daily environmental temperatures within the home range of each individual shark. Regression analysis of a small pilot study examining the relationship between internal body and external water temperature showed a highly significant relationship ( $R = 0.995$ ;  $p < 0.001$ ) and suggested that juvenile lemon sharks have a relatively small thermal inertia. Consequently, body temperature data show that juvenile sharks did not attempt, and perhaps were precluded from, behaviorally maintaining a constant internal ecritic temperature. Rather the sharks appeared to behaviorally exploit home range thermal heterogeneity in a way that allowed the body temperature of the juveniles to approach the upper end of the temperatures available. The heat loading phenomenon was observed at all times but was most pronounced in the hours between mid-afternoon and dusk ( $p < 0.001$ ). It is possible that by maximizing heat loading lemon sharks prolong the efficiency of activities such as feeding or digestion well into the cooler periods of the night. Large fluctuations in body temperature may also have negative bioenergetic impacts that may explain the slower growth rates of juveniles in Bimini compared to other known lemon shark nurseries. Laboratory work relating to the temperature preference of lemon sharks and temperature mediated respirometry would shed more light into the importance of these findings and allow a better understanding of the physiological implications of thermal habitat selection in this group.

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#### Population genetics and phylogeography of the endangered species

##### *Etheostoma percnurum*

*Etheostoma percnurum* is currently known from six localities in the Tennessee and Cumberland River basins. Prior to successful propagation and stocking, only four populations of this taxon remained. The limited distribution combined with estimated population sizes resulted in listing the species as endangered in 1993. Molecular genetic data have become pervasive in conservation and, indeed, preservation efforts, but no data of this sort have been presented for *E. percnurum*. In this study, 67 individuals from the four historic, i.e. pre-stocking, localities were analyzed at four microsatellite loci and the mitochondrial Cytochrome *b* gene. Preliminary analyses indicate two distinct evolutionary units within *E. percnurum*, one from the Cumberland River and one from the Tennessee River. These data argue strongly for caution in captive propagation and stocking of endangered species when genetic data are lacking.

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Effects of environmental conditions during embryonic development on neonates of the imperiled Blanding's turtle (*Emydoidea blandingii*)

Blanding's turtles have been listed as a species of special concern, threatened, or even endangered by states and provinces within their range. One reason that populations are susceptible to decline or extinction is long distance migration to nesting sites that tend to be near roadways and railways. In addition to increasing mortality of nesting turtles, these localities may artificially elevate the temperature and reduce the soil moisture of the nests. To explore the effects of altered environmental conditions during embryonic development on neonates, we incubated 220 eggs from 26 clutches of *E. blandingii* from Nebraska at 26, 27, 28, 29, and 30°C and at -150 and -850 kPa. Turtles from warmer temperatures hatched sooner than those from cooler temperatures. Consistent with results for other species of turtles with flexible-shelled eggs, we found that turtles from warmer, drier treatments were smaller than those from cooler, moister treatments. We also expect that turtles from warmer temperatures will be more likely to be female than those from cooler temperatures and that turtles from drier substrates will exhibit inferior locomotor performance compared to those from moister substrates. Our laboratory findings ultimately will be complemented by, and interpreted in the context of, measures of thermal and hydric properties of roadside/railway vs. natural nest locations as well as values for the same phenotypic parameters measured on hatchlings deriving from these field nests. Our research will provide insight into secondary effects of roadways/railways on these imperiled turtles that can aid development of successful conservation plans.

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Herpetofaunal conservation in the rainforest: Perceptions of ecotourists

Perceptions of ecotourists toward the treatment of wild animals may differ depending on the animal group concerned. Tourists often have deep affection for monkeys and parrots, but less affection for animals such as caimans, turtles, or frogs. In Tambopata, Peru the wild animal handling practices differ widely. To determine if the conservation practices of rainforest tourist lodges in southeastern Peru matched the wishes of their ecotourists, tourists were requested to fill out a questionnaire concerning their attitudes towards reptiles and amphibians. In total 114 questionnaires were completed by ecotourists staying at four sites. Tree frogs were the most familiar herpetofaunal group, followed by caimans. Tourists were least familiar with coral snakes, poison dart frogs, and pit vipers. The most commonly seen herpetofaunal species were caimans, followed by turtles, lizards, and tree frogs.

Although not regularly offered, tourists expressed interest in participating in a night hike to view nocturnal animals, including most herpetofaunal species. Just over half of the tourists participated in a nocturnal boat journey to view caimans. Contrary to the beliefs of most lodge operators, the majority of tourists did not wish to see reptiles and amphibians kept as pets or approve of guides capturing caimans during the nocturnal boat ride. The large majority of tourists stated that herpetofaunal conservation is as important as bird and mammal conservation. The highly significant results of this study were remarkable. Contrary to common expectations, visitors had strong opinions about viewing and protecting reptiles and amphibians. Visitors desired to experience more reptiles and amphibians in their natural setting and did not wish to have them captured or kept as pets. In addition, respondents were concerned about the conservation status of these foreign, secretive animals, just as they would be for more charismatic mammals and birds.

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#### Changes in a northwestern Florida Gulf Coast herpetofaunal community over a 28-year period

Population declines of amphibians and reptiles throughout the world have led to the initiation of projects to monitor their status and trends. Historical collections give an indication of which species occurred in an area at one time, although the ambiguity surrounding locations and environmental conditions associated with collection decreases the value of this information source. Resampling using the same general protocols can give valuable insights to changes in community structure, however, when sampling methodology and exact site locations are known. From 2002-2005, we resampled 12 sites in St. Marks National Wildlife Refuge in Florida's panhandle, an area in which intensive herpetological surveys were conducted in 1977-1979. We documented a general decrease in species richness among the diversely managed sites, changes in dominant species and diversity, and an increasing trend toward homogeneity of the herpetofaunal community among habitats. Changes were attributed to four possible causes: 28-yrs of forest community succession, changes in management practices, non-detection of species due to variation in sampling conditions, and an actual decrease in occupancy by 4 amphibians and 3 reptiles. The use of population and habitat-related indexes helped define possible influences on community change and can be used to target species for monitoring. Research should be directed at identifying the causes and extent of decline of the 7 herpetofaunal species we identified as decreasing on the refuge. Such declines are of concern, especially considering the protected status of the refuge and its increasing isolation as surrounding landscapes are converted to urbanized settings.

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## Gill slit morphologies among extant sharks

The number of gill slits that an elasmobranch species possesses is often counted for taxonomic classification; however, the length of each slit relative to total body length, the spacing among the slits, and position of the slits relative to the pectoral girdle and fin have not been measured or compared phylogenetically. In this study, these variables are analyzed among species within each family of extant sharks. While it was expected that the slit morphologies would be similar among species within each family, we found differences in length, spacing, and position by order, family, and even genera, thus showing diverse slit morphology among extant sharks. However, there are three predominant morphologies: 1) all slits of similar length, spaced evenly apart, and positioned in front of the pectoral girdle and fin, 2) all slits of similar length, spaced evenly apart, and positioned just adjacent to the pectoral fin, and 3) all slits of similar length, anterior four slits spaced evenly with the fourth and fifth slit spaced with about half the distance between them as compared to slits one through four, and with at least slits four and five positioned dorso-laterally to the pectoral girdle and fin. The diversity among extant sharks indicates that slit morphology may not be influenced phylogenetically as much as by specific habitat, ventilatory mode, or locomotor style.

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## Description of a white shark aggregation in the eastern Pacific (Guadalupe Island, Mexico) using photographic methods

White sharks, *Carcharodon carcharias*, aggregate annually around Guadalupe Island, Mexico. A method of photo-identification (photo-ID) was developed and used to document individual white sharks present at the island from 2001 through 2005. The most reliable features for repeat identification across multiple years were the pigment patterns on the gill flaps, pelvic fins, and caudal fins. Pigment patterns in all three regions were asymmetrical on the right and left sides making it necessary to photograph both sides to catalogue each individual. However, once catalogued, an individual could be identified using less than the full complement of observations from both sides. The present study, based upon this photo-ID method, addressed the following questions: (1) Do individual sharks identified at Guadalupe Island demonstrate annual site fidelity?, (2) What is the sex ratio of the Guadalupe Island white sharks? and (3) how many white sharks frequent Guadalupe Island? This study identified over 60 individual sharks around Guadalupe Island, many of which have been sighted on several occasions over multiple years. This project has identified Guadalupe Island as an important aggregation site for white sharks and in the future may be used to complement studies on long-range movements, population dynamics, and recruitment of white sharks in the Pacific.

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Large scale movement patterns of Guadalupe Island, Mexico, white sharks (*Carcharodon carcharias*) described from archival tag data

Published satellite tagging data from the Farallon Islands, California (USA) and the coast of South Africa have proven white sharks (*Carcharodon carcharias*) to be capable of lengthy basin-scale migrations. A satellite tagging program targeting an annual aggregation of white sharks found off Guadalupe Island, Mexico, was initiated in 2000. Seventy-two popup tags were deployed on white sharks resulting in tracks of up to 386 days. Seven of the tags were physically recovered allowing us to study high-resolution tag data from several individuals; three of these were recovered from sharks upon their return to the island. White sharks were found to remain near Guadalupe Island between the months of August and April, with a large degree of variability between individuals with respect to the actual time spent at the island. When sharks left Guadalupe, movement was always westerly, with one individual going as far as the Hawaiian Islands. The offshore region occupied by these sharks is large and diffuse; this region appears to be the same as that described by researchers studying white sharks off the central California coast, indicating some degree of connectivity between these aggregations.

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Extinction susceptibility of Micronesian fishes

Numerous fish species found on inshore reefs and in insular freshwater systems of Micronesia have life history characteristics that, in conjunction with certain factors, render them susceptible to extinction. Criteria defined by the IUCN/SSC Extinction Susceptibility Matrix recognize two major kinds of relevant factors: intrinsic and extrinsic. Intrinsic factors include low actual or potential population growth rate, ecological specialization, and range size. Extrinsic factors include those pertaining to habitat and exploitation. Data for 1,528 species of reef and insular fishes from eleven Micronesian localities were examined with the Extinction Susceptibility Matrix to detect species having one or more factors that may render them susceptible to localized extinctions. The analysis indicated that many predatory and some herbivorous species in reef fisheries are especially susceptible because of over-exploitation, that coral-dwelling species are susceptible because of coral-bleaching and habitat degradation, and that insular freshwater species are susceptible because of habitat degradation and invasive species.

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### Communal nesting in reptiles and amphibians

Communal nesting or oviposition, whereby mothers deposit eggs with or near those of conspecifics, is widespread among reptiles and amphibians, yet little attention has been given to why it occurs. Is communal nesting adaptive (and if so in what way), or is it merely an artefact of scarcity of available nest sites? We review evidence for each, introduce a conceptual model for the evolution of communal nesting, and discuss game theory scenarios and applications of the model. Our review indicated that communal nesting is much more common than appreciated (> 300 species), especially in lizards and snakes. A series of experiments and a field study are under way to determine the ultimate cause of why so many species nest communally.

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### Anatomy and evolution of the dorsal pharyngeal feeding apparatus of Catostomidae (Cypriniformes)

All species of Order Cypriniformes lack oral teeth. Consequently, mastication of food occurs in the pharynx. The pharyngeal feeding apparatus of cypriniforms is composed of gill rakers, pharyngeal teeth and a dorsally located structure referred to as the palatal organ. The palatal organ comprises dorsal elements of the gill arches, a ventrally directed process of the basioccipital bone, a keratinized chewing pad and mucosa. In this study, I take a comparative, phylogenetic approach to determine homology of this structure. Morphological characters of the structure were coded and mapped onto a phylogenetic tree of cypriniforms generated from nuclear growth hormone and mitochondrial ND4/ND5 gene sequences. The aim of this work is to determine 1) how the pharyngeal feeding apparatus varies across cypriniform taxa and 2) what is the evolutionary origin of the specialized structure seen in catostomids.

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### Assessing the conservation status of New York snakes

While conservation of all species is not possible in the face of the numerous factors causing rapid extinctions, some species may more likely require immediate attention than others. Policy recommendations for prioritization should ideally be based on extended studies of populations and ecosystems; unfortunately, funding and time for these studies are in short supply. Snakes face particular problems because baseline information on abundance is non-existent in most cases and because nonprotected species are often intentionally exterminated. Here we investigate three methods for determining past abundances of New York snake species and necessary conservation action to prevent future declines. We examined historical records, data from museum collections, and shared life history traits to determine changes in species abundance over time and to assess the risk of future declines. We found that late female maturity and habitat specificity were significant predictors of decline, and that suites of life history characters closely reflect phylogeny, signifying an increased likelihood of an extinction threat to entire lineages rather than single species. The combined use of all three types of data suggests that several species have experienced decline in the last two hundred years and deserve increased protection. These types of information can help us guide future conservation efforts.

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### Analysis of introgressive hybridization among Colorado River suckers (Catostomidae) using SNPs

Numerous factors contribute to the decline of indigenous fishes in western North America. While habitat alteration is a major concern for indigenous fish communities, impromptu introduction of alien species is probably a more serious threat to their long-term survival. Impacts of the latter are less immediate, and often go unnoticed by the general public. Introgression of alien genes gradually erodes the genetic integrity of native species, and irreversibly alters the local genetic adaptation that has evolved over millions of years. As a result, indigenous genes become replaced and the endemic fauna is effectively eliminated. We applied a molecular genetic approach to define the extent and magnitude of hybridization between the introduced White Sucker (*Catostomus commersoni*) and endemic suckers of the Colorado River Basin, the Flannelmouth Sucker (*C. latipinnis*) and the Bluehead Sucker (*C. discobolus*). These

three hybridize in areas of the Upper Green and Colorado Rivers, where White Sucker has been introduced. Species-specific nuclear markers were developed to assess the status (i.e., pure or hybrid) of over 800 specimens. SnapShot (multiplex primer-extension) PCR reactions were used to screen diagnostic SNPs (single nucleotide polymorphism). Results demonstrated that morphological and genotypic identifications were congruent with over 95% of the individuals. Further, non-native fishes and hybrids appear to more prevalent in areas with perturbed habitat.

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**Evolution of rattlesnakes (Viperidae; *Crotalus*) in the warm deserts of western North America shaped by Neogene vicariance and Quaternary climate change**

During Pleistocene, the Laurentide ice sheet rearranged biotic distributions in eastern North America, yet had minimal physical impact in western North America, where lineage diversification is hypothesized to result from climatic changes. If desert species were impacted by Pleistocene climate, they would reflect demographic bottlenecks concomitant with restricted gene flow. Molecular evidence for refugia should be present within distributions, and for range expansions as conditions improved. We sought answers to these questions by evaluating mitochondrial (mt) DNA sequences from four rattlesnakes restricted to southwestern North America [*Crotalus cerastes*, (Sidewinder), *C. mitchellii* (Speckled Rattlesnake), *C. ruber* (Red Diamond Rattlesnake), *C. tigris* (Tiger Rattlesnake)]. We inferred relationships using parsimony, tested intraspecific clades for population expansion, and applied an isolation-with-migration model to determine bi-directional migration among clades. Significant range expansion was present in 2 (of 6) clades in two species (*C. m. pyrrhus*, *C. tigris* clade 2). Two others (*C. cerastes*, *C. mitchellii*) displayed distributions concomitant with vicariant separation into subclades by northward displacement of Baja California from mainland Mexico. Effects of Pleistocene climate fluctuations were found in all four species, with three patterns identified: (1) shallow genetic diversity that resulted from Pleistocene climatic events (*C. ruber*, *C. tigris*); (2) deep Pleistocene divisions indicating allopatric segregation of subclades within refugia (*C. cerastes*, *C. mitchellii*); and (3) lineage diversifications extending into Pliocene (*C. cerastes*, *C. mitchellii*). Clade-diversifying/ clade-constraining effects impacted desert rattlesnakes unequally. We found high levels of molecular diversification in two broadly distributed species (*C. cerastes*, *C. mitchellii*), with lower levels of genetic diversification in species with restricted ranges (*C. ruber*, *C. tigris*). Furthermore, subspecific distributions were most often incongruent with molecular information, and we propose one taxon (*C. mitchellii stephensi*) be elevated to full species (*C. stephensi*).

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## **DRASS, DENICE**

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### Tilefish larvae of the genus *Hoplolatilus*

Tilefish larvae are distinguished by the elaborate spination on various bones of the head. The posttemporal, supracleithral and preopercular bones all develop spines that become very ornate. The development of a rostral spine and frontal ridges add to the ornamentation. The genus *Hoplolatilus* develops a spike-like rostral spine that is distinctive from the anchor-shaped rostral spine of the genus *Malacanthus* and the blunted rostral spine found in the other three genera, *Branchiostegus*, *Caulolatilus* and *Lopholatilus*. Two types of rostral spine have been observed in the genus *Hoplolatilus*, one is the spike-like spine and the other is a bifurcated spine. Of the fifteen specimens examined, only two exhibit the split rostral spine.

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### Demography and viability of the eastern massasauga (*Sistrurus catenatus*) at Carlyle Lake

Estimates of demographic vital rates such as age-specific survival and reproduction are necessary in both life history studies and the formulation of conservation plans. For reptiles, long-term studies are often required to estimate these parameters and construct life tables. Elasticity and sensitivity analyses can be conducted using these data to determine the rates that most affect population growth and can be subsequently used in conservation plans through population viability analysis. We have been studying a population of Eastern Massasaugas (*Sistrurus catenatus*) at Carlyle Lake, Clinton County, Illinois since 1999. We have followed several cohorts through maturity, which has allowed us to address the demographic parameters of age-specific mortality rates, generation time, and reproductive value. Using these data, we will assess the viability of the Carlyle Lake *S. catenatus* population.

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### Turtle assemblages in northeastern Illinois

Turtles are an integral component of freshwater ecosystems because their longevity, coupled with low biomass productivity, results in the retention of nutrients for decades. Although their role within communities is integral, many factors relating to turtle assemblage structure and composition remain poorly understood. Therefore, we examined relative abundance and diversity of turtle assemblages in northeastern Illinois. Species diversity ranged from 0.30 to 1.26 (two to eight species), with *Chrysemys picta* comprising from 50% to 91% of the assemblages. Together, *C. picta* and *Chelydra serpentina* accounted for 78% to 100% of each assemblage. Results will be discussed in terms of habitat characteristics and the continuing development of the region.

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### Distribution and biology of the white shark (*Carcharodon carcharias*) in New Zealand waters

The US Atlantic seaboard, South Africa, North Pacific, and southern Australia have long been recognised as centres of abundance for the white shark. Historically the occurrence of white sharks from New Zealand waters was generally considered to be exceptional by the New Zealand public and scientific community. Locally recognised hotspots for white sharks were all located around southern New Zealand and included the Chatham Islands, Otago, Stewart Island and Fiordland. Popular belief was that white sharks straggled to New Zealand from warm Australian waters. Marine scientists gave scientific credibility to this belief by suggesting that oceanic circulation around New Zealand produces a thermal cul-de-sac that trapped white sharks off the east coast of South Island and at Chatham Islands. The distribution of captures, sightings and predation events in New Zealand waters documented by the author since 1991 contrast dramatically with this popular view of white shark distribution and ecology. White sharks are widely distributed within the New Zealand exclusive economic zone, occurring in coastal and oceanic waters from about 33°S to 52.5°S (Campbell Island). Information on distribution, nursery areas, size at maturity, diet and potential threats obtained from more than 460 records of white sharks from New Zealand is presented. This information provides the biological context to the collaborative satellite tagging studies currently being undertaken at the Chatham Islands and around mainland New Zealand, and will be used along with information from these and other tagging studies to inform the conservation and management of the species in the southwest Pacific.

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### On the taxonomic ambiguity of *Fundulus blairae* and *F. dispar*

The *Fundulus nottii* species complex includes five species of North American topminnows: *F. nottii*, *F. escambiae*, *F. lineolatus*, *F. dispar* and *F. blairae*. Recent phylogenetic analysis places *F. lineolatus* basal to the sister species pairs *F. escambiae* – *F. nottii* and *F. dispar* – *F. blairae*. Two broadly defined habitats are identified for starhead topminnows, including coastal blackwater streams and other tannin stained backwater habitats characteristic of *F. lineolatus*, *F. escambiae* and *F. nottii*, and floodplain backwaters and sloughs of larger rivers, characteristic of *F. dispar* and *F. blairae*. This pattern suggests that two ecological trajectories developed early in the cladogenesis of this group. Allopatric speciation was originally proposed for the complex; however, taxonomic issues were later raised for *F. dispar* and *F. blairae* when morphotypes attributable to both species (i.e. males with vertical bars in *F. dispar* and absence of bars in *F. blairae*) were taken syntopically from the Buffalo River in extreme southwest Mississippi. The continued loss of floodplain habitat throughout the alluvial Mississippi Valley and Gulf Coast warrants urgency in resolving the distribution and taxonomy for these species. Herein, we report on >50 new collections made for *F. dispar* and *F. blairae*. The syntopic occurrence of barred and non-barred males was documented in the Big Black, Pearl and Pascagoula Rivers and the Mobile Basin. Phylogenetic analysis of the complete mitochondrial cytochrome *b* gene for 25 individuals supports the recognition of *F. dispar* and *F. blairae* as distinct species; however, barred and non-barred males were found within each of the two clades recovered in the cytochrome *b* phylogeny. Additional data are needed to determine if the loss of vertical bars is in fact an apomorphic trait for *F. blairae* or if this incongruence is the result of introgression.

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**EARL, JULIA E.**

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### Measurement error in image analysis of fluctuating asymmetry

Fluctuating asymmetry (FA) is a population-level measure of developmental stability, or the ability to buffer stress during development. FA examines the frequencies within a population of minor deviations from perfect bilateral symmetry within one trait or a combination of traits and may be a useful conservation tool for evaluating population stress. For FA analyses to be effective, it is necessary that measurement error (ME) be minimized, and image analysis is useful in this regard. One strategy is to take one photograph and measure each image three times to account for ME. However, this method assumes that all measurement error results

from the image analysis, when overall ME actually consists of two components: image analysis ME and positioning error (PE). To determine the importance of PE, a sample of tadpoles (*Pseudacris crucifer*) and newly metamorphosed toads (*Bufo fowleri*) were used to determine ME due to positioning. ME was calculated for one picture measured three times (image analysis ME) and for three pictures measured once each (overall ME). In some traits, such as eye width and tibia length in toads, there was extremely low ME in both analyses. On the other hand, traits such as eye to nare in tadpoles and femoral length in toads showed almost no image analysis ME but highly elevated overall ME. In this case, if only one picture was used, the sample would be considered suitable for FA analysis, when the overall ME was actually too high due to PE. Thus, we recommend that three pictures be taken in all FA analyses utilizing photographs, lessening the chance that ME is artificially reduced and increasing the efficacy of FA analyses. There are time costs associated with taking multiple photographs per individual, and it may be suitable to test a sub-sample of individuals for PE with multiple photographs.

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**\*EBERT, DAVID A.; BIZZARRO, JOSEPH J.**

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### Standardized diet composition and trophic levels of skates

Skates (Rajiformes: Rajodei), although fairly conservative morphologically, are the most diverse elasmobranch group with approximately 275 recognized species. They are common components of benthic communities in temperate and boreal regions, where they serve important trophic roles. Most skate species are benthic or infaunal predators on unconsolidated substrates. Although somewhat restricted in habitat, skates exhibit considerable dietary diversity, consuming a variety of prey taxa, including: polychaetes, molluscs, crustaceans, and fishes. Trophic estimates for these benthic predators, however, are virtually non-existent. Therefore, to better understand the ecological role of skates in demersal marine communities, we present standardized diet compositions and trophic levels calculated from published quantitative studies. Trophic level values were estimated for all available species and compared among taxa, size classes, and regions. Given the diversity and abundance of skates in many regions, results of this study could prove useful for elucidating benthic food web dynamics and for effective ecosystem-based management.

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Age, growth, and reproduction of six Alaskan skates (Chondrichthyes: Rajiformes: *Bathyraja* and *Raja*)

In Alaska, skates are taken in large numbers as bycatch in groundfish fisheries, with an estimated 55 million pounds caught in 2002. Additionally, a directed fishery for skates has emerged in the Gulf of Alaska. Given the large available biomass of skates and the need for alternative fishery targets and better bycatch utilization, Alaskan skates are likely to be increasingly targeted. Because many elasmobranchs, including skates, have life history characteristics that make them especially vulnerable to fishing (e.g. slow growth, large size at maturity, low fecundity), it is extremely important to harvest these species with caution. A lack of life history information on Alaskan skates, however, severely limits the potential for effective management. To address this knowledge gap, the age, growth, and reproductive biology of two rajid and four common bathyravid species are being determined. Field sampling is taking place in the Eastern Bering Sea and Gulf of Alaska. To date, approximately 176 *Raja binoculata*, 156 *R. rhina*, 701 *Bathyraja aleutica*, 382 *B. interrupta*, 268 *B. minispinosa* and 134 *B. taranetzi* have been sampled during survey cruises. Vertebral centra, caudal thorns and reproductive tracts have been collected from these specimens. Successful completion of this project will provide fishery scientists and resource managers with critical biological information for effective management of these four Alaskan skate species. Establishing species-specific regulations and/or quotas as fisheries are being developed is necessary to ensure sustainability of these potentially susceptible batoids.

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Extreme pelagic dispersal in the reef fish *Myrripristis berndti* (Holocentridae)

To assess patterns of large-scale genetic connectivity among widely distributed Indo-Pacific reef fishes, we surveyed mitochondrial DNA of the bigscale soldierfish, *Myrripristis berndti* (Holocentridae). Our multi-scale approach included sampling the entire range of the species, spanning 240° of longitude from the western Indian Ocean to the eastern Pacific (N = 278), along with intensive sampling at one of the largest and most isolated archipelagos (the Hawaiian Islands; N = 147). Analysis of cytochrome *b* sequences indicates that common haplotypes were shared among all sample localities, there is modest population structure overall ( $s_t = 0.211$ ;  $p < 0.001$ ),

no structure within the Hawaiian Islands ( $s_t = 0.0004$ ;  $p = 0.4107$ ), and no structure across the central-West Pacific. Population separations across the East Pacific Barrier ( $s_t = 0.107 - 0.424$ ) were significant, but notably weaker than those between the Pacific and Indian Oceans ( $s_t = 0.329 - 0.810$ ). Although *Myripristis berndti* is abundant on both shallow and deep reefs (to at least 160m), mismatch distributions indicate a recent coalescence on the order of 500,000 yr similar to other, shallow reef species that experienced reduced habitat and abundance during glacial periods. Overall, the mtDNA data indicate a dispersal capability in *M. berndti* which far exceeds that of other reef fishes. We attribute this finding to an extended pelagic juvenile stage known in other holocentrids but hypothesized here for *Myripristis*. While recent examples demonstrate limited larval dispersal in some reef fishes, it is clear that others, including soldierfishes, are world-class dispersers.

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Resistance to tetrodotoxin in garter snakes from Santa Lucia Preserve, Monterey County, California

Garter snakes (*Thamnophis*) and newts (*Taricha*) are involved in arms-race coevolution around the phenotypic interface of toxicity and resistance. The common garter snake (*Thamnophis sirtalis*) and the aquatic garter snake (*Thamnophis atratus*) both show geographic variation in resistance to tetrodotoxin (produced by *Taricha*). Resistance differences are frequently large for sympatric species of snakes; this difference is apparent at several sites along the California coast. The Santa Lucia Preserve, Monterey Co., CA. however, is an exception. We see, at the Santa Lucia Preserve, extensive variation within sympatric populations of both *Thamnophis sirtalis* and *Thamnophis atratus*. The same variation in resistance, at this locality, raises questions about selection on both predator and prey species.

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Genetic structuring in morphologically diverse agamid lizards:  
Phylogeographic studies of the *Diporiphora australis* and *Amphibolurus nobbi* species complexes

Australian agamids (Amphibolurinae) form an adaptive radiation of 70 species covering continental Australia. Poor taxonomic resolution within and between genera is a significant problem in the Amphibolurinae, with many of the current genera, such as *Diporiphora*, representing artificial groupings of unrelated species. Many species within *Diporiphora* lack consistent morphologically diagnostic

characters, making it difficult to confidently identify species. In addition, *Diporiphora* contains a number of wide ranging species with highly variable morphologies, which are believed to be species complexes. Two species within *Diporiphora* are of particular interest because of their morphological diversity and extensive distributions in eastern Australia. *Diporiphora australis* and *Amphibolurus nobbi*, for which recent genetic work has shown are sister species, have overlapping distributions along virtually the full extent of eastern Australia – spanning more than 2000 kms across dramatic environmental gradients from wet tropical forests to shrubby deserts. The range of *D. australis* extends from northern Queensland, south to north coastal New South Wales (NSW), and is thought to be a species complex due to extreme morphological variation throughout its range. *A. nobbi* mirrors this range and extends through central and western NSW into northwestern parts of Victoria and mideastern parts of South Australia. This species is known to consist of two subspecies; *A. nobbi nobbi* with a range similar to that of *D. australis*, and *A. nobbi coggeri* which occupies the remainder of the species range. There has been some suggestion that these subspecies are in fact distinct species. We have undertaken a phylogeographic study of these species to resolve these taxonomic problems and determine the evolutionary patterns of morphological diversification across their distributions. We sampled individuals of both species approximately every 200km throughout their ranges and then sequenced <1350bp of mtDNA, including the complete protein coding gene ND2. We will discuss the species complex hypothesis, the significant genetic structuring within both species, and relevant biogeographic influences on the evolutionary history of each species.

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**EGGE, JACOB J. D.**

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**Solving a prickly problem: Venom gland structure and evolution in madtom catfishes (*Noturus*: Ictaluridae)**

Madtom catfishes, genus *Noturus*, are an easily recognized and important component of the North American ichthyofauna. They are best known for their diminutive size and well developed dorsal and pectoral spines. In all madtom species, the dorsal spine and both pectoral spines are surrounded by a venom gland. Among different species, dorsal spines vary in size, but are otherwise monomorphic. The pectoral spines, however, show a great deal of variation. Some species have recurved pectoral spines with multiple anterior and posterior serrations, while others have straight smooth spines completely lacking serrations. While much is known about the shape and size of the pectoral spines, almost nothing is known about their associated venom glands. I sectioned and stained paraffin embedded pectoral spines from several madtom species representing all major *Noturus* lineages to examine their venom glands and determine if there is a relationship between venom gland structure and pectoral spine shape. Results demonstrate that both the size and shape of the venom gland vary between species with different pectoral spine morphologies, indicating that multiple different venom delivery systems have evolved within

*Noturus*. These results will be discussed with reference to *Noturus* phylogeny and other ictalurid taxa.

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**\*EIMERMACHER, THOMAS G.; BROADLEY, DONALD G.; CROTHER, BRIAN I.**

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Phylogenetic relationships of dispholidini (Serpents: Colubridae)

The Dispholidini are a clade of African colubrids that contain five genera of venomous rear-fanged colubrids, at least several of which are known to be of medical importance. The phylogenetic relationships of this group have not been investigated, and may reveal both new and synonymous taxa. We are using both molecular and morphological data for phylogenetic analysis, utilizing members of the genus *Philothamnus* as outgroups. Presented here will be the results from the external morphological data, composed of 16 characters taken from 1417 individuals across 12 species. The data were analyzed using a frequency coding approach and the gap weighting method.

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The biology of smalleyed ray *Raja microocellata* in the Bristol Channel

Smalleyed ray *Raja microocellata* has a restricted distribution in north-western Europe, though is locally abundant in sandy bays. The Bristol Channel is an area where it is relatively abundant, and it is the second most important rajid in this area, accounting for 34.9% (by numbers) and 37.8% (by biomass) of the rajid assemblage. Juvenile fish ranging from 160-320 mm length are abundant in intertidal areas and, during the summer, grow at a rate of 0.91mm.d<sup>-1</sup> (0.98g.d<sup>-1</sup>). Larger fish occur further from shore and the overall sex ratio in this area is 1:1. Data on the morphology, dentition, distribution and reproductive biology are provided. The diet is composed primarily of Crangon crangon, mysids, teleosts and amphipods.

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### Distribution and abundance of a melanistic variant within the *Plethodon glutinosus* complex

While performing field surveys, we observed a melanistic morph within the *Plethodon glutinosus* complex from South Carolina. Discrete color morphs are commonly observed in *Plethodon cinereus* and we have observed occasional melanistic individuals within other populations of the *P. glutinosus* complex. The population we observed in South Carolina is unique in that it contained a relatively high percentage of melanistic individuals (20 percent, n=56) in comparison to a population from Pennsylvania (2.5 percent, n=41). There have been isolated reports of this melanistic morph in the literature for the last 150 years but detailed information has been lacking. We decided to re-visit these historical sites and to conduct a more thorough survey of the distribution and abundance of this melanistic variant. The melanistic variant has some morphological differences between it and its sympatric forms. It also occurs in the ranges of at least 2 species of the *Plethodon glutinosus* complex. The morphological differences and its distribution suggest that it should be given additional attention in light of the many sibling species found within this complex of eastern plethodontid salamanders.

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### Genetic structure of *Graptemys gibbonsi* in the Pearl and Pascagoula Rivers

*Graptemys pulchra* (*sensu lato*) was originally described as inhabiting coastal rivers of the Gulf of Mexico ranging from the Pearl River drainage in Louisiana to the Yellow River in Florida and south Alabama. However, based on morphological data, *G. pulchra* has been split into three distinct species including two new species, *G. gibbonsi* and *G. ernsti*. Mitochondrial DNA sequence data later validated the split and the newly described species. Also, the molecular data supported the recognition of a *G. pulchra* clade including *G. pulchra*, *G. barbouri*, *G. ernsti*, and *G. gibbonsi*. The species' distributions within this clade are drainage-specific with the exception of *Graptemys gibbonsi*, which is found in two rivers, the Pearl and Pascagoula. Interestingly, the sister species *G. oculifera* and *G. flavimaculata* are endemic to the Pearl and Pascagoula rivers respectively. *Graptemys gibbonsi* populations in the Pearl and Pascagoula rivers likely experienced the same evolutionary events that led to the speciation of *G. oculifera* and *G. flavimaculata*. This poster presents some preliminary findings attempting to clarify the evolutionary history of *G. gibbonsi*. Using 15 microsatellite loci developed for other species of turtles, we examined the amount and pattern of intra- and interdrainage genetic variation of *G. gibbonsi* populations in

the Pearl and Pascagoula Rivers. These findings have management and systematic implications for this species and other in the *Graptemys* genus.

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Population viability analysis and response to habitat change in the spotted turtle (*Clemmys guttata*)

The spotted turtle (*Clemmys guttata*) is listed as endangered in Canada and as vulnerable by IUCN. Our project will address two aspects of spotted turtle conservation; changes in behaviour and population demography following habitat change, and population viability. Alteration of a breeding aggregation pond by a beaver occurred in recent years at a long-term study site. Following this habitat alteration, the use of the pond by spotted turtles during spring breeding decreased and eventually ceased. Potential changes in behaviour and fecundity of spotted turtles following the habitat alteration will be examined. Preliminary results suggest that at least some turtles have moved to alternate breeding sites. Demographic data from the long-term site will be used to develop population models. The models will allow estimation of extinction risk for this, and possibly other, populations of spotted turtles, and will provide insight into the relative efficacy of various conservation strategies for this declining species.

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Systematics of *Desmognathus* in the mountain and Piedmont regions of Virginia and North Carolina, USA

We analyzed cytochrome b nucleotide sequences, nuclear allozyme markers, and morphometric characters to investigate species boundaries and phylogenetic relationships among dusky salamanders (*Desmognathus*) in the southern Blue Ridge and adjacent Piedmont Physiographic Provinces of Virginia and North Carolina. Our results revealed four distinct mtDNA clades which are also characterized by distinct allozyme markers. One clade consists of sequences derived from populations distributed from New England to southwestern Virginia that are referable to *Desmognathus fuscus* Rafinesque. A second clade consists of sequences derived from populations referable to *Desmognathus planiceps* Newman, which we resurrect from synonymy under *D. fuscus*. *D. planiceps* and *D. fuscus* are distinguishable using discriminant function analyses of 26 morphometric characters and differ in mandibular tooth shape. Two other sequences recovered from populations along the Blue Ridge escarpment in southern Virginia are quite divergent from those of the previous two clades, and these populations may represent yet another distinct species. Sequences from a population in the Brushy Mountains in the Piedmont of

northern North Carolina are similar to those of *D. carolinensis*.

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**ERISMAN, BRAD E.**

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Unusual sexual and spawning patterns in the leopard grouper, *Mycteroperca rosacea*, from the Gulf of California

Epinepheline serranids (groupers) are diverse with respect to their reproductive patterns, although several consistent trends have been identified in studied species. Groupers that form spawning aggregations typically spawn in rhythm with the lunar cycle at specific sites, exhibit dusk spawning, are solitary during non-reproductive periods and are protogynous hermaphrodites. We studied the reproductive behavior and sexual pattern of the leopard grouper, *Mycteroperca rosacea*, in the central Gulf of California from 1999-2005. Similar to other aggregating groupers, adults formed site-specific breeding aggregations of several hundred individuals. Spawning occurred from 2 hours before sunset until dark within groups of seven to >100 individuals. Several reproductive patterns observed in leopard groupers are uncommon or unknown in other aggregating groupers. First, *M. rosacea* spawning aggregations persisted throughout the spawning season, and spawning occurred daily with no relationship to the lunar cycle. Second, adults formed small to large aggregations throughout the year. Third, histological, population, and behavioral characteristics indicate that leopard groupers are functional gonochores, a characteristic known only in one other grouper species. The lack of a lunar signal in the temporal spawning patterns of *M. rosacea* may be a consequence of high gene flow within the physically and biologically heterogeneous Gulf of California. Persistent, non-spawning aggregations are apparently associated with the feeding behavior of this species. Lastly, the social system of *M. rosacea* likely contributed to the evolution of gonochorism from protogynous hermaphroditism.

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Artisanal marine fisheries in Sinaloa coast: Regional management

Sinaloa state is the most important coast in Mexico for artisanal fisheries, because there is the high number of fishermen and boats, as the incrementing fish species catches and recognized social organizations in the Pacific coast. We made a comparative analysis in two zones (North-center and South) between the specific fish composition and their zoogeographic affinities, the historical catches, seasonal coastal

resources and trade. The main focus has been know, if the biological and socioeconomic differences exist between the north-south region and then, if will be necessary give a particular management measures for each one. The fieldwork was made in Santa Maria la Reforma bay in February and July-August, 1999, and in the Mazatlan, Piaxtla y Teacapan area, during 2002 and 2003. It was included a fishes list published where were identified 53 marine fish species, that were registered in the 24 commercial names of the State fishery office (2003); next six groups lisa, sierra, chihuil, botete, mojarra, and pargos summarize the 80% of total catches, but also, it was founded that 170 fish species were in the geographical area and they are target species. It was included sharks (30 spp), rays (17 spp) and bones (123 sp). The biologic and geographic criteria were indicated two zones along the coast: some species showed geographic north-center and south limits. *Scomberomorus concolor* , *S. sierra* and *Squatina californica* - *Gymnura crebripunctata*, *G. marmorata* and *Brotula clarkae*.

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Aggregation in Andean anurans: Why do high-elevation toads group?

Aggregation has been studied in a variety of animals and found to have important social, ecological, and physiological benefits. Amphibians commonly aggregate during the breeding season to attract or secure mates, but some also group for physiological reasons like reducing water loss or increasing heat gain. We recorded the conditions associated with aggregation in a high-elevation (>4300 m) population of recently metamorphosed Andean toads (*Bufo spinulosus*) in an attempt to identify the benefit(s) achieved from grouping. The population we studied occupies a reach of the Río Cobres (Salta, Argentina) with numerous small hot springs (to >55 °C), which heated the river water 15 °C or more above sections lacking thermal seeps. Metamorphic toads aggregated only on land and when exposed to relatively unobscured solar radiation. Few aggregations were recorded when the sun was low on the horizon (early morning or near sunset) and aggregating toads dispersed when dense clouds moved overhead or when they were experimentally shaded. Under relatively unobstructed solar exposure, juvenile *Bufo spinulosus* raised their body temperature an average of 2.3 °C higher when in groups than when alone. Toads were always found within 1 m (usually <10 cm) from the river, and body sizes did not differ between solitary individuals and those found in groups suggesting that aggregating is not imposed by a need for reducing evaporative water loss. Our results indicate that aggregation by metamorphic Andean toads provides thermal benefits, which should translate into faster rates of growth. However, other hypotheses (e.g., grouping for antipredator defense) require additional testing.

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### Testing developmental instability and genetic diversity as tools to assess environmental stress over frog populations

Amphibian population declines are suspected to be under course in threatened Brazilian biomes such as the Atlantic Forest and the Cerrado, nevertheless hypotheses about potential causes are at most speculative. High genetic diversity and developmental stability are expected to occur in healthy populations, so that a reduction in heterozygosity and/or an increase in fluctuating asymmetry may indicate that a population is undergoing some problem before declines occur and in time for some conservation strategy to be planned. We aimed to test the usefulness of both these parameters to infer the impacts suffered by Brazilian frog populations under several levels of human disturbance, which are inferred based on area covered by different human settlements/activities around the studied population using Geographic Information Systems. Population structure is also assessed, since migration patterns are important for the maintenance of genetic variability and may be disrupted by habitat fragmentation. The treefrog *Bokermannohyla saxicola* (Anura, Hylidae) is used as a model. By now, 27 adult individuals have been collected from five different localities and are being measured (radio-ulna and tibio-fibula) to assess developmental instability. Two microsatellite sites were located through library screening and used in a preliminary analysis of population structure and heterozygosity at the limits of the National Park of Serra do Cipó (Minas Gerais state), using 77 tadpoles from five sites. Additional microsatellites are being searched for in a genomic library built with 7,500 clones of *E. coli*. Preliminary results show high heterozygosity. The microsatellite markers revealed lack of pairwise genetic differentiation in spatially close populations and also in some distant ones, a pattern that may be caused by the combination of past event effects and limited migration ability contingent upon good habitat conditions for frog movement. Human settlement and related activities may be altering habitat conditions and can ultimately influence frog population structure.

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**EYTAN, RON I.**

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Metabolism and mutations: Contrasting levels of genetic differentiation in Caribbean reef fishes (Chaenopsidae: *Acanthemblemaria*)

Closely related species that share similar life histories are expected to have similar levels of genetic subdivision among populations. Exceptions will manifest as two different patterns with different causal mechanisms. If one species shares more alleles among populations than the other, interspecific differences in dispersal capability or degree of ecological specialization could be responsible. If species have the same propensity to share alleles between populations but the genetic distances among alleles are greater for one species than the other, mutation rates may differ between species. This pattern is predicted by recent theory for species that differ in their metabolic rates. I am comparing ecological and genetic differentiation in two closely related species of coral reef fishes, tube blennies in the genus *Acanthemblemaria* with different metabolic rates. *A. spinosa* and *A. aspera* both live in empty invertebrate holes and co-occur over a large part of their ranges in the tropical Western Atlantic. They share the same mating system and pelagic larval duration, but differ in degree of ecological specialization. Both prefer holes with high vertical profiles. *A. spinosa* populations go locally extinct when this habitat is destroyed, but *A. aspera* can persist in sub-optimal microhabitats. *A. spinosa* consistently out-competes *A. aspera* for these holes where they co-occur. This may result from *A. spinosa*'s metabolic rate, which is significantly higher than *A. aspera*'s. Ecological and physiological differences coincide with differences in levels of genetic subdivision between populations. While both species rarely share mitochondrial *cytb* alleles among populations (corrected  $F_{ST} = 1.0$ ), the genetic distance between alleles is over 10-times greater within *A. spinosa* than *A. aspera*, a pattern found in both *cytb* and nuclear *-tropomyosin*. These results support the hypothesis that metabolic differences and their effect on rates of molecular evolution are responsible for contrasting levels of genetic differentiation in these fishes.

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Chromosomes of Nurseryfish *Kurtus gulliveri* (Kurtidae: Perciformes)

The perciform family Kurtidae is composed of two species: *Kurtus indicus* occurs from India to Borneo, and the nurseryfish, *Kurtus gulliveri*, occurs in coastal rivers of northern Australia and southern New Guinea. This latter species is remarkable for its unique method of egg brooding. Male nurseryfish carry the eggs on a supraoccipital hook. Its life history has been under study since 2001. Preliminary molecular data

suggest that *Kurtus* may be close to the Apogonidae. We studied the chromosomes of *Kurtus gulliveri* in order to describe its karyotype and investigate its ploidy and sex chromosome status. We determined a modal diploid chromosome number  $2n=44$  in both sexes of *K. gulliveri*. The chromosomes are very small (the largest pair is approximately 4 microns while the smallest pair is only 0.5 microns), and only the largest three pairs are distinguishable morphologically. The largest chromosome pair is submetacentric while the rest are telocentric. Reverse fluorescent staining (Chromomycin A3 and DAPI) identifies a male-specific heterochromatic element in some cells, indicating male heterogamety (XX/XY) in this species. Further investigation, involving advanced molecular cytogenetic techniques such as CGH is required to confirm the sex chromosomal system in this species.

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**\*EZCURRA, JUAN M.; O'SULLIVAN, JOHN B.; MOLLET, HENRY F.**

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#### Captive feeding and growth of a juvenile white shark, *Carcharodon carcharias*, at the Monterey Bay Aquarium

The Monterey Bay Aquarium conducted a three year program with the support of colleagues from the Hopkins Marine Station of Stanford University, the Shark Lab at California State University at Long Beach and the Southern California Marine Institute to display a live white shark, *Carcharodon carcharias*. This program culminated in the display of a juvenile white shark in the 1.2 million gallon Outer Bay exhibit for 198 days, during which time attendance at the aquarium increased 34%. The Outer Bay exhibit displays a variety pelagic fishes such as yellowfin tuna, *Thunnus albacares*, Pacific bluefin tuna, *Thunnus orientalis*, and scalloped hammerhead sharks, *Sphyrna lewini*. This exhibit is 27.5 m long, 16.0 m wide, 10.7 m deep and maintained at 20 degrees C. During this time the white shark was fed mostly king salmon, *Onchorhynchus tshawytscha*, and Pacific mackerel, *Scomber japonica*, at a mean daily ration of 747 grams  $\pm$  558 (S.D.) or 1.6 % body mass per day  $\pm$  1.4 (S.D.). The initial mass of the white shark on September 14, 2004 was 28.0 kg and total length was 151 cm (over the curve); the final mass on March 31, 2005 was 73.4 kg and total length was 194 cm. The captive white shark gained a total of 45.4 kg for a gross conversion of 30.9 % and grew at an annual rate of 79.3 cm/yr, which is over two times faster than the estimated growth in the wild.

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**\*FABER, JOSEPH E.; RYBKA, JENNIFER M.; WHITE, MATTHEW M.**

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### Phylogeography of the stonecat madtom *Noturus flavus*

Evolutionary relationships of populations of the stonecat madtom *Noturus flavus* were analyzed using mitochondrial DNA control region sequences. Distributions of phenotypic variability predict that genetically divergent populations will be found within the large geographic range of this species. Samples were obtained for populations from eleven drainages and for the outgroup species *Noturus gyrinus*. Partial sequences of the control region identified six haplotypes, with pairwise sequence divergence ranging from 0.2% to 4.8%. Highly divergent haplotypes were identified in the Cumberland and the Tennessee River drainages, suggesting long-term geographic isolation of these populations. Low levels of genetic divergence throughout the Mississippi River and Great Lakes drainages suggest a recent and widespread range expansion. The relationship between genetic divergence and morphological variability is discussed.

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**\*FAIZI, HIWA; RASTEGAR-POUYANI, N.**

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### Geographic variation in skull morphology of Iranian Scincid lizards, *Trachylepis aurata transcaucasica* (Reptilia: Scincidae)

The *Trachylepis* Fitzinger 1843, of Iranian Scincid lizards is currently identified by three taxa: *Trachylepis aurata transcaucasica* from northern to central parts of Zagros Mountains, western Iranian plateau, *Trachylepis septemtaeniata*, from southern Zagros Mountains. and *Trachylepis vittatus* from Western Zagros Mountains. We examined a total of 36 dry skull specimens of the Iranian *Trachylepis aurata transcaucasica* to investigation of geographic variation based on morphology in skull characters from four distinct localities in the western Iranian plateau, W. Azarbaijan (9 specimens), Kurdistan (9 specimens), Kermanshah (9 specimens), Lorestan (9 specimens) provinces. Information obtained from 36 specimens has been used to demonstrate geographic variation in this taxon. Post-ANOVA pair wise analysis (Tukey test) and three multivariate analyses includes Principal Component Analysis (PCA), Canonical Variate Analysis (CVA) and Cluster analysis of these populations based on 30 morphometric and 6 ratios cranial and dental characteristics across all groups verified significant differences in some important characters includes: Angle of snout, Skull length, Condylbasal length, Posterior width of rostrum, Jugal length, Nasal length, Quadrat length, Sphenoid length, Lower jaw length, and Coronoid high. And also some characters have a clinal variation from North toward South of its distribution. Canonical variate analysis based on used characters confirm that the Kurdistan population tends to differ from the other three populations. These

differences were more clear between Kurdistan and Lorestan specimens. Collectively, each population exhibits approximately the different level of morphological distinctiveness; 88.9% W.Azarbaijan, 100% Kurdistan, 77.8% Kermanshah, and 55.6% Lorestan were assigned to the correct a priori group by classification result in canonical variate analysis. Taxonomy and biogeography of the genus *Trachylepis* are briefly discussed.

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Further studies on the lizards cranial osteology, based on a comparative study of the skull in *Trachylepis aurata transcaucasica* and *Laudakia nupta* (Squamata: Sauria)

In the present paper, the skull roof, palate, braincase, lower jaw and dentition of the skull of the adult *Trachylepis aurata transcaucasica* have been described and compared with those of the skull in *Laudakia nupta*. Patterns of diversity between lizard skulls in two species were studied from a morphological and functional perspective. We provide a detailed description of the cranial osteology, lower jaw and dentition of two distinct species in two different families including *Trachylepis aurata transcaucasica* (Scincidae) and *Laudakia nupta* (Agamidae), based on 10 dry skull preparation. We showed detailed descriptions of all bones as well as the overall architecture of the skull. Individual variation within each of these two species is discussed and compared together. The greatest interspecific variation was observed in features that vary taxonomically including thickness of the individual bones, degree of elongation or expansion of processes, form and type of dentition and lower jaw, the status of temporal fenestra, differences in basioccipital, and especially in palatal and associated structures.

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**\*FAMILIAR-LOPEZ, MARIEL; SANTOS-BARRERA, GEORGINA;  
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Climatologically, geographical and altitudinal analysis of Mexican amphibians, related with emerging infection disease *Batrachochytrium dendrobatidis*

Dramatic amphibian populations declines have been occurring worldwide, with main causes reported including habitat loss, climate change, introduction of exotic species, chemical contamination, the interaction of all these and more recently, the presence of the chytrid fungal disease caused by (Bd). Recent reports suggest that climate change is likely to be a key factor in amphibian declines, by encouraging

outbreaks of certain pathogens like Bd. Mexico holds a great diversity of amphibians (361 species), 62% of them endemic and some other declining. In this study we conduct a climatologically, geographical and altitudinal analysis, in order to relate the presence of Bd in Mexican amphibian populations and the climatological factors that determine the susceptibility of the species to the infection. We performed an altitudinal analysis of Mexican amphibians distribution, and applying climatic modeling, using temperature data obtained from 3500 Mexican meteorological stations, to describe tendencies or patterns of the disease to identify critical areas and species. We suggest that main susceptible habitats are the Mexican humid mountain forests. Altitudinal intervals for Mexican amphibians are concentrated into the, 1001-1500m (152), and 1501-2000 (146) intervals of altitude. We identified 80% of Mexican amphibians with a distribution range from 1000-2000m, that can correspond with Bd distribution reported (1000-1800m). In addition, 79 of these species are included in the Global Amphibian Assessment (GAA) as endangered or critically endangered species, therefore these are the priority species to work with. The data compiled till now for the presence of Bd in Mexican states is not enough so far to suggest a clear tendency for geographical distribution of the disease, however more information is being compiled to depict a pattern of the infection in Mexico. The results generated by this study will offer a better knowledge to plan management strategies for conservation of Mexican amphibians.

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#### Taxonomy review of the Sawfish (Chondrichthyes, Pristidae)

Sawfishes are among the most endangered elasmobranch species. But conservation measures have been hampered due to the unsettled situation of the taxonomy of this group. The goals of this study were to answer the three primary and urgent questions about sawfish taxonomy. Question 1: How many species (real entities) exist? To answer this question we examined external morphology (morphometric and meristic characters) of specimens deposited in 14 public museums located in the USA, Brazil and five European countries. In addition, molecular evidence was investigated by sequencing a partial mitochondrial gene from representative museum specimens and four mitochondrial and three nuclear genes from specimens directly sampled in the field. Question 2: What is the distribution range of each one of these entities? Information was gathered from identification of museum specimens, review of museum and literature records, archaeological remains and anthropological artifacts. Question 3: What are the most appropriate names (available nominal species) to be assigned to each one of these entities? In order to answer this question we reviewed original descriptions and examined historical specimens deposited in collections. The obtained results will be discussed in the context of a formal proposal about valid sawfish species.

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**\*FELDMAN, CHRIS R.; PFRENDER, MICHAEL E.; BRODIE, EDMUND**

**D., III; BRODIE, EDMUND D., JR.**

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Is there more than one way to skin a newt? Parallel evolution in the newt-garter snake coevolutionary system

The interaction between toxic newt prey and resistant predatory garter snakes has provided a model system for the study of predator-prey coevolution. Until now, this system has involved only two species, *Thamnophis sirtalis* and *Taricha granulosa*. Here, we present information documenting parallel arms races involving novel garter snake and newt species pairs. We show that *T. couchii* and *T. elegans* in the Sierra Nevada range are resistant to the neurotoxin produced by *Taricha* (TTX) at levels seen in sympatric populations of *T. torosa*. Additionally, populations of *T. atratus* along a portion of the central California coast are highly resistant to TTX. We then examine the genetic underpinnings of elevated TTX resistance across *Thamnophis* species to determine whether elevated resistance to TTX in *T. atratus*, *T. couchii*, *T. elegans* and *T. sirtalis* has evolved independently multiple times. Our data allow us to address notions of phylogenetic and phenotypic constraints on coevolution, and answer the question, is there more than one way to skin a newt?

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Is there a relationship between the steroid hormone progesterone and egg case production/dynamics in oviparous elasmobranchs?

In most mammalian vertebrates, progesterone ( $P_4$ ) is known as the hormone of pregnancy. Not only does it regulate reproductive cycles and fertility, but it also inhibits uterine contractions, thickens cervical mucus, and builds the endometrium. However, the role of this hormone in non-mammalian vertebrates is not well understood. In oviparous elasmobranch fishes, for example, past research suggested that this hormone may be involved with egg case formation and/or oviposition in the little skate and the winter skate. In the current study, we examined whether such a relationship between  $P_4$  and egg case production/dynamics exists in the smooth skate, *Malacoraja senta*, a small oviparous elasmobranch that inhabits the shores of the western north Atlantic. Gross morphology and reproductive status were noted for mature females. In addition, plasma samples were extracted before  $P_4$  concentrations were determined by radioimmunoassay. When the profile of plasma  $P_4$  was plotted over a 12-month period, a trend was observed whereby high concentrations of  $P_4$  were observed in the months that preceded sampling of females with egg cases. However, when  $P_4$  concentrations in females with egg cases were compared to those

without egg cases, our preliminary analysis indicated that mature females without egg cases may have higher P<sub>4</sub> concentrations than females with egg cases. Being incomplete, the present results await further analysis before we can determine whether P<sub>4</sub> has a possible relationship to egg case production/dynamics during the reproductive cycle of the female smooth skate.

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Taxonomic revision of the genus *Knodus* Eigenmann, 1911 (Characiformes, Characidae)

*Knodus* was proposed originally by Eigenmann (1911) to include *K. meridae*, described from Merida, Venezuela. *Knodus* species are small sized, not usually surpassing 70 mm of standard length, present two series of pre-maxillary teeth, (the internal hemi-series with four teeth), a dorsal fin with two unramified rays followed by eight ramified rays, and scales partially covering the caudal fin. They are distributed in some of the main hydrographic basins of South America: Amazon, Parana-Paraguay and Tocantins. The validity of the genus is debatable, with some specialists considering *Knodus* as a possible junior synonym of *Bryconamericus*. In addition, *Knodus* is a genus Incertae sedis within Characidae. For this study, 17 morphometrics and 15 meristics characters were taken of each studied specimen. The most important features for the diagnoses of the species are: body height, diameter of the eye, number of teeth in the maxillary bone, number of rays in the anal fin, number of perforated scales in the lateral line, and number of scales above and below the lateral line. Of the 18 nominal species of *Knodus*, 16 are recognized as valid. The geographical distribution of *Knodus* is shown to be wider than that previously registered. In addition, three new species were discovered during the course of this study.

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Interspecific interactions between marine mammals and sea turtles

The National Marine Fisheries Service conducted an aerial survey during July-August 2004 from Ft. Myers, Florida to Atlantic City, New Jersey, to estimate distribution and abundance of bottlenose dolphins on the continental shelf. On several occasions, the senior author observed bottlenose and Atlantic spotted dolphins harassing loggerhead sea turtles. The dolphins chased the turtles, tossed them out of the water, and pushed the turtles underwater with their rostrums

(beaks). These observations led us to the question of how frequent and to what extent these types of interactions occur, both in the wild and in captivity. To address this question, we conducted a preliminary review of the interactions of marine mammals with sea turtles in the wild and in captivity. We located reports of interactions between 10 cetacean (whale/dolphin), 4 pinniped (seal/sea lion), and 1 sirenian (dugong) species with 7 sea turtle species. Very often, there was no observed interaction between marine mammals and nearby sea turtles. Reported interactions include dolphins apparently feeding on fish hiding under turtles, as well as potentially mischievous and aggressive (e.g., harassment) encounters by cetaceans and pinnipeds. These interactions include physically moving turtles across tanks in captivity; chasing and poking at turtles; attempting to flip sea turtles onto their backs; grabbing the turtle's flippers; pushing turtles underwater with their rostrums; and even tossing turtles high out of the water or onto sandy beaches. Instances were noted of a sea turtle being crushed to death by a pinniped rolling on top of them, while hauled-out. Attempted and successful predation attempts by both cetaceans and pinnipeds were also documented. Reported free-ranging interactions came from a variety of locations including Australia, New Zealand, French Polynesia, Hawai'i, Panama, Mexico, the Gulf of Mexico, Brazil, the Azores, and the Mediterranean.

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**\*FLUKER, BROOK L.; PEZOLD, FRANK; MINTON, RUSSELL L.**

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### Molecular systematics and morphological variation of the inland silverside, *Menidia beryllina*

Previous studies explain the extensive morphological variation of *M. beryllina* from the lower Mississippi Valley in conflicting ways. One explanation is ecophenotypic plasticity of a single species (*M. beryllina*), while another attributes this variation to two parapatric species occupying estuarine and fresh water habitats (*M. beryllina* and *M. audens*, respectively). Similarly, morphological analysis of lower Mississippi Valley *Menidia* populations within the present study revealed extensive morphological variation that is open to multiple interpretations. To test the validity of *M. audens* and to assess the genetic relationships among population samples of both putative species, partial sequences of the mitochondrial control region (d-loop) and cytochrome *b* gene were obtained for 80 individuals of each morphotype (40 *M. audens* and 40 *M. beryllina*). Phylogenetic analysis of composite mtDNA sequences did not support the monophyly of *M. audens*. *Menidia audens* and *M. beryllina* together formed a single well supported clade, though relationships within the *M. audens*/*M. beryllina* clade were highly unresolved. Additionally, low levels of mtDNA sequence divergence were found between *M. audens* and *M. beryllina*. The phylogenetic relationships of *M. audens* and *M. beryllina* will be discussed in addition to preliminary results of population genetic structuring of freshwater and estuarine populations of *M. beryllina*.

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### Host-parasite relationships of the roundworm *Camallanus cotti* and its fish hosts in Hawaiian streams

Exotic fishes, mainly poeciliids, introduced the roundworm *Camallanus cotti* into Hawaiian streams where the parasite is now considered a conservation threat to native fish hosts. Four of the five amphidromous gobioids as well as aholehole, *Kuhlia xenura* in Hawaiian streams are susceptible to infection. We have determined that the free-living first juvenile stage of *C. cotti* can tolerate salinities greater than 23 ppt but marine fishes were not infected. Several species of near shore coral reef fishes harbored specimens of a close relative, *Spirocamallanus istiblenni* and native sleepers, oopu akupa, *Eleotris sandwicensis*, inhabiting stream mouths were hosts to both camallanids. In the laboratory, we could complete the life cycle of *C. cotti* indirectly by feeding fish infected copepods harboring third stage juveniles, but could not complete the life cycle directly by exposing fish to first stage juveniles. We determined that oopu naniha, *Sicyopterus stimpsoni*, the only gobioid that did not harbor *C. cotti* infections, did not include copepods in its diet. In Hakalau Stream, oopu alamoo, *Lentipes concolor*, was uninfected when it reached headwaters of the stream, but acquired infections after arriving at this site, even though infected poeciliids were not present there. We studied parasite-induced host mortality by infecting fishes in the laboratory with *C. cotti* and demonstrated that both juvenile and adult parasites are able to kill their fish hosts. Histopathological examination of both naturally and experimentally infected fishes revealed that the sclerotized mouthparts of the roundworms slash intestinal mucosa and the parasites feed on both host tissue and blood. (Funded by State of Hawaii, Division of Aquatic Resources.)

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### Phylogeography, niche modeling and microsatellites variation in California Ringneck Snakes (*Diadophis punctatus*)

The ringneck snake (*Diadophis punctatus*) is a common yet secretive snake that ranges through out most of California, absent only from large portion of the Central Valley, high mountains and regions east of the Sierra-Cascade Crest. These long-lived snakes occupy a variety of ecological habitats and have a low vagility. Previous

morphological studies have used scutellation patterns, body size and color patterns combined with geographic range to recognize seven subspecies. Our combined analyses of two mitochondrial genes inferred three lineages from throughout California. The two northern clades are separated by the Sacramento and San Joaquin with a third clade restricted to south of the Los Angeles Mountains. Analyzing multiple mitochondrial genes has allowed us to identify the geographic barriers separating these lineages and to test if these barriers are affecting the geographic and evolutionary history of these lineages. The purpose of this study is to use available data to model the ecological niche of each lineage in order to identify the specific ecological factors that underlie their inability to cross the geographic barriers and to identify the environmental factors that predict the distribution and limits to the geographic range. A second step is the incorporation of microsatellite data to examine gene flow within and between lineages, estimate effective population size and assess demographic history of each lineage. This multi-model approach will provide a better understanding of the representative biodiversity, conservational status and evolutionary history of *D. punctatus* throughout California.

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**\*FONTENOT, CLIFFORD L.; LUTTERSCHMIDT, WILLIAM I.; CROTHER, BRIAN I.**

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Snake assemblage comparison between two surveys done 13 years apart in southeast Louisiana

Highway 51 in Southeast Louisiana represents a 37 km transect along a 5 km-wide strip of land between Lakes Maurepas and Pontchartrain. This area borders both the Joyce and Manchac Wildlife Management areas and contains a species-rich herpetofauna that is known only from a species list published in 1989. Once a Cypress-Tupelo swamp, most of the area has been converted to brackish marsh, degraded by deforestation, subsidence, saltwater intrusion, canal dredging, roadways, and introduced species. To document the herpetofaunal composition (focussing on snakes), road mortality, and changes over time, road surveys were conducted along the 37 km section of Highway 51 from Ponchatoula to LaPlace, LA and back. Surveys were done every third night for one year from 1 September 1990 through 1 September 1991, and again 13 years later from 1 September 2003 through 1 September 2004. Species lists, relative abundance, and habitat correlation are presented, and the 1990 and 2003 data sets are compared for differences in snake assemblage composition. Preliminary analyses also show distinct species differences in occurrence on the road, as well as condition (dead vs alive).

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Oophagy as an anti-pathogenic strategy by a brooding salamander  
*Desmognathus fuscus* (Rafinesque)

Female dusky salamanders remain with their eggs from oviposition until hatching (40-60 days). Clutch survivorship is markedly increased when the female is present, and unattended clutches rapidly succumb to predation, fungal infestation or desiccation. Our research focuses on the role of the female in preventing fungal infestation of her eggs. To document that fungi are more likely to infect clutches in which one or more eggs have died, we split clutches and isolated them in the field. One half of each split-clutch received a killed egg, the other half served as a control. The half clutches containing the killed egg were infested more rapidly than the controls. When an egg dies, females typically remove it from the clutch by practicing oöphagy (egg eating). To confirm the adaptive significance of this behavior in preventing fungal infestation, we inoculated the clutches of 20 females with a dead egg rolled in a petri dish supporting a fungal mycelium. Half of the females were prevented from eating their eggs by suturing their mouth closed. The others females were sham treated but able to consume the dead egg, whereas the controls received a sham treatment (a suture through the lower jaw). All control females consumed the dead egg and their clutches remained free of fungal infestation. Experimental females could not practice oöphagy and 78% experienced clutch infestation within 10 days. We conclude that oöphagy has been selected as a primary anti-pathogenic strategy in the dusky salamander.

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**FORTNER, ALLISON M.**

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Density-dependent effects on growth and reproduction of the orangethroat darter, *Etheostoma spectabile* (Pisces: Percidae)

Density dependence is an important factor structuring biological systems and can affect various aspects of an organism's life history. The orangethroat darter, *Etheostoma spectabile* (Percidae), occurs across the midwestern U.S., from tributaries of the Great Lakes, west to Nebraska, and south to gulf drainages in Texas, and usually inhabits shallow gravel riffles, runs, or pools of clear headwaters or creeks. I conducted an experiment to determine the effects of population density on growth rate and reproduction. Young-of-year orangethroat darters were housed in outdoor 190-liter riffle-like mesocosms for eight months at four densities. Length of fishes and evidence of reproductive maturity were recorded every two months. Darters in low-density treatments showed accelerated growth compared to those in high-density treatments, and a higher percentage of fish in low-density treatments reached sexual maturity. In addition, darters in low-density treatments were reproductive earlier in the season than in the high-density treatments and size at reproduction varied with

density. Since body size influences many aspects of reproduction in fishes, these results suggest that reproduction in *E. spectabile* is density-dependent.

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*Ranavirus* and *Batrachochytrium dendrobatidis* in endangered and diseased populations of the frog *Atelognathus patagonicus* in northern Patagonia, Argentina

*Atelognathus patagonicus* was once very abundant in the Laguna Blanca National Park (PNLB) area in northern Patagonia, Argentina. The species has been extirpated from Laguna Blanca itself, but the frog is found at high densities in surrounding smaller lakes within and outside of the park. All populations present clinical signs of disease. Clinical signs are found mostly in both late-stage tadpoles (e.g., hemorrhages in the tail, abdomen, back legs, and throat; swollen, edema in the body cavity; frequent excretion of bloody mucus from the vent; impaired swimming ability and proper buoyancy; labored respiration; frequent death upon capture) and recent metamorphs (e.g., intense redness of the venter, thighs, and abdomen; white blotches on the dorsum; edema on the throat; impaired locomotion; frequent death upon capture), but less commonly in adults. In both life forms, hemorrhages in various internal hematopoietic organs suggest a systemic infection. From previous collections of tissues from diseased frogs from four small lakes within PNLB, Fox et al. confirmed the widespread prevalence of ranaviral pathogen (APV) using PCR amplification of DNA. These are the first confirmed cases of ranaviral epizootics in South America associated with population die-offs. In addition, one sample (three pooled animals) from one lake tested positive for *B. dendrobatidis*. The clinical signs, which have reoccurred each year since at least 2001, are attributed to the ranavirus. Infection by *B. dendrobatidis*, which is only the second case reported in Argentina, may be non-pathogenic in this species. We now present the incidence of both pathogens as diagnosed from histopathology and PCR from a larger sample of animals collected from a wider set of lakes in and around PNLB.

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**FRANCIS, MALCOLM P.**

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**Habitat, movements and life history of the deepwater Antarctic starry skate, *Amblyraja georgiana***

Antarctic toothfish (*Dissostichus* spp.) are targeted by a longline fishery in 600-1500 m depth in the Ross Sea, Antarctica. Skates, mainly Antarctic starry skate *Amblyraja georgiana*, are an important bycatch of the fishery, comprising around 10% of the catch. In recent years, most skates have been released from the longlines at the surface on hauling, and many of these have been tagged. Recapture rates are low, but there have been some between-season recaptures, and moderate movements, showing that some skates survive capture and tagging from depths greater than 1000 m. The spatial and depth range of the starry skate are summarised using commercial and observer data. Starry skates mature at about 64 cm pelvic length (PL) for males and 66-69 cm PL for females. Length-frequency data indicate that a large proportion of the catch is immature. Vertebrae and caudal thorns were examined for their utility as ageing structures, and the latter were used to age specimens and generate growth curves. Although the age estimates are unvalidated, they suggest that starry skates grow rapidly, reaching sexual maturity at 6-7 years for males and 8-11 years for females. The oldest skate was 14 years, but this probably underestimates longevity.

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**Surface cruising and deep diving during ocean crossings by white sharks (*Carcharodon carcharias*)**

Until the advent of data-recording electronic tags, accurate information on the depth distribution of large marine animals was nearly impossible to obtain. This technology has opened an exciting new window into the vertical behaviour of white sharks. Through an international research collaboration, pop-up archival tags were attached to white sharks at the Chatham Islands, east of mainland New Zealand, in April 2005 and March 2006. Preliminary results indicate that the sharks spend nearly all of their time shallower than 100 m depth while patrolling near a seal colony over a period of 2-5 months. During trans-oceanic migrations of up to 3,000 km, their behaviour changes dramatically, with most of their time being spent in water shallower than 10 m (including a high proportion in the top 1 m), punctuated by periodic deep dives. This produces a strongly bimodal depth distribution, which is consistent with the behaviour shown by the two other migrating white sharks reported in the literature

to date. In some sharks, we observed diurnal variability in the diving behaviour. This vertical movement pattern, in combination with a migration from cool temperate waters to the tropics, results in the sharks experiencing a very wide range of ambient water temperatures. We present several hypotheses that might explain the observed patterns.

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Behavioral strategies of space use by young lemon sharks (*Negaprion brevirostris*) in their primary nursery areas

We studied a population of neonate and juvenile lemon sharks within two primary nursery areas at Bimini, Bahamas using both active and passive telemetry to answer questions about movement patterns and habitat selection. Between July 2002 and December 2005 we implanted transmitters in 66 neonate and juvenile lemon sharks; actively tracking 50 individuals and monitoring 16 using bottom mounted acoustic receivers. Ten individuals were tracked for longer than one year and one individual was monitored for the entire 3-year study. Research questions being investigated include: Do lemon sharks exhibit habitat selection within the primary nursery areas; do environmental factors affect the movements of juvenile sharks; are movements within the nursery correlated with areas of low predation risk and/or high prey availability; does time of day, season, age of shark, or site affect either activity patterns or habitat preference; is the shift from primary to secondary nursery area gradual or rapid? Answers to these questions will help define the role of nursery grounds as essential fish habitat (EFH) and provide information on the early life history and evolution of lemon sharks. Initial results suggest that juvenile lemon sharks have clearly defined home ranges which remain relatively restricted during the first 3 years of life. Preliminary analysis shows that sharks increase home range during the wet season and spend more time in rather low productivity nursery areas where predation risk is lower. As individuals approach 1 meter in length, space use begins to increase and sharks utilize previously unknown areas which may be facilitated because predation risk decreases as size increases to a critical length. Habitat selection in the primary nursery is apparently correlated with water depth, temperature, prey availability, and predation risk. These interrelated factors are the driving influence in habitat choice for neonate and juvenile lemon sharks.

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### Geographic analysis of pesticide exposure in salamander populations in the Great Smoky Mountains National Park

Pesticides are one of several environmental stressors likely to be involved in global amphibian declines. Numerous studies have demonstrated that very low levels of pesticides may have significant negative biological effects. Further concern has been raised by evidence for aerial transport by wind of pesticides over considerable distances from agricultural areas into pristine wilderness and preserved areas, including national parks. We investigated geographic patterns of pesticide residues in black-belly salamanders *Desmognathus quadramaculatus* (Plethodontidae) in the Great Smoky Mountains National Park (GSMNP). In 2001 we conducted a pilot study, collecting tail tissue from 2 sites (north and south of the eastern continental divide) near the western boundary of the GSMNP. At the northern site, the samples revealed detectable levels of DDT metabolites and the organophosphate chlorpyrifos. In 2003 we conducted a large-scale geographic analysis of pesticide residues in black-belly salamanders by collecting tail tissue from the same two sites and an additional 6 sites, forming two east-west transects on either side of the continental divide. We expected to find a residue gradient increasing towards the western side of the park, since prevailing winds are westerly. The results revealed measurable levels of numerous pesticide residues, including DDT and its metabolites, chlordane, heptachlor, endosulfan and atrazine. However the geographic pattern was highly heterogeneous and did not match our predictions. Our study indicates that amphibians within the GSMNP are being exposed to both historical and current use pesticides. These environmental stressors may therefore pose a significant risk to some amphibian species within the park. Further studies are required to identify and explain spatial and temporal patterns of pesticide deposition within the GSMNP, which is recognized as a critical hotspot for salamander diversity in the United States.

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### Population status of eastern hellbenders in southeast Tennessee

Eastern hellbenders *Cryptobranchus alleganiensis* (Cryptobranchidae) are the largest salamander in the United States. Recent studies indicate that they have suffered population declines over most of their range, including Tennessee. Much of the highest quality habitat for hellbenders in Tennessee is found in the Cherokee National Forest and Great Smoky Mountains National Park (GSMNP) in southeast

Tennessee. Using historical records as a starting point, we are mapping the current distribution of hellbenders in the Cherokee NF and GSMNP. When a population is identified, we are assessing the age structure and population viability, and investigating potential environmental stressors. We have identified just two rivers in which all size classes are represented, including gilled larvae (indicating current reproduction and recruitment). The hydrology and productivity differs considerably between the two rivers, and this appears to be reflected in population density (estimated by capture rate) and body length/cube root mass (body condition index). Gilled larvae exhibited some differences in habitat use compared to adults, being found under significantly smaller rocks. Preliminary tissue analyses revealed the presence of DDT metabolites and mercury residues; however the levels are very low, and unlikely to be biologically significant. We also found four additional rivers containing hellbenders, however population densities appear relatively low, and as yet there is no evidence of current reproduction. Our data confirm that hellbenders have declined across their historical range in southeast Tennessee. Likely causes include habitat fragmentation, siltation, and dam construction.

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**Life history parameters of Black Perch (*Embiotoca jacksoni*) within the southern California Bight**

Black perch (*Embiotoca jacksoni*) are a common reef fish associated with nearshore habitats along California with the majority of the population occurring within the southern California Bight. Black perch were collected monthly from January 2004 to January 2005 with a Hawaiian Slings, as by-catch from the Ocean Resources Enhancement and Hatchery Program (OREHP) for white seabass and as by-catch from power plant collections. Animals were collected throughout southern California from Santa Barbara to Carlsbad including Santa Catalina Island. Specimens were collected and processed to determine their physical characteristics, growth, sex ratio, periodicity of reproduction and gestation. Additionally, courtship observations were conducted on SCUBA along the King Harbor Breakwall in Redondo Beach, California from January 2004 to December 2005 to verify periodicity of courting and the associated behaviors. Specimens ranged from 75-215 mm standard length and from 18-487 g in total body weight. Six age classes were determined with the majority of the growth occurring between age class zero and one. The majority of specimens captured ranged from age class one to three. Pregnant individuals were recorded from December to May with the youngest pregnant female being age class one. Mature females ranged from 145 mm standard length (SL) carrying four embryos to 190 mm SL carrying 17 embryos. Mean monthly GSI for males peaked from July to November with the highest mean occurring in October (GSI = 1.47). Courtship behaviors were seen among aggregations and in pairs from July to November, with

the males being the primary aggressors. Courtship postures occurred along the bottom of the reef with pairs departing into caves for final copulation.

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#### Gene flow and population fragmentation analysis of the federally threatened Cherokee Darter

Stream alterations such as pipe culverts and small impoundments are common in the Etowah River system of northwest Georgia, but their potential impact as barriers to gene flow of small benthic fishes has not been investigated. In this study, we examine the effects of culverts, reservoirs, and other physical impoundments of varying ages and designs on the genetic structure of the federally threatened Cherokee Darter (*Etheostoma scotti*), endemic to the Etowah River system. Population samples were taken by fin clip collections at several locations both upstream and downstream of the physical barriers. Individuals were genotyped at five microsatellite loci, and statistical analyses, including heterozygosity, private alleles, and  $F_{ST}$ , were conducted. Little population structure was demonstrated between individuals collected upstream and downstream of the culverts being examined. However, using Fisher exact tests, the allelic frequency distributions were significantly different between the *E. scotti* populations located upstream and downstream of all three of the small reservoirs studied for two to four out of the five microsatellite loci.  $F_{ST}$  analyses did not reveal any significant population structure across stream barriers. The preliminary results of this study suggest that extreme physical barriers like small impoundments in place for approximately 50 years can fragment darter populations, causing genetic differences between populations upstream and downstream of these barriers.

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#### Genetic evaluation of the blueline snapper (*Lutjanus kasmira*) introduction to Hawaii

The shallow water snapper, *Lutjanus kasmira*, was introduced to the Hawaiian island of Oahu over 50 years ago from two source populations: the Marquesas and French Polynesia. Following their introduction, the snapper quickly spread across the archipelago culminating in a record from Midway Atoll in 1992, over 2000 kms from the point of introduction. Molecular analyses of the mtDNA control region and a nuclear growth hormone intron have shown that the two source populations are

genetically distinct. These genetic markers reveal that the descendents from both source populations are present throughout the archipelago and in similar ratios to that of their initial introductions (3.4:1), indicating similar reproductive success among the two lineages. Surprisingly we have found no loss of genetic diversity either during the initial introduction or during the subsequent spread and establishment of this species.

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### Longline hook selectivity in shark capture in the southern Gulf of California

Selectivity in the capture of sharks and large pelagic fish was determined in the form of hooks used on longlines. The research was done aboard shark ships off Mazatlan, Mexico for the benefit of shark fisheries management. Four different types of hook were used, all of the same size. The types were: straight hook, flat tuna hook, kirbed tuna hook, and circle hook. Sharks comprised 66% of the 567 pelagic fish that were caught: *Prionace glauca*, *Alopias pelagicus*, *Carcharhinus obscurus*, *Isurus oxyrinchus* and *Sphyrna zygaena*. The other 34% were associated species: *Makaira nigricans*, *Coryphaena hippurus*, *Dasyatis violacea*, *Tetrapturus audax*, *Xiphias gladius*, *Thunnus albacares*, and *Chelonia agassizi*. The average capture by set was 14.9 individuals. The circle hook had the highest capture efficiency (4.4 organisms/100 fishhooks). In the capture of shark-associated species, the flat tuna hook was less selective (72% sharks, 28% associate species). Size distribution was determined for two species: *Prionace glauca*, and *Makaira nigricans*. All four hook types were used for capturing these species, and there was high overlap among them, so there was little evidence to caught a determined predator size vs. hook type.

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### Use of reproductive value in the conservation and management of exploited shark populations

Certain life history traits of sharks make juveniles particularly vulnerable to exploitation. Reproductive value and reproductive potential are used to quantify the impacts of age specific removals via the harvest (directed or incidental). The Leslie matrix and a harvest matrix are used to compare the harvests of a long lived and short lived species. A new theorem in demographic analysis is presented. The theorem allows the estimation of population removals as a function of the fraction of reproductive potential removed by a harvest, instead by the instantaneous rate of

fishing mortality, F. Stochastic projections also associate risk of depletion with the fraction of reproductive potential removed. The bottom line: Conservation efforts should be focused upon preservation of reproductive potential.

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**\*GAMBLE, LLOYD R; MCGARIGAL, KEVIN; COMPTON, BRADLEY**

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### Isolated wetlands, connected populations: Lessons from marbled salamanders in southern New England

The spatio-temporal dynamics of amphibian populations and the models that describe them are largely influenced by the frequency of dispersal among breeding sites; however, dispersal has rarely been addressed rigorously in empirical studies. In a 7-year landscape-level investigation, we monitored breeding populations of marbled salamanders (*Ambystoma opacum*) among 14 wetlands in western Massachusetts to quantify dispersal rates, distances and the degree of natal site fidelity. Upon capture at drift fences, emerging juveniles at all ponds received cohort marks and adults were digitally photographed for individual identification using dorsal pattern analysis. We found that 9.0% of first-time breeders and 3.6% of experienced breeders dispersed to ponds different from their original capture ponds, representing movement distances between 50 and 1400 meters. This dispersal frequency suggested that significant genetic differentiation would be unlikely among breeding populations in our study area. However, returning individuals far outnumbered immigrants at all ponds, indicating that local variables (e.g., hydroperiod, reproductive success) were of primary importance in determining short-term population success. In addition, several breeding ponds remained uncolonized despite their proximity to established populations, potentially indicating some level of active habitat selection. We discuss these results and their implications for metapopulation dynamics and conservation in pond-breeding amphibians.

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### Geckos in the classroom: Using lizards to enhance the K-12 science curriculum

Science education is most effective when students are active participants in learning and can experience concrete examples related to abstract ideas and theories. We participated in the National Science Foundation funded GK12 program that teams graduate students in the sciences with K-12 teachers. The GK12 program is designed to help graduate students (1) learn to present their own research to a wider audience, (2) learn pedagogical methods from expert teachers, and (3) better understand the challenges and rewards of K-12 education. The program helps teachers, (1) develop

partnerships with university scientists, (2) gain science content, and (3) engage students in real scientific research. K-12 students (1) learn the process of science, (2) gain science content, and (3) see themselves as potential scientists. We provide specific examples of projects and lessons centered on lizards that were used to enhance the existing science curriculum at Galtier Elementary School in St. Paul, Minnesota. Projects included: the influence of diet on gecko growth rates, the relationship between gecko toe-pad structure and substrate, the structure and importance of pigment cells, and sound and communication.

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**GANSER, LISA R.**

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Sex differences in the hindbrain of *Xenopus laevis*

Sex differences in morphology and reproductive behavior in anurans are often easily defined. The neuroanatomical areas that govern these sexually different reproductive behaviors are not as easy to discern. In many anuran species, males will attract mates by calling. Though females are able to emit sound, most do not vocalize for the purpose of attracting a mate. In *Xenopus laevis*, laryngeal motor nuclei associated with mate calling are found in the caudal medulla of the hindbrain. Previous studies by Kelley (1988), Kelley et al. (2001), and Yamaguchi and Kelley (2000) identified these neuroanatomical sex differences in *X. laevis*. I treated larval *X. laevis* with atrazine to assess any effects on these hindbrain structures. I used several histological methods for nucleus identification and analysis including Cresyl Violet stain for light microscopy and fluorescent Nissl stain and the retrograde tracer, DiD, for confocal microscopy.

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**GARDINER, JAYNE M.**

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Multisensory guidance: The roles of olfaction, mechanoreception and vision in food localization behaviors of the smooth dogfish, *Mustelus canis*

Since turbulent dispersal causes many odor plumes to consist of chemical and mechanical (momentum) discontinuities, aquatic animals may localize the source of these odor plumes by simultaneous chemo- and mechanoreception: Eddy-chemotaxis. Benthic animals may also be able to determine the direction of flow using visual information, in a process known as visually-guided rheotaxis. The objective of this study was to examine the specific contributions of olfaction, mechanoreception, and vision to the food localization behaviors of a benthic shark, *Mustelus canis*. Two turbulent plumes were created in a flume: a) squid rinse and b) seawater. The sources of odor and turbulence were physically separated by placing a

brick downstream from each oozing odor source. The small odor sources created minor turbulence; each brick caused a major turbulent wake. Sides were alternated to account for side bias. Sharks were tested in two states: lateral line intact and lateral line lesioned following streptomycin treatment. Each shark (n=8) was allowed to acclimate and then confined downstream while the plumes were established. After release its behavior was monitored for ten minutes. The number of strikes on each object was counted under two light conditions: fluorescent and infrared. With the lateral line intact, strikes on either target on the non-odor side were rare. On the odor side, all animals struck the source of turbulence significantly more than the actual source of odor. More strikes occurred in the lit condition but preference for the source of odorous turbulence did not change. Preliminary lesion experiments have shown that eliminating lateral line input causes serious disruption of localization behavior. These results show that the smooth dogfish is using simultaneous information from olfactory and turbulence detection systems when searching for food and that they may be using additional visual information.

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#### Diet composition of a stream-associated cottonmouth (*Agkistrodon piscivorus*) population in southwest Missouri

Variation in snake diet composition may be explained by numerous factors including prey size selection, differences in foraging tactics, and prey availability. We investigated the diet of a cottonmouth (*Agkistrodon piscivorus*) population associated with a stream environment in southwest Missouri using analysis of stomach and intestinal contents. Relatively little dietary ontogeny was observed with mammals representing the dominant prey at all snake body sizes. Reptiles, amphibians, birds, and cicadas formed the remainder of the diet. In addition, telemetric monitoring of adult individuals indicates relatively little activity associated with the aquatic environment. We suggest that the apparent lack of aquatic foraging activity in this population may be explained by the stable hydrology and cold (spring fed) nature of the stream environment which collectively present challenging circumstances to an opportunistically piscivorous species. Moreover, the dietary breadth of *A. piscivorus* may confer an unusual degree of dietary plasticity allowing exploitation of whatever prey are most abundant or accessible in a given environment.

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**GBURSKI, CHRISTOPHER M.**

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Age and growth of the big skate (*Raja binoculata*) and the longnose skate (*Raja rhina*) being targeted in the Gulf of Alaska

An on-going skate fishery targeting the big skate (*Raja binoculata*) and the longnose skate (*Raja rhina*) in the Gulf of Alaska has created a need for age data. Stock assessment requires age estimates to properly manage and conserve marine fishes. Elasmobranchs, notably skates and rays (Rajidae), have been identified as a particularly vulnerable group to exploitation due to their large body size, late maturation, and low fecundity when compared to teleosts. In this study we generated age and growth estimates from big and longnose skate thoracic vertebrae. The total length (TL) of both species ranged from 30 to 190 cm. Vertebral thin sections appeared to provide the most reliable ageing preparation. Vertebral bands for the big skate were clearer than those for the longnose skate. Samples from sub-adults (< 60 cm TL) were limited for both species; therefore, back-calculation was performed using image analysis. The maximum estimated age for the female big skate was 13 years (180 cm TL). For the female longnose skate, the maximum estimated age was 17 years (160 cm TL).

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Ontogeny reveals unexpected origins of the complex head musculature of loricariid catfishes (Loricarioidea, Siluriformes)

The suckermouth armored catfishes of the Neotropical loricariid family display a complex array of cranial muscles. These are involved in the movements of the extremely specialized sucker mouth, enabling respiration, adhesion to substrates, and the scraping of food particles off these substrates. In our broader study on loricariids the functioning of these muscles is being examined (X-ray kinematics, EMG), and the functional-morphological diversity is assessed. The morphology and functioning of the cranial muscles in young embryonic and larval stages is another, main part of the research project, and the topic of the current presentation. The differently oriented suspensorium and hyoid bar suggest an altered respiration mechanism in the fry. Comparison of various stages, including 3D-reconstructions of some of the earliest, as well as muscle innervation patterns and comparison with embryonic callichthyids, reveal the identity of some of the more obscure but highly developed muscles, several of which are unique to loricariids. Evidence is given for the striking non-homology of the retractor tentaculi in loricariids and callichthyids (and other siluriforms). The high (but varying) number of muscles derived from the adductor mandibulae complex and the adductor arcus palatini are discussed, in view of their

possible early embryonic and larval functionality, as well as their ontogenetic and evolutionary origin. The absence of a true protractor hyoidei in loricariids and the specialization of the intermandibularis are compared to the situation in other siluriforms and teleosts.

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How do you scrape? Diversity and development of teeth and horny lip projections among the Loricariidae

The Neotropical suckermouth armored catfishes use their sucker-like mouth to adhere to submerged substrates. They have drastically modified jaws that point their teeth ventrally, towards the substrate. It is a well-known fact that the many loricariid species differ in habitat, feeding habits, and preferred type of food. These facts are examined from an ecomorphological point of view. Not only the jaws and the associated musculature vary between species, but also the scraping devices themselves: both teeth and unicellular horny lip projections (unculi). The loricariid teeth are among the most remarkable of all fishes, being Z-shaped, equipped with an asymmetrically bifid crown, and being highly variable in shape and size. Light microscopy and scanning electron microscopy revealed the details of some aspects of this diversity, in addition to tooth morphology, intraspecific variability and wearing patterns. The ontogenetic sequence of simple conical teeth in embryos to the fully developed scraping teeth in adults is discussed, as well as the growth of each individual tooth and the recruitment of new teeth rows that replace worn and lost teeth. The inner surface of the lower lip is exposed to the substrate too, and is covered by a varying number of papillae bearing the unicellular unculi. These brush-like structures are as diverse as the teeth themselves, and are hypothesized to assist in the scraping of fine material, like encrusted algae. Analogous to teeth, these epidermal brushes may be shed when worn. The loricariid teeth and unculi are less studied morphological features, even though they are extremely decisive characters determining the feeding and specialization abilities of the members of this largest Neotropical fish family.

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### Variations in breeding success and reproductive endocrinology of bonnethead sharks (*Sphyrna tiburo*) from four Florida estuaries

Previous studies on reproduction of the bonnethead shark (*Sphyrna tiburo*) have reported high rates of infertility in populations of this species residing in pollutant-impacted regions on Florida's Gulf coast. The objectives of this study were to determine the physiological factors that lead to the production of non-fertile ova in *S. tiburo* and investigate whether these abnormalities were associated with exposure to endocrine-disrupting pollutants, in particular, estrogen-mimicking organochlorine pesticides (OCPs). Reproductive endpoints and serum gonadal steroid concentrations were examined and compared in bonnethead sharks from four Florida estuaries experiencing differing levels of OCP contamination: Apalachicola Bay (high), Tampa Bay (high), Charlotte Harbor (intermediate), and Florida Bay (low). Infertility rate was lower in Florida Bay *S. tiburo* (1.5%) than in sharks from all other sites (7-10%). The higher rate of infertility in Tampa Bay and Charlotte Harbor sharks, in particular, may be associated with less efficient sperm storage in females from these estuaries, based on differences in the vitality of spermatozoa obtained from the female sperm storage organ. Variations in egg quality may also contribute to infertility, based on lower serum concentrations of 17-estradiol in vitellogenic females from sites exhibiting high rates of developmental failure. Despite endocrine-related differences between populations, the absence of the xenoestrogen biomarker vitellogenin in male *S. tiburo* from all study sites does not support the hypothesis that sharks from populations with high infertility rates are physiologically altered by OCP exposure. Therefore, the link between infertility and OCP contaminants is tenuous at best. Future studies will investigate other factors, both natural and anthropogenic, that may contribute to the reproductive complications observed in this species.

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### Bilateral jaw muscle activity in spiny dogfish

Asynchronous activation of bilateral jaw muscles permits a higher degree of motor control during feeding and food processing. Most previous studies of motor activity in elasmobranchs and bony fishes have implanted electrodes unilaterally to determine basic feeding patterns. Detailed studies of basal bony fish show synchrony during the initial strike at the prey and asynchrony during prey manipulation. Spiny dogfish modulate their behavior dependent on prey type. We predict that dogfish will use synchronous activity during suction or biting, but asynchronous muscle activity during head-shaking. We investigated bilateral muscle activity during feeding on multiple prey items. Electrodes were implanted bilaterally in the dorsal and ventral quadratomandibularis, preorbitalis (jaw adductors), epaxialis (head elevator) and unilaterally in the coracomandibularis (mouth opener) to determine the timing of muscle activation during prey capture. The dorsal and ventral quadratomandibularis, preorbitalis and epaxialis were bilaterally and synchronously active during suction feeding and biting on small pieces of herring, supporting our hypothesis. All muscles were active asynchronously during prey processing. Therefore, dogfish are able to modulate jaw muscle activity based on prey type. Additionally, this implies that independent neural control over the jaw muscles may be an ancestral trait in vertebrates since it is exhibited by a shark, the most basal vertebrate, and a basal bony fish.

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**GERSON, MARINA M.**

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The function of the tail-wagging behavior of the zebra-tailed lizard, *Callisaurus draconoides*, and the frequency of caudal autotomy

Several hypotheses have been proposed to explain the function of the conspicuous tail-wagging behavior of the zebra-tailed lizard (*Callisaurus draconoides*): the flash concealment hypothesis proposes that a predator's focus is drawn to the tail banding and when these bands are quickly hidden, the lizard effectively disappears; a distraction – autotomy hypothesis suggests that the predator's attention is drawn to the expendable tail, which can be lost with little harm to the lizard; the warning signal hypothesis proposes that lizards might warn conspecifics about an approaching predator; and the pursuit deterrent hypothesis suggests that tail-wagging by *C. draconoides* signals to a potential predator the lizard's preparedness to make an escape. I examined the tails of field collected *C. draconoides* as well as museum specimens to determine the frequency of caudal autotomy, as evidenced by the presence of regenerated tails. I also compared rates of tail loss in different

localities and over time to indirectly assess the incidence of lizard – predator interactions.

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**\*GERVELIS, BRIAN J.; MELLO, JOSEPH J.**

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**Incidental catch of sharks from gillnet and otter trawl fisheries from North Carolina to Maine as seen by the Northeast Fisheries Observer Program**

Many shark species are caught incidentally in both the otter trawl and gillnet fisheries from North Carolina to Maine. Data collected by the Northeast Fisheries Observer Program were used to examine the numbers of sharks caught incidentally in otter trawl and gillnet fisheries as documented by onboard observers. Twenty-eight species were documented as incidental catch (n=9,074) from 1993 to 2005. The thresher shark, *Alopias vulpinus*, porbeagle, *Lamna nasus*, sandbar shark, *Carcharhinus plumbeus*, dusky shark, *Carcharhinus obscurus*, blacktip shark, *Carcharhinus limbatus*, Atlantic angel shark, *Squatina dumerili*, and Atlantic sharpnose shark, *Rhizoprionodon terranova* comprised over 78.9% of the incidental shark catch of observed trips based on numbers of individuals. *C. plumbeus*, was the most prevalent at 34.5% of the incidental shark catch. *S. dumerili* made up the largest percentage of incidentally caught sharks in the observed otter trawl fishery, while *C. plumbeus* made up the highest percentage in the observed gillnet fishery. Of all the sharks caught, 50.8% were alive when initially brought up in the gear, 38.9% were dead and 10.3% were of unknown status. Of the fish brought up alive, 20.5% were kept for market, 73.4% were released alive, 2.9% were discarded dead, and 3.2% were discarded with an unknown status. 55.7% of the fish brought onboard dead were kept for market and 44.3% were discarded. Of the fish with unknown status 89.4% were discarded, 10.4% were kept and 0.2% were unknown. The majority of the individuals in the incidental catch from observed trips were immature based on their size distributions. Further analyses should be conducted to determine the accuracy and precision of these estimates and to examine what effect these levels of incidental catch may have on shark populations in the Northwest Atlantic.

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**Cold-climate and testicular cycle regulation in lizards**

Testicular cycle as the results of coactions between geoclimatical factors and microevolution in each lizard during gradual evolution. Therefore during this coactions have stabilized testicular cycle in lizards. Cold climate is dominance climate in high latitudes especially in northern hemisphere. This study in the high

elevation of Zagros of western Iranian plateau has been done. Therefore I selected 3 species of lizards which distributed in Zagros MTs. our study based on morphological and histological characters of testis, during biological activity lasted. Our results have showed two obvious phases; degenerative which occur in the spring and summer and regenerative which occur in the autumn and winter. In cold climate lizards showed hibernation and during this period have occurred regeneration of testis volume. This strategies for hibernate lizards in cold climate is as a results of natural selection during evolution. But in other climate has been showed continuous (tropic) and weak seasonal (subtropics) testicular cycle. Consequently, geographic position in both hemispheres with climate conditions regulated testicular cycle. This regulation for tropical altitude (continuous) and up to 30 degree S especially 30 degreeN (associated) has strongly established and confirmed affects of altitude into testicular cycle. In other hand, between this altitudes testicular cycle associated to climate condition.

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Variation in trophic morphology in poeciliine fishes (Teleostei, Cyprinodontiformes)

The Subfamily Poeciliinae includes the fishes commonly known as livebearers with over 200 extant species natively distributed in North, Central, & South America. This group of fishes offers a unique opportunity to study the evolution of a placental connection because placentas likely have evolved multiple times in the family, and closely related species exhibit variation in degree of development of placental connection. Because the placenta is a structure involved in nutrient transfer to embryos, how the female obtains her own nutrition is of particular relevance. This study explores the correlation of female trophic characteristics with degree of placental nutrient provisioning, particularly in the genus *Poeciliopsis*, for which a well-supported molecular phylogeny and life history data have been produced. In addition, this study documents the large range of trophic morphologies (oral jaw anatomy, pharyngeal jaw anatomy, gut anatomy) exhibited within this group.

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An investigation of the effects of select environmental contaminants on an novel component of the amphibian immune system

Global amphibian populations are currently declining at an alarming rate. Because amphibian species are regarded as sentinels of environmental quality, these declines

suggest widespread environmental degradation. Chemically-induced immunosuppression may increase the susceptibility of amphibians to emerging pathogens such as the chytrid fungus, *Batrachochytrium dendrobatidis*, which has been implicated in several localized amphibian declines. This project investigates the effect of environmental contaminants on the bioactivity of protective peptides secreted from amphibian dermatous granular glands. A growth inhibition assay using *B. dendrobatidis* zoospores and antimicrobial amphibian secretions was validated as an amphibian immunobioassay in our laboratory. We used this bioassay to investigate the effects of representative pesticides (atrazine, carbaryl) and locally collected surface waters on peptide secretion/bioactivity of the amphibian model, *Xenopus laevis*. Experiments were environmentally relevant, including acute and chronic exposures of juvenile and larval animals, respectively. Acute exposures (24 hours) of juvenile *X. laevis* to atrazine or carbaryl (0, 1.25, 2.5, and 5 ppm) did not significantly affect measured protein levels or bioactivity. However, *X. laevis* exposed to agricultural runoff containing atrazine (maximum concentration = 7 ppb) throughout metamorphosis (75 days total) had significantly increased peptide secretion. Alternatively, peptide secretion and subsequent bioactivity were significantly decreased following chronic exposure of *X. laevis* larvae to high concentrations of locally collected sewage treatment plant and landfill effluents. Our data suggests that the release and bioactivity of protective amphibian secretions can be modulated through exposure to environmental contaminants and that the described bioassay is a sensitive measure of these immunosuppressive effects.

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**\*GIENGER, C.M.; DOCHTERMANN, N.; TRACY, C. RICHARD**

*Program in Ecology, Evolution, and Conservation Biology, University of Nevada-Reno, Reno, NV, 89557, USA*

### Detecting geographic body size trends: the trouble with turtles

Geographic body size trends have recently enjoyed renewed interest and investigation in the literature. Many taxa demonstrate pronounced change in body-size along their latitudinal distributions, and these patterns have been attributed to a variety of ecological and evolutionary mechanisms. We investigated geographic body size trends in turtles and conclude that currently available data may not be sufficient to demonstrate trends for most species. The ability to detect a statistically significant trend (statistical power) is highly influenced by both sample size and geography. Our analyses suggest that current methods of determining geographic body size trends are inadequate, as they likely lack sufficient statistical power, and that results from previous studies may be artifacts of sampling regime.

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### Herpetofaunal inventory of Anaho Island, Pyramid Lake, Nevada

We report here on the herpetofaunal diversity of Anaho Island, Pyramid Lake, Nevada. During the spring and summer 2006, we used visual encounter surveys and trap arrays to determine reptile and amphibian diversity of Anaho Island. Common species included *Uta stansburiana*, *Callisaurus draconoides*, *Sceloporus magister*, *Aspidoscelis tigris*, *Crotalus lutosus*, and *Pituophis catenifer*. The island does not appear to harbor any species of amphibian or chelonian.

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### An online survey of ichthyological and herpetological collections in the USA

We designed an online survey of herpetological collections to provide valuable data that will enhance long-term support and maintenance of herpetological collections in the USA. This survey captures general collection information, as well as more specific information on collection and data management policies (e.g., loan procedures, availability of electronic catalogs). A periodic evaluation of the status of American ichthyological and herpetological collections will help assess whether collections are adequately meeting needs for research and education, as well as identify new opportunities and challenges facing collections. We also hope to aid in identification of other issues, such as growth and space requirements, funding priorities, or weakly documented geographic areas. Curators and collection managers of collections of all origins, sizes, and types are strongly encouraged to participate.

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**GILLETTE, DAVID P.**

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### Effects of terrestrial arthropod subsidies on three species of stream fishes

Resource subsidies from adjacent habitats have been shown to influence consumer abundance in many systems, including freshwater rivers and streams. In these habitats, input of terrestrial invertebrates from the riparian zone can dominate diets of some insectivorous and generalist fishes. Because temperate stream fish assemblages consist of many different species with greatly varying trophic ecologies, the importance of such riparian arthropod subsidies might be expected to differ

among taxa. The present study used experimental manipulation of terrestrial arthropod input into experimental streams to examine how this subsidy affected three stream fishes from different trophic guilds; bigeye shiner (*Notropis boops*), a drift-feeder; blackstrip topminnow (*Fundulus notatus*), a surface-feeder; and orangethroat darter (*Etheostoma spectabile*), a benthic-feeder. All three species were maintained in monoculture over a five-month period. Effects of terrestrial invertebrate input on fish growth and body condition, and stream benthos density and benthic primary productivity, were examined.

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Lizards, eggs, and ultrasound: Testing the efficacy of quantifying reproductive effort in squamate reptiles using portable ultrasonography

Most studies of reproductive effort in lizards have required that individuals be sacrificed to obtain population level data on life history traits such as clutch and egg size. While this approach provides insight into population level life history traits it precludes a critical examination of individual performance over both intra-annual and inter-annual time scales. These insights are crucial for broader knowledge of how individuals allocate resources to reproduction over varying lifetimes in the face of environmental variation. In this study we validated the use of a laptop sized portable ultrasound system as a non-destructive means of quantifying reproductive investment in five species of lizards with a range of body sizes, forms, and life histories. We present data from 42 gravid females in sizes and forms ranging from *Uta stansburiana* to *Crotaphytus collaris* and *Phrynosoma cornutum*. Lizards were scanned live while mechanically restrained, and egg number and dimensions were measured and recorded using virtual calipers. Observations were then validated by sacrifice and dissection. We found that ultrasound scans produced egg counts that deviated from the true counts by  $0.39 \pm 0.06$  SE for clutch sizes of 2 to 7 eggs (mean  $4 \pm 1.91$  SE) and  $5.5 \pm 1.69$  SE for clutch sizes of 18 to 41 eggs (mean  $26 \pm 3.74$  SE). Egg measurements using the virtual calipers produced clutch volume measurements that deviated from the true measurements by  $25.67\% \pm 0.59$  over all species (clutch volumes ranged from 0.068 to 20.26 cm<sup>3</sup>). This study shows that ultrasonography in the field is a viable nondestructive method for quantifying reproductive effort in lizards.

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**GIOVANETTO, LAINE A.**

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Habitat use and resource partitioning in two species of sympatric, congeneric turtles.

During a demographic study of the fresh water turtle community at Rainbow Springs State Park, Florida, data on the habitat use of *Pseudemys concinna suwanniensis* and *P. floridana peninsularis* was collected to investigate resource partitioning in these herbivorous turtles. *P. concinna suwanniensis* and *P. floridana peninsularis* represent an example of closely related species that should not coexist due to competitive exclusion and therefore make an excellent reptilian model to test Gause's Principle. Fieldwork took place from November 1995 through November 2002. The vegetation in the study area was categorized into several classes: bare substrate, submergent vegetation less than half the water depth, submergent vegetation greater than half the water depth, and emergent vegetation. There were significant differences in vegetation class use in these turtles. Although both species were similar in their use of emergent vegetation, there were significant differences in the use of the two submergent vegetation classes. *P. floridana peninsularis* used submergents less than half the water depth more than *P. concinna suwanniensis*, and *P. concinna suwanniensis* used submergents greater than half the water depth more than *P. floridana peninsularis*. There were no significant differences between males and females in either species, but there was a significant difference in habitat use between adults and immature individuals in *P. concinna suwanniensis*. As far as spatial habitat use is concerned, these results appear to support Gause's Principle of Competitive Exclusion.

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**\*GLAUDAS, XAVIER; ANDREWS, KIMBERLY M.; WILLSON, JOHN D.; GIBBONS, J. WHITFIELD**

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Migration patterns in a population of cottonmouths (*Agkistrodon piscivorus*) inhabiting an isolated wetland

Few studies have examined spatial and temporal migration patterns of snakes to and from active-season habitats. We conducted a year-long population-level analysis of cottonmouth (*Agkistrodon piscivorus*) migration patterns by monitoring snakes entering and leaving a Carolina bay wetland that was encircled by a continuous terrestrial drift fence. Cottonmouths used the wetland during the active season and left the bay in the fall to overwinter in other habitats. Adults arrived at the bay earlier and left later than juveniles. Spatially, captures of adult cottonmouths entering and leaving the bay were distributed non-randomly, with capture peaks corresponding to

the directions to the nearest permanent aquatic habitats. Juvenile immigration patterns in the spring were biased in the same directions as those of the adults, but they left non-directionally in the fall, suggesting that neonates do not rely on adult scent trailing to locate hibernacula. Our study suggests that in a region with moderate winter temperatures, high-quality summer habitats (wetlands) may be a more limited resource than overwintering sites. Additionally, our study demonstrates that cottonmouths make extensive use of upland habitats and underscores the importance of both critical upland habitat and forested corridors between wetlands and hibernacula for the conservation of wetlands herpetofauna.

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**GLOR, RICHARD E.**

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Speciation, niche conservatism, and ecological incumbency in the Hispaniolan green anoles (*anolis chlorocyanus* group)

The island of Hispaniola is home to a clade of four trunk-crown anole species. These striking green lizards are represented by two distinct macrohabitat specialists: lowland and montane. It has long been thought that speciation within each macrohabitat category has occurred across a low-lying valley that has been periodically flooded with seawater. I use molecular phylogenetic and phylogeographic data to test this hypothesis. Molecular clock methods are used to provide an estimate for the age of divergence events. In the case of ancient divergence events, niche modeling is used to distinguish two possible explanations for long-term range stability: (1) ecological niche incumbency, and (2) environmental adaptation.

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Population ecology and feeding activity of *Sternotherus odoratus* at Reelfoot Lake, Tennessee

Precise times of feeding activity for aquatic turtles are poorly documented in the literature because of passive capture techniques. In a roadside slough adjacent to Reelfoot Lake, we sampled a population of stinkpots, *Sternotherus odoratus*, periodically from September 2004 to November 2005 using deep-water crawfish nets baited with chicken. This novel technique, in 32 samplings with an average duration of 7.5 h, has captured 866 stinkpots, comprising 655 individuals. The overall and individual sex ratio was significantly male-biased, but the recapture sex ratios did not differ. Jolly-Seber estimate predicted a population of 876 individuals, which yielded a density of 984/ha, and a biomass of 104 kg/ha. We estimated the feeding activity season to be 218 days for 2005 (16 April – 19 November). We did not observe gender or size differences for feeding times. Stinkpot feeding activity was

crepuscular, with a peak between 0600 – 1100 h, and a less pronounced peak between 1600 – 1900 h. Although we captured some individuals overnight, nocturnal feeding was not prevalent. Stinkpot capture was affected by the time of initial net placement; 52% of total captures came within the first three hours of setting the nets. Density and biomass estimates for stinkpots in this study were larger than any reported in the literature. By late 2005, we were obtaining recapture percentages of 40 – 50%, which provided reliability for our Jolly-Seber estimate. We propose that our capture technique may lead to more efficient sampling of some turtle species, and provide detailed accounts of feeding activity.

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Effects of oceanography, habitat discontinuity, and geographic distance on population structure of copper rockfish, *Sebastes caurinus*, along the Oregon coast

In non-migratory groundfishes such as the copper rockfish, *Sebastes caurinus*, physical and therefore genetic movement among populations can be largely attributed to the dispersal of pelagic larvae and juveniles. Larval dispersal distance may be influenced by entrainment into oceanographic currents, habitat discontinuities, and/or may be a function of geographic distance from location of release. Though understanding gene flow is critical to effective fisheries management and conservation, knowledge of larval biology is limited by the fact that many larval rockfishes are morphologically indistinct at the species level. Successful recruitment of larvae along the Oregon coast may be interrupted by the offshore jet produced by Cape Blanco or an expanse of poor habitat north of the cape. Due to the high larval mortality associated with advection far offshore and settlement onto unsuitable substrate, both situations serve as barriers to gene flow. PCR-based microsatellite DNA genotyping analyses were used to gather information about population structure and gene flow within the species. DNA was isolated from 726 fish collected over 4 years from locations closely spaced along the coast of Oregon and Washington, USA. Genotypes were assembled for each individual across 6 loci. Traditional population genetic analyses were combined with individual based analyses that used the general linear model to discern the importance of oceanography, habitat availability, and isolation by distance on population structure at fine-scale resolution.

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### Demographic analysis of salmon sharks in the North Pacific; testing the intrinsic rebound potential model

The majority of demographic analyses on elasmobranch fishes have used deterministic life-tables (or Leslie matrix models) to calculate intrinsic rates of population increase and other vital rate parameters. While density-dependent compensation is a standard concept in ecology and fisheries biology, incorporating the effect of uncertainty in vital rates into demographic analyses of elasmobranchs is a relatively new and extremely useful approach to demographic modeling. We used life-table models incorporating uncertainty by establishing probability distributions for maximum age, age at first reproduction, fecundity and survivorship at age for salmon sharks in the eastern and western North Pacific. Monte Carlo simulations were then used to generate population growth rates, generation times, net reproductive rates, mean life expectancies, population doubling or halving times, and fertility, juvenile and adult elasticities. In order to utilize life-table models for analyses where fishing mortality was included, density-compensation values generated from the Intrinsic Rebound Potential model (of Au and Smith) were incorporated into the life-table models. The goals of this research are to provide the first estimates of demographic parameters for salmon sharks in the eastern and western North Pacific, and observe whether the Intrinsic Rebound Potential model adequately predicts the necessary degree of compensatory survival in sub-adult age classes to keep population growth rates and other demographic parameter estimates stable under various levels of fishing mortality.

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### Habitat use by the Western Rattlesnake (*Crotalus oreganus*) in the interior of British Columbia, Canada

From a conservation perspective, it is essential to identify elements critical to the survival of a species, particularly when the species in question already is declining. In 2005, we used radio-telemetry to examine summer habitat use by 11 adult, male western rattlesnakes (*Crotalus oreganus*) from 2 denning areas in the interior region of British Columbia, Canada. We recorded the percentage cover or minimum distance to structural habitat features that could affect biological activities such as thermoregulation and predator avoidance. Two of the snakes that we radio-tracked for the entire active season (April-October) remained in lower elevation (< 400m)

grasslands and 6 ventured into upper elevation (> 1000m) forested areas. Thus, our study provides the first evidence that some individuals from northern populations of *Crotalus oreganus* use upper elevation forested habitats for the majority of the active season. Graphical exploration of our microhabitat data shows that percentage cover of shrubs, soil and rock may be indicative of summer habitats used by the Western Rattlesnake. We currently are using multivariate statistics to evaluate hypothesis about summer habitat use at our study sites. In 2006, we will examine 2 potential mechanisms underlying habitat use by the Western Rattlesnake: temperature and prey activity.

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The shape of things to come: Linking larval plasticity to juvenile morphology in frogs

The morphology of postmetamorphic frogs often varies with environmental conditions during the larval phase. Developmental plasticity of tadpoles has effects that carry over to the next life stage, affecting traits such as relative limb length and head shape. However, similar changes in larval period (e.g. delayed metamorphosis) induced by different environmental factors (e.g. temperature, competition, predator presence) can result in different changes in shape. Tadpoles can partially decouple growth and development, i.e. grow with little developmental change or develop with little increase in size. A mechanistic framework to explain the effect of larval environment on juvenile morphology should incorporate the relative magnitude of environmental effects on growth and development. We suggest that environmental factors inducing long larval periods through reduced growth rate will produce metamorphs with relatively shorter limbs while factors inducing long larval periods by slowing down development will produce metamorphs with relatively longer legs. To test this idea, we manipulated time to metamorphosis in red-eyed treefrog tadpoles (*Agalychnis callidryas*) by altering temperature and larval density, which have large impacts on development and growth, respectively. Tadpoles were reared at three temperatures with *ad libitum* food, or at a common temperature with three levels of competition for food. Froglets were preserved after metamorphosis and measured for snout-vent, hindlimb, and head length. Low temperature and food availability (high competition) both increased the larval period. Decreased food availability reduced mass at metamorphosis, but temperature had no effect on size. Analyses of covariance of the morphometric traits showed that low temperature and low food availability had opposite effects on size-corrected limb length and head length, as predicted, even though they had similar effects on the larval period. Differences in juvenile shape are primarily the consequence of allometric scaling of shape to body size, but environmental factors may also alter allometric relationships.

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Oasis or mirage: Use of a golf course and surrounding desert areas by tiger rattlesnakes

In heavily populated areas of Europe and the eastern United States, golf courses have serendipitously become strongholds of biodiversity in a sea of human development. In the western United States, where large tracts of nature remain undeveloped, golf courses may play a similar role in the future, as populations continue to expand. Our goal was to learn more about how golf courses affect wildlife, and then use this information to help ensure that golf courses can support healthy populations of animals in the future. Therefore, we studied a population of Tiger Rattlesnakes (*Crotalus tigris*) living on and adjacent to a golf course and development in the Sonoran Desert of southern Arizona. From 2002-2005, we captured 346 snakes, which we recaptured 255 times. We also studied 60 snakes (31 females and 29 males), which we have located 4713 times using radiotelemetry. We draw on this rich data set to examine various aspects of Tiger Rattlesnake ecology. Specifically, we compare relative abundance, demography, spatial ecology, reproduction, growth, diet, and habitat use of snakes whose home ranges did and did not encompass the golf course. The golf course is dramatically different than surrounding desert areas with regard to water availability, vegetative cover, and prey abundance. Tiger Rattlesnakes have fared better on the golf course so far, but is the golf course really an oasis for Tiger Rattlesnakes, or will it turn out to be a mirage? That is, will the addition of critical resources ultimately result in an ecological trap as snakes are brought into closer contact with increasing numbers of humans while the surrounding development continues to grow? We speculate on this question, and make management recommendations that will hopefully promote coexistence of rattlesnakes and humans, and lead to more wildlife-friendly golf courses.

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*Xenopus* tadpole's responses to mirrors

Tadpoles of several species in the genera *Bufo*, *Bombina*, and *Rana* prefer to look at themselves in mirrors with their left eye. This unusual lateralized behavior suggests that tadpoles can recognize the image of conspecifics and may use this visual information to assess their density. Indeed a recent study showed that *Rana sylvatica* (but not *Bufo americanus*) tadpoles raised in aquaria with various amounts of mirrored walls, responded to the mirrors as if they were being raised at higher physical density. We examined both eye preference in *Xenopus laevis* tadpoles and the effect of mirrored aquaria walls on their growth. Contrary to other species, *X. laevis*

tadpoles prefer to view themselves in mirrors with their right eye (!) rather than their left. However, this eye preference disappears by early hind limb bud stages. We raised *X. laevis* in 11 liter aquaria under four treatments for 20 days, starting at Gosner stage 30: a) mirrored walls with 20 tadpoles/tank; b) mirrored walls with 20 tadpoles/tank; c) no mirrors with 20 tadpoles/tank; and d) no mirrors with 40 tadpoles/tank. Tadpoles raised in the 'no mirrors' aquaria, regardless of physical density had increased tail length, total length, and reached a later Gosner stage earlier than in mirrored aquaria. Contrast analysis revealed no significant differences between the two mirror conditions versus the two non-mirror conditions. This indicates that the growth rate of *X. laevis* tadpoles is not negatively affected by an increase in physical density up to 2 tadpoles/L, but is affected by mirror images. The amount of mirror ( vs. of the walls) did not significantly impact growth or development. In sum, *Xenopus laevis* tadpoles have a reversed eye preference from other anurans tested to date and also react differently from them when raised in mirrored aquaria.

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Utilizing fisheries independent bottom longline catch data to determine optimum sampling levels for coastal sharks

Since 1995 the National Marine Fisheries Service Mississippi Laboratories (MSLABS) has conducted annual bottom longline surveys in U.S. territorial waters of the Gulf of Mexico. Using standardized survey gear and a consistent survey design has facilitated development of a fisheries independent data set useful for assessing species-specific interannual variability in catch per unit effort. Based on MSLABS time series data, species-specific optimum sampling levels, with varying levels of precision, have been established. Customizing a species-specific survey design within acceptable precision levels is possible for both geographically broad or discrete areas.

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Are hormone peaks indicative of the mating season in snakes? The cottonmouth (*Agkistrodon piscivorus*) as a case study

The study of animal mating systems suffers from a lack of information on the proximate mechanisms of secretive taxa. Pitvipers exemplify a group whose mating systems are difficult to examine and from which we lack endocrine profiles of reproductive hormones. In some species the mating season is not known with certainty or is based only on misleading anecdotal information. To better understand the proximate causation of two observed mating seasons in North American

pitvipers (unimodal vs. bimodal annual patterns), we conducted an integrative field study of the cottonmouth (*Agkistrodon piscivorus*) in Georgia from September 2003-May 2005 that included an extensive observational regime and collection of tissues and blood samples for behavioral, anatomical, histological, and hormone (enzyme immunoassay) analysis. Evidence from the annual testosterone (T) and sexual segment of the kidney (SSK) cycle provide correlative support for a unimodal late summer mating season in this pitviper, as these features consistently track the mating season in all snakes previously examined under natural conditions. These results have implications for the study of pitviper mating patterns and snake mating systems in general.

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#### Amphibian declines and fish introductions: the need for direct evidence, an example using Yosemite toads

Alien or introduced predators such as fish will often compete, displace or prey upon native amphibians. Amphibians that have evolved in fishless habitats often lack the necessary chemical defenses and behavioral responses to avoid predation and are thus unable to resist or co-occur with introduced predators due to the lack of a shared history. Toads, however, possess noxious chemicals that may be adequate to deter non-native predators which may allow co-occurrence with alien predators, even when the same introduced predator has already been implicated in the decline of other amphibian species. Yosemite toads (*Bufo canorus*) have experienced population declines throughout their range in which trout have been widely introduced, but it is not clear whether trout are responsible for the decline through direct predation of larval life stages. Through a series of no-choice palatability trials, antipredator response experiments and choice experiments we determined the level of threat brook trout (*Salvelinus fontinalis*) pose to larval Yosemite toad life stages. Firstly, brook trout found all early life stages of Yosemite toads to be unpalatable and unlikely rely on these stages as a primary food source in aquatic montane environments. Secondly, Yosemite toad tadpoles did not respond to chemical cues of brook trout. Thirdly, even though Yosemite toads were sampled by trout the toads they did not suffer any ill effects. Since trout have played a major role in the decline of other Sierran amphibians such as the mountain yellow-legged frog (*Rana muscosa*) and Pacific treefrog (*Pseudacris regilla*), the need for direct evidence of predatory threat should be assessed in order to make more informed management decisions about other potential causes for decline.

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**\*GRAY, MATTHEW J.; BURTON, ELIZABETH C.; SCHMUTZER, A. CHANDLER**

## Influences of cattle on amphibians in a predator-rich aquatic environment

Amphibians are declining globally in response to anthropogenic stressors. Agricultural cultivation and deforestation negatively influence amphibian populations; however, few studies have quantified the impacts of cattle grazing in temperate wetlands on resident amphibians. A natural experimental design exists at the University of Tennessee Plateau Research and Education Center, where four wetlands have been exposed to cattle grazing for >10 years and four additional wetlands in close proximity have never had direct cattle access. Therefore, we measured total and species-specific relative abundances of resident amphibians at each wetland from March–August 2005 using capture data from pitfall traps. Abundances were compared between cattle-access treatments ( $n=4$  wetlands/treatment) using 2-sample t-tests. Although no differences in total relative abundance (all species combined) were detected ( $P=0.59$ ) between land-use treatments, this was interpreted as a consequence of outlier results from one cattle-access wetland. In this wetland, relative abundance was 8X and 2X greater than other grazed and non-grazed wetlands, respectively, and likely was a result of fewer ( $P<0.001$ ) fish predators compared to the other wetlands. After removing this wetland from the analyses, mean daily and total capture of amphibians was greater ( $P<0.03$ ) at wetlands without cattle than in cattle-access wetlands. Species-specific tests revealed that metamorph green frogs (*Rana clamitans*) were 4X more abundant at wetlands without cattle than at cattle-access wetlands. No statistical differences were detected ( $P>0.13$ ) between treatments for other species and age classes. The environmental cofactors of cattle land use driving these responses are unknown; however, they may include a combination of increased pathogen prevalence in tadpoles, decreased water quality and shoreline vegetation, and trampling of egg mass in cattle-access wetlands. Our results suggest that cattle may negatively influence amphibians in temperate wetlands, although this effect may be species and age dependent, and affected by the presence of aquatic predators.

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## Short seasons and limited resources: Large wood turtle (*Glyptemys insculpta*) home range sizes in northern environments

In northern extremes of their range, turtles are confronted with harsh conditions which include lower productivity, shorter active seasons, and extremely cold climates. We hypothesize that in order to achieve the same amount of nourishment as southern conspecifics, turtles will have to be more active and increase their home range sizes to cope with limited resources and time. The purpose of this study was to describe seasonal home range size, habitat use, and movements of wood turtles (*Glyptemys insculpta*) in Ontario at the northern extreme of their range to test for an

increase in home range size with latitude. Fourteen wood turtles (5 males, 9 females) were radiotracked 2-3 times per week from 2 May until 2 September 2005. The study period was divided into three distinct behavioural periods: spring, nesting, and summer. We found that home range sizes did not differ between the sexes (females = 58 ha, males = 59 ha). Females displayed large movements (> 1 km) to nesting grounds with one turtle moving 5.7 km to nest. However, males were more active than females during the study, and when the nesting period was removed from the analysis, home range sizes differed between the sexes (females = 7 ha, males = 59 ha). The large discrepancy in home range size between the sexes may be due to increased searching for mates by males in order to increase their fitness in the short growing and activity period in the north. We also found that turtles used different habitats and had different movement patterns among seasons and between the sexes. Data collected from this study provide a better understanding of variable wood turtle requirements among populations and have implications for management and conservation of this species at risk.

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#### Phylogeny of palm-pitvipers (*Bothriechis*) inferred from nuclear DNA

The genus *Bothriechis* is a clade containing nine species of arboreal pitvipers that occur in the neotropics. They range from southern Mexico through Central America and into northern South America. The phylogeny of the genus has been inferred previously using morphology, allozymes, and mitochondrial DNA. The morphological and allozyme datasets were found to be congruent and consistent with the geological history of the region. The mitochondrial dataset was not found to be congruent with the nuclear-based datasets. To develop a well-corroborated hypothesis, we have sequenced additional nuclear genes from species of *Bothriechis*. We will also discuss the phylogenetic utility of these genes at an intergeneric level of divergence within *Bothriechis*.

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#### Age structure instability and its effects on population size in Fowler's toad, *Bufo fowleri*

Fluctuations in population size among amphibians and other organisms are the result of many, oftentimes synergistic, influences upon recruitment and survivorship rates but, in a small ectotherm, growth rate may also be an important factor affecting recruitment into the adult population. Intensive long-term population studies are

invaluable for providing data on how individual populations may behave under changing conditions and for estimating demographic parameters. A population of Fowler's toads (*Bufo fowleri*) on the north shore of Lake Erie has fluctuated considerably over 18 years with little obvious pattern. Age determinations of using skeletochronology and mark/recapture methods have been made for this population for more than a decade. Although the majority of adult males breed at two years of age, both age structure and age-specific survival are highly variable from year to year. In particular, the proportion of one-year old adults varies considerably from year to year, evidently coupled with the opportunity for rapid growth by juveniles the previous year. Coupled with low survivorship amongst all ages classes, this may explain the observation that adult males tend to be smaller on average when the censused adult population size is high. Along with birth and death rates, growth rate leading to variable age of recruitment into the adult population may be the third important factor affecting amphibian population size.

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**Fight, flight, or just hide: A quantified study of crypsis in the timber rattlesnake (*Crotalus horridus*)**

Background color matching of *C. horridus* has been inferred from its ability to camouflage itself within the habitats it occupies; however, crypsis in this species, or any other snake species, has never been quantified. Spectroradiometry was used to measure the spectral radiance of the dorsal skin of 10 *C. horridus* (4 adults, 6 neonates) using a standardized technique where each snake was measured 20 times. Sampling was conducted according to one of three specific body regions; head, midbody, and tail. Spectral radiance of the habitat was measured in the laboratory by using 3 pieces of substrate (e.g., leaf, grass, bark, rock, etc.) collected from 100 field locations where *C. horridus* has previously been observed. It was determined using PCA that 3 extracted factors corresponding to brightness, hue, and chroma explained more than 99% of the variance measured between snakes and habitats. Habitats did not differ among the three factors; however, certain colors of *C. horridus* were found to match better than others with the background habitat.

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### Phylogeny of the enigmatic Madagascan geckos of the genus *Uroplatus*

Since its discovery in the 17th century, the morphological peculiarities of the genus *Uroplatus* have generated a great deal of attention. A large number of skeletal, integumentary and visceral features are autapomorphic for the genus and the more well-known members of the group possess such aberrant characteristics that a separate family was once recognized to accommodate them. Recent phylogenetic analyses confirm that *Uroplatus* is a typical gekkonid gecko, but the specific affinities of the genus, as well as its intrageneric relationships remain unresolved. Both nuclear (Rag1) and mitochondrial (ND2, ND4, 16S, 12S and cytochrome *b*) genes were sequenced for all major lineages of *Uroplatus*, as well as a variety of African and Madagascan and Indian outgroups. The DNA sequences were analyzed using parsimony, likelihood and Bayesian methods. The large bodied forms of *Uroplatus* (*U. fimbriatus*, *U. henkeli*, and *U. sikorae*) form a monophyletic group, and the small-bodied, short-tailed species are also monophyletic (*U. ebanau* and *U. phantasticus*). The phylogenetic hypothesis based on combined DNA sequence data is largely concordant with previous hypotheses of relationships based on morphological characters. The closest relatives of *Uroplatus* are most likely other endemic Madagascan geckos, lending support to the hypothesis that most genera of the speciose and morphologically diverse Malagasy gecko fauna comprise a single evolutionary lineage.

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### Phylogeography of the Middle American microhylid genus *Hypopachus*

We present a molecular phylogeny of the Middle American microhylid genus *Hypopachus*, which currently includes one lowland (southern Texas to central Costa Rica) and one highland species from four disjunct, montane localities (Chiapas, Mexico, Honduras, Guatemala, and El Salvador). We analyzed partial sequences of mitochondrial (12S and 16S) and nuclear (rhodopsin) genes (1237 bp total) to infer a phylogeny of the genus. Maximum parsimony, maximum likelihood, and Bayesian analyses were conducted on combined datasets of 35 populations of *Hypopachus*. Outgroups included *Gastrophryne* and *Elachistocleis* (sister groups to *Hypopachus* identified in a separate analysis), and trees were rooted with *Breviceps*. *Hypopachus*

*barberi* is strongly supported as a disjunctly distributed highland species, and at least five cryptic, lowland lineages are identified in the Atlantic versant of Middle America, Northern West-central Mexico, Southern West-central Mexico, Pacific versant of Central America, and Interior Valley of Guatemala.

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The marine gobies of the Hawaiian Islands

A total of 34 species of gobies is known from the Hawaiian Islands, four of which are freshwater species. The 30 marine species are illustrated and information on their distributions and habitat associations is presented.

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Comparing the effects of fish predation on *Rana capito* and *Rana sphenocephala* larvae

Southern leopard frogs *Rana sphenocephala* and gopher frogs *Rana capito* are two species of anurans found in the southeastern United States. *R. sphenocephala* is a habitat generalist occurring in virtually all aquatic habitats within its geographic range whereas *R. capito* is a species of conservation concern and breeds only in semi-permanent fishless ponds. The introduction of predatory fish into historically fishless *R. capito* breeding sites has been suggested as a cause of *R. capito* population declines. This project was designed to test the effects of fish predation on larvae of these two anurans species. I performed a factorial experiment which evaluated survival, injury rate, and hiding behavior of *R. sphenocephala* and *R. capito* with Warmouth sunfish *Lepomis gulosus*, Blue spotted sunfish *Enneacanthus obesus* and Mosquitofish *Gambusia holbrooki*. Tadpole survival was affected by the predator species present. Of the three predators, *Lepomis gulosus* was the only one that had any effect on tadpole survival consuming an average of 32.7% of the *R. sphenocephala* and 24.2% of the *R. capito* per tank. Tadpoles were not only eaten, but were physically damaged by the predators. More injuries were inflicted to the tadpoles by *G. holbrooki* than by the other fish. *Rana capito* tadpoles were significantly more susceptible to injury by this predator: 63% of *R. capito* tadpoles in the presence of *G. holbrooki* were missing parts of their tails as compared with only 13% of *R. sphenocephala* tadpoles. In response to the presence of both *G. holbrooki* and *L. gulosus*, a higher proportion of the tadpoles seek refuge and hide, and *R. capito* has a higher rate of hiding than *R. sphenocephala*. The results of this study suggest that fish predation may play a role in population declines of *R. capito* and even smaller fish such as *G. holbrooki* may have significant negative effects on *R. capito* larvae.

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Keeping still to avoid predation? Immobility as a response to handling in snakes

Most studies of anti-predator behaviour in animals focus on avoidance of capture, but, given the common occurrence of injuries in many species, escapes from predators' clutches apparently do occur. Once caught, an individual's options for escape obviously are limited, but one response to capture in some snakes is to feign death. Death-feigning is spottily distributed across various taxa of snakes, but is well known in hognose snakes (*Heterodon*) and in the grass snake (*Natrix natrix*). At a study site in southern England, about of captured grass snakes exhibit some degree of death-feigning, which often involves voluntary supination and is affected by several factors, including amount of handling. Although death-feigning, at least in its most extreme form, is unusual behaviour, it is perhaps best viewed as an elaboration of simple tonic immobility, which is widespread in nature. For example, garter snakes (*Thamnophis*) often remain immobile for some period of time following routine handling. In a study of this behaviour in *Thamnophis elegans* in British Columbia, 24% of captured snakes remained immobile for minimum times of 10-600 s following handling. Of these, remained supine when placed in that position. Immobility and supination were most frequent in gravid females, which also were more likely than other snakes not to move before capture. Presumably, the reduced locomotory capabilities of gravid females sometimes force them into alternative anti-predator tactics rather than immediate attempts to flee. At first glance, immobility in the face of extreme danger seems maladaptive, but a review of the literature suggests that it can buy time to escape from predators that do not kill and eat their prey immediately.

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Folliculogenesis and oocyte development in the Red Drum

Folliculogenesis and the development of oocytes in the Red Drum, *Sciaenops ocellatus*, have been studied using plastic embedding suitable for both light and electron microscopy. The epithelium forming the surface of the ovarian lamellae is a germinal epithelium composed of epithelial cells and oogonia which become the follicle cells and oocyte, respectively- together they compose the follicle. The follicle remains attached to the germinal epithelium throughout oocyte development since they both share a short portion of basement membrane. The follicle basement membrane joins to that beneath and supporting the germinal epithelium, and they become one.

Oocyte development is divided into four stages: early development or preprimary growth, primary growth, secondary growth or vitellogenesis, and final oocyte maturation. Final oocyte maturation is further divided into four substages depending on the degree of coalescence of lipid yolk globules, clearing of protein yolk, and nuclear migration. At the end of final oocyte maturation, the oocyte is preovulatory and becomes an egg.

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### Long-term population stability of large coastal sharks in the main Hawaiian Islands

Worldwide populations of large coastal sharks have been heavily exploited over the past three decades. While many nearshore resources in the main Hawaiian Islands have been heavily exploited, the region supports one of the few relatively unexploited populations of large coastal sharks. The only significant source of fishing mortality in the population was through a number shark control programs conducted by the State of Hawaii beginning in the late 1950s in response to concerns over public safety following fatal shark attacks. From 1959 to 1976, these programs caught 2,849 sharks in state waters comprising 17 species. More than 50% of the sharks caught were sandbar sharks (*Carcharhinus plumbeus*). Tiger sharks (*Galeocerdo cuvier*) were the next most common species (19%). The only significant commercial exploitation of coastal sharks in the region occurred when about 50 metric tons per year (dressed) were harvested by a single bottom longline vessel in 1997 and 1998. Longlining was subsequently banned in nearshore waters. In 2002, a fishery-independent longline survey began to monitor seasonal and inter-annual changes in abundance of large coastal sharks along the windward coast of Oahu in the Main Hawaiian Islands. Approximately 46% of the sharks caught in the historical shark control programs were also caught around the island of Oahu. Analyses of data collected from 2002-2005 were compared to historical data from the shark control programs of the late 1950s and late 1960s to examine long-term changes in inter-annual and inter-seasonal abundance of coastal sharks. Comparisons of length frequency data and sex ratios were also examined between the two time periods for sandbar sharks. In addition, stomach contents were collected from approximately 200 sandbar sharks during the current survey. These data were compared to published historical data to examine changes in diet that may be a function of exploitation of prey taxa.

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Thiamine concentrations in egg yolk of bonnethead sharks (*Sphyrna tiburo*) and their association with infertility

Thiamine (Vitamin B1) is essential for the development and survival of progeny of egg bearing vertebrates. A reduction in thiamine concentration in egg yolk has been linked to diseases that cause low offspring survival rates in both salmonid and American alligator populations. In this study, thiamine status of bonnethead shark (*Sphyrna tiburo*) egg yolk was examined to determine if a link can be established between thiamine deficiency and high rates of infertility in several coastal Florida populations of this species. Thiamine levels per gram of egg yolk were measured by means of a new rapid solid phase extraction method. The results indicated no difference among three different stages of reproduction: pre-ovulation, peri- and post-ovulation and early pregnancy. A significant difference was demonstrated among three coastal Florida populations, with yolk from Apalachicola Bay sharks having the lowest thiamine concentrations, followed by samples from Florida Bay and Tampa Bay sharks, respectively. The thiamine concentrations in the Tampa Bay populations were higher than expected given the high infertility rate of this population. However, a significant difference was observed between the infertile and fertile ova from Tampa Bay sharks that justifies further investigation on the relationship between thiamine status and shark fertility.

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Evaluation of seven aquatic sampling methods for amphibians and other aquatic fauna

In order to design an effective and efficient monitoring program researchers must have a thorough understanding of the capabilities and limitations of their sampling methods. Although previous studies have compared sampling techniques for aquatic macrofauna, few direct comparative studies exist for amphibians. The objective of this study was to simultaneously compare seven aquatic sampling methods implemented in the same 10 wetlands in order to compare amphibian species richness and number of individuals. Four sampling methods allowed data collection of counts of individuals (metal dipnet, D-frame dipnet, box trap, crayfish trap) whereas the other three methods allowed collection of detected/not detected data (visual encounter, aural, and froglogger). Amphibians were the focus of this study. However, the efficacy of the four count sampling methods at sampling other taxa was also analyzed because fish and aquatic invertebrates are important covariates of

amphibian habitat distribution. Amphibian species richness was greatest with froglogger, box trap, and aural samples. For anuran species, the sampling methods by which each stage was detected was related to relative length of larval and breeding periods and tadpole size. Sampling with the box trap resulted in the most precise amphibian count, but the precision of the four count-based methods was low (coefficient of variation >145 for all samplers). Fish were collected at similar species richness and counts with the four methods, whereas invertebrate species richness and count was greater in box traps. An effective wetland amphibian monitoring program in the southeastern United States should include multiple sampling methods to obtain the most accurate assessment of species community composition at each site. The combined use of frogloggers, crayfish traps, and dipnets may be the most efficient and effective monitoring protocol.

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Why is the size distribution of snakes log normal?

Recent summaries of macroecological patterns suggest that large clades of organisms exhibit a right-skewed distribution of body sizes. One explanation for this distribution is the reproductive power model, which suggests that an organism's ability to gain energy from the environment scales to the  $3/4$  power of body mass and the ability to use energy for reproductive work scales to the  $-1/4$  power of body size. These two physiological constraints yield a unimodal distribution of body sizes with a right skew. However, our data for 1042 species of the world's snakes documents a log-normal distribution for this group. This observation indicates either that the reproductive power model is false or that certain groups fail to reach the potential predicted by the model. In the later case, three possible explanations emerge from examination of body size distributions of other groups. One explanation is that ectotherms are limited in the sizes that can be attained above the modal size. This explanation is suggested by the observation that the reproductive power model correctly predicts the size distribution of birds and mammals but not of snakes and mollusks. A second explanation is that locomotor constraints associated with overall body shape limit patterns of body size. This explanation is suggested by the observation that elongate and frequently limbless tetrapods (snakes, caecilians, and salamanders) have log-normal body size distributions whereas globose tetrapods (birds, mammals, frogs, and turtles) have right-skewed distributions. A third explanation is that the expectations of the reproductive power model are attained only for groups that include a wide variety of foraging modes. This explanation is suggested by the observation that large groups with a single principle foraging mode (mollusks, the major clades of squamates, carnivores) are log-normal whereas those with a variety of foraging modes (birds and mammals) are right-skewed.

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**Eating something bigger than your head: Pleurocerid snails and River Darters, *Percina shumardi***

We report food habits of River Darters (*Percina shumardi*) in Brushy Creek and the Sipsey Fork Black Warrior River, Alabama, USA. River Darters preyed heavily on pleurocerid snails in both streams. Snail feeding varied widely among sample dates and was highest in October when snails represented nearly 100% of darter food items. Snail feeding declined through the spring, nearly ceasing by May, but increased to high levels again in July when hatchling snails composed about 80% of darter food items. Mean and maximum size of snails eaten increased with darter size, but minimum snail size was not related to darter size, indicating a broadening of prey size for larger darters. Non-snail food items were dominated by chironomid, trichopteran, and ephemeropteran insect larvae; these food items were most commonly eaten during periods of low snail feeding or feeding on hatchling snails. Specialization for snail feeding is suggested for all species in the subgenus *Imostoma*, including *P. shumardi*, but this feeding habit is well documented only for *P. tanasi*. Published diet studies for other species of *Imostoma*, including populations of *P. shumardi* from elsewhere in its range, did not document snail feeding; most other observations of snail feeding for the group are anecdotal. Few other darters or other fish species are documented to prey heavily on riverine snails. Although the limited amount of published information makes it difficult to assess the degree to which *Imostoma* as a group relies on snails as a food source, *P. shumardi* and *P. tanasi* represent two of the few native fishes that exploit the abundant and diverse pleurocerid snail fauna of eastern North America.

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**Elemental signatures in the vertebral cartilage of the round stingray, *Urobatis halleri*, from Seal Beach, California**

Although numerous studies have utilized elemental analysis techniques for age determination in bony fishes, little work has been conducted utilizing these procedures to verify age assessments or temporal periodicity of growth band formation in elasmobranchs. The goal of this study was to determine the potential of laser ablation inductively coupled plasma-mass spectrometry (LA-ICP-MS) to

provide information on the seasonal deposition of elements in the vertebrae of the Round Stingray collected from Seal Beach, California. Spatially resolved time scans for elements across the Round Stingray vertebrae showed peaks in calcium intensity that aligned with and corresponded to the number of seasonal growth bands identified using standard light microscopy. Higher signals of calcium were associated with the wide opaque bands while lower signals of calcium corresponded to the narrow translucent bands. While a close alignment between the numbers of calcium peaks and annual growth bands was observed in round stingray samples aged five years or younger, this relationship was less well defined in vertebral samples from round stingrays over 11 years old. To the best of our knowledge, this is the first study of its kind to utilize ICP-MS to verify age assessments and seasonal band formation in an elasmobranch. The results from this preliminary study indicate that LA-ICP-MS elemental analysis of the vertebral cartilage of the round stingray may have potential to independently verify optically derived age assessments and seasonal banding patterns in elasmobranch vertebrae.

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#### Ecology of the redbelly snake (*Storeria occipitomaculata*) in the Black Hills of South Dakota

The redbelly snake, *Storeria occipitomaculata*, is widespread across the eastern United States, with isolated populations in the Black Hills and Bear Lodge Mountains of South Dakota and Wyoming. We studied the ecology of the Redbelly Snake in the Black Hills in 2004 and 2005. Male to female ratio was 1:1.3. Females averaged 177.7 mm SVL ( $\pm 22.5$  mm SD; range = 101.0 - 234.0 mm; n = 102) and males 154.4 mm SVL ( $\pm 20.9$  mm SD; range = 92.0 - 197.0) mm; n = 79). Females were significantly longer than males ( $t = 7.094$ , n = 181,  $p < 0.05$ ). GPS readings taken at each capture or sighting provided data on general habitat associations. Redbelly snakes were found, on average, 13.8 m ( $\pm 20.53$  SD; range = 0.5 - 153) from water. Snakes were primarily found under cover (97%), with 2.5% foraging and 0.5% basking. Redbelly snakes were found under rocks (75%), wood (21%), and boards, tin, and other cover (5%). Average temperature under cover objects was 17.2 °C ( $\pm 4.5$  SD; range = 4.1 - 34.0) compared average ambient temperatures of 26.3 °C ( $\pm 6.5$  SD; range 11.5 - 41.0). Snakes were dimorphic for color with 59.9% grey phase and 40.1% brown phase. Few young snakes were found, with four collected August 24, 2004 and one collected August 18, 2005. Snakes were marked by a ventral scale clip. One recapture was recorded in both seasons. Vouchers were collected to examine stomach contents, analyze taxonomic features, and record species occurrence. Feeding trials of 51 snakes were conducted to determine food preferences. A GIS-based Boolean model was created to determine predicted and non-predicted habitat of redbelly snakes.

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Finding the right microhabitats, food, and physicochemistry for successful recruitment in bottomland hardwood floodplains

The Atchafalaya River basin (ARB) in Louisiana is the largest remaining floodplain in North America. The substantial ecological productivity present in temperate floodplains, like the ARB, has been linked to a dynamic combination of hydrological and geomorphological processes that result in seasonal inundation. The arrival of floodwaters creates new habitat, food resources and reproductive opportunities for fishes. Yet, the suite of physical factors that govern successful fishery recruitment in temperate floodplain ecosystems appears to vary considerably during the peak spawning times of many floodplain-dependent fishes. If larval survivorship is linked to specific physicochemistry and/or food availability, the most successful spawning strategy may require an ability for ichthyoplankton to tolerate variable physical conditions until optimal ones arise. To determine the critical factors driving recruitment in the ARB, we examined the distribution and abundance of larval and juvenile fishes in channels (both natural and man-made), isolated lakes, and newly inundated areas across the floodplain before and after the arrival of floodwaters. Zooplankton densities were also compared with ichthyoplankton populations to determine if food availability might regulate successful recruitment within dissimilar microhabitats.

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**\*HALSTEAD, BRIAN J.; MCCOY, EARL D.; STILSON, TERRI A.; MUSHINSKY, HENRY R.**

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Analysis of juvenile gopher tortoise (*Gopherus polyphemus*) foraging paths using correlated random walk models

Large adult gopher tortoises (*Gopherus polyphemus*) are nearly immune from predation, but juvenile tortoises experience high predation rates. Attaining rapid levels of growth through consumption of high-quality forage plants is imperative for young tortoises. Juvenile tortoises spend most of each day in their burrows, emerging only occasionally to forage, and when they do emerge must balance foraging requirements and predation risk. A juvenile tortoise could employ foraging tactics to either forage close to its burrow, allowing rapid retreat into the burrow and risking insufficient forage consumption, or forage farther from its burrow, allowing sufficient forage consumption and risking increased exposure to predators. Foraging paths of juvenile gopher tortoises were observed in the field and analyzed using correlated random walk models. Because of the central place foraging habit of the gopher tortoise, the sinuosity of foraging paths was compared to the sinuosity of an

optimal central place forager. Juvenile gopher tortoise foraging paths could not be distinguished from a correlated random walk, but mean squared displacement was greater than expected as individuals moved away from their burrows and less than expected as they returned. Sinuosity was less than expected for an optimal central place forager. Juvenile gopher tortoises travel a greater distance from their burrows when foraging than expected for a central place forager. Young tortoises may give up the security of remaining near their burrows during frequent foraging bouts to forage until satiation. Correlated random walk models provide a useful method for examining the demographic consequences of the movement behavior of individual tortoises.

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Long term effects of prescribed fire on reptile and amphibian communities in a Florida sandhill habitat

We examined the effects of fire frequency on reptile and amphibian communities defined at different spatial and temporal scales in a periodically burned sandhill habitat in west-central Florida. Herpetofaunal species abundances were measured using drift fence/pitfall trap arrays from 1984-87 and again in 2004. There were no significant differences in species richness, diversity, or evenness indices between years or fire frequency treatments. Community structure in 2004 was significantly different from the 1980s, but there were no differences between years from 1984-87. Abundance of most species was significantly higher in 2004 than in the 1980s. Data collected in 2004 also show significant differences between treatments of time since the last burn. Differences between burn treatments were characterized by three lizard species (*Aspidozelis sexlineata*, *Eumeces inexpectatus*, and *Scincella lateralis*), and were strongly correlated with mean percent leaf litter. Management of sandhill habitats with prescribed fire regimes that allow for high heterogeneity in habitat structure increase herpetofaunal species diversity.

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The effect of flood suppression on diet and competition of natricines

When disturbances commonly occur at intermediate intensity, organisms within the ecosystem may become adapted to the stochasticity. In floodplains, periodic flooding provides pulsed resources that some species can become dependent upon. To investigate the effect of disturbance suppression, this study compared the diet of natricine snakes when floods commonly occurred and when they were absent for a period of time in a bottomland forest. Natricine snakes, *Nerodia erythrogaster*, *Nerodia*

*fasciata*, and *Thamnophis proximus*, from the Old Sabine Bottom Wildlife Management Area in east Texas were palpated for prey items from 2000-2001 and 2003-2005. Individuals were grouped into either flood or no flood periods and prey items were classified as crayfish, salamanders and their larvae, anurans and their larvae, or fish. The prey diversity, frequency of prey type consumed, and importance value of prey types were compared between flood and no flood periods. The Pianka index was used to compare differences in competition between species in the years with floods and those without. When floods did not occur, fish were absent from the diet of all three species examined. Thus, in the absence of floods, the number of prey types consumed by *N. erythrogaster* and *T. proximus* decreased, and although the number remained the same for *N. fasciata*, composition of prey types changed. The frequency of prey types consumed during flooded years was significantly different from the period of flood suppression for all three natricines. Anurans were the most important prey type for all three snake species regardless of flooding events. The order of importance of the other three prey types shifted in the absence of floods. The prey overlap between *N. erythrogaster* and the other two species was relaxed in the absence of floods. For *N. fasciata* and *T. proximus* the prey overlap doubled.

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How much land do desert tortoises (*Gopherus agassizii*) in the Mojave Desert need?

Home range estimation is an important tool in managing areas for the conservation and recovery of endangered animals such as the desert tortoise. This study was designed to have a large sample size and high numbers of relocations in an effort to better define the home range of the desert tortoise (*Gopherus agassizii*) in the West Mojave Desert, CA. Past studies on the desert tortoise have used irregular spaced sampling regimes with a low number of relocations per individual. Several of these past studies on desert tortoises have found that small sample sizes obscure what may be statistically relevant information, such as differences between males and females. During our study, thirty-five adult tortoises (21 male, 14 female) were intensively monitored throughout 2004 and 2005. The resulting sample sizes are two or more times larger than that of published studies on desert tortoises. Using an ANCOVA model, with carapace length as a covariate, minimum convex polygon values were not significantly different between years ( $F=1.65, p>0.05$ ), but values were significantly different between the sexes ( $F=56.64, p<0.05$ ). Past studies have not found a correlation between tortoise size and size of home range and have concluded that this may be because of small sample sizes. A significant correlation between carapace length and home range size was not observed using this ANCOVA model ( $F=2.22, p>0.05$ ) on our larger data set. Our estimates of home range size for desert tortoises are close to two times larger than published mean home range values from

other studies, possibly due to the larger sample sizes and more frequent locations per individual. Data will be presented recommending a minimum number of samples for accurate representation of home range using minimum convex polygon. These estimates of home range more accurately represent total land usage by the desert tortoise and will be useful in recovery and management of the species.

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#### Morphological and molecular characters applied to *Gobiodon* phylogeny (Teleostei: Gobiidae)

*Gobiodon* species are commensal fishes living in association with mainly acroporid corals of the tropical Indo-Pacific. The genus contains about 17 valid species, although there are several undescribed forms. A well-supported phylogenetic tree would be an aid in our studies of evolutionary processes. We recently developed a phylogenetic dataset containing portions of the 12S and 16S rRNA regions of the mitochondrial genome. To solve the problem of poor resolution, particularly in the basal parts of the phylogeny, and to bring to bear on the problem all available evidence, we surveyed 24 morphological characters for a morphologically based analysis, and for incorporation with the sequences in a total evidence analysis. These characters were mainly osteological, but some from pigmentation patterns and other body components were also used. Outgroups for the analyses were *Paragobiodon echinocephalus*, *P. xanthosomus*, *Ctenogobius shufeldti*, *Dormitator maculatus*, and *Eleotris amblyopsis*. Similar levels of overall support were obtained for each partition of the analyses: morphology (2 trees, CI = 0.6222), molecules (2 trees, CI = 0.6199), morphology and molecules combined (2 trees, CI = 0.6117). The principal difference in topologies is the relative position of a clade containing *G. acicularis*, *G. ceramensis*, *G. citrinus*, and *G. okinawae* with respect to another containing *G. quinquestrigatus* and *G. rivulatus*. The morphologically based analysis places the *acicularis* group basal-most in the genus, with the *quinquestrigatus* group at the next level higher in the tree, whereas the molecular and total evidence analyses have these two clades switching places. The molecular characters evidently outweighed the morphological characters with respect to the relative placement of those two clades. Morphological characters provided needed resolution for interrelationships among some of the more derived clades within *Gobiodon* for which there were few applicable characters from the molecular data.

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### Density dependence in the terrestrial life history stage of two anurans

Populations of species with complex life cycles have the potential to be regulated at multiple life history stages. Previous studies have demonstrated strong density dependence in the aquatic stages of many pond-breeding amphibian species and have often assumed that populations are regulated at this life history stage. Theoretical modeling has shown that this assumption, if found to be untrue, could lead to drastically different conclusions about population regulation in species with complex life cycles. To determine the effects of population density on survival, growth and reproductive development in the terrestrial life history stage of pond-breeding amphibians, I raised juvenile wood frogs (*Rana sylvatica*) and American toads (*Bufo americanus*) at six densities in terrestrial enclosures. A total of 48 enclosures were stocked with individually marked juvenile wood frogs in 2004 and with American toads in 2005 at densities ranging from 1 to 10 individuals m<sup>2</sup>. Growth and survival were monitored at three week intervals throughout the summer and early fall. Animals were removed from enclosures after one year and dissected to determine sex and reproductive condition. Density had a strong negative effect on both growth and survival. Animals raised at the lowest densities experienced growth and survival rates over twice as great as those raised at the highest density. Terrestrial density also had a strong effect on reproductive development in males and females of both species. Male wood frogs reached reproductive maturity within a year only in the lowest density treatments. Highly convoluted oviducts, an indication of reproductive development in females, were seen only in wood frogs that experienced densities lower than 2 frogs m<sup>2</sup>. These results demonstrate that density in the terrestrial life history stage of amphibians can impact growth, survival and reproductive development and may play an important role in amphibian population dynamics.

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### Dietary drift during darter diversification

The ecological relationships between species competing for similar trophic resources have long been a topic of interest in the study of darter (Etheostomatinae) natural history. Many published studies have sought to assess the degree of dietary overlap among co-occurring populations of darter species. In spite of this attention over the past several decades that has documented varying degrees of trophic partitioning in darter communities, there has yet to be revealed an underlying rule guiding these relationships among darter species. The niche conservatism hypothesis suggests that species derived from a more recent common ancestor should share more ecological characteristics due to greater morphological similarity and shared evolutionary

histories. In this study, I have gathered diet data from the literature for approximately 75 darter species, in an attempt to analyze this ecological character from a broad evolutionary perspective. Combining this dietary data with information from a fossil-calibrated molecular phylogeny, I apply the estimated node ages and phylogenetically weighted dietary overlaps for each node in the darter tree to test for a relationship between divergence time and similarity of diets. As the mode of speciation in the darter radiation presumably has been allopatric, my goal is to test if ecological traits of darter species, such as diet, have a tendency to 'drift' through evolutionary time.

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### Evolution of the female dewlap in *Anolis* lizards

The theory and study of the evolution of visual signals has progressed considerably in recent years. Studies focusing on the use of male signals to influence mate selection are common; however few studies have focused on signal use in females. *Anolis* lizards present an excellent opportunity to explore the ecology and evolution of female visual signals because they demonstrate a wide variety of habitat specialization, life histories, and male dewlaps — a region of gular skin that can be held erect to display colorful skin and scales. Extensive literature on the function of the male dewlap has set the stage for the examination of female dewlaps, which also vary substantially in size and color. We hypothesized three functions of the female dewlap. First, it may aid in species recognition in diverse communities. Second, it may play a role in attracting mates in species where males exercise mate choice, and may be unnecessary in species where female choice is dominant. Finally, the female dewlap may be a byproduct of selective pressure for a large male dewlap. To test these hypotheses we gathered data on 240 species of *Anolis* including 1) presence/absence of the female dewlap, 2) size of the male dewlap (large or small), 3) degree of sexual size dimorphism, and 4) whether the species is the solitary inhabitant an island or if it occurs in a multispecies community. We tested hypotheses of character correlation on a phylogeny of *Anolis* using modern comparative methods.

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### Recent renovations in herpetology and ichthyology at the Museum of Comparative Zoology (MCZ)

In recent years, extensive renovations that facilitate collection storage and collection-based research have taken place at the MCZ, including in the Departments of Ichthyology and Herpetology. Renovations to the predominately spirit collections began with an NSF-funded project in Herpetology that was completed in 2004, and continue today in both departments funded with MCZ and University funds. The MCZ collections span multiple contiguous buildings that were constructed independently from 1859 to 1889. This proud history presents special considerations when modernizing, and the collection-area renovations are addressing all historical and current concerns, including collection storage expansion (increased available lineal shelving by 30 to 78% depending on room configuration; tank-rack storage holding over 50 tanks), storage efficiency (new tank-rack designs for both departments, including a composite large and small tank-rack unit), as well as infrastructure concerns (removal of old brick and concrete floors to accommodate compactor rails). The resulting collection benefits for Ichthyology include two of the six renovated collections rooms which store almost one-half of the 1.3 million fishes in the MCZ, including the vast mid-water collection. In Herpetology, the renovation of the last collection ("lizard") room will allow the incorporation of the extensive anoline lizard holdings (48,000 specimens representing 85% of the known taxa) previously stored in the departmental library. The overall goal for the museum is to continue to use the most efficient storage technology to maximize the available space to provide for the maintenance of its valuable collections to promote research. Along with the collection-area improvements, other facility renovations, including the installation of an automontage imaging system and a new digital x-ray unit, will promote collections and enhance the research capabilities at the MCZ.

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### The role of temperature in habitat selection by Eastern Massasauga rattlesnakes in Ontario

Temperature should be one of the most important factors influencing habitat selection in terrestrial ectotherms, because physiological processes depend on body temperature and body temperatures depend primarily on the habitats they occupy. The importance of temperature in habitat selection should be amplified in cool climates and for ambush predators, which must select habitats warm enough for them to detect and strike prey quickly. Using 4 years of telemetry data from 34 individuals, I investigated the role of temperature in habitat selection by eastern

massasauga rattlesnakes (*Sistrurus c. catenatus*) on the Bruce Peninsula, Ontario, near their northern range limit. Consistent with theory, snakes thermoregulated less accurately (i.e., body temperatures were further from preferred levels) when environmental temperatures were low, but thermoregulatory effort (i.e., how close body temperatures were to preferred levels, relative to environmental temperatures) varied with environmental temperature in different ways for different snakes. In general, lethally low temperatures were a lesser concern for snakes during the active season than temperatures routinely too low for basic functions like prey capture and reproduction. Gravid females altered habitat use (i.e., used less forest cover and basked more) when necessary to maintain suitable body temperatures for embryogenesis. Males and nongravid females did not make similar adjustments, and in fact became more cryptic when environmental temperatures were low. Gravid females may be required to bear the costs of high thermoregulatory effort (e.g., reduced foraging success, increased predation risk) to reproduce successfully in an environment with a short and cool active season. Cold incubation conditions, a short time window between parturition and hibernation, and cold overwintering conditions likely result in high rates of neonate mortality, possibly limiting the northern distribution of massasauga rattlesnakes.

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A reappraisal of South American *Dipsas* (Serpentes: Colubridae)

A review of South American *Dipsas* identified several new characters of squamation, coloration, morphometrics, and hemipenial and visceral morphology. Lung morphology is more variable and informative than previously thought, whereas hemipenial morphology is relatively conservative among Dipsadini. Alizarin staining of hemipenes revealed previously unreported structures and allowed for more accurate assessment of calcification patterns. The suite of new characters allows a reappraisal of existing species groups and alpha taxonomy of species complexes. Phylogenetic analysis of the new characters improves our knowledge of dipsadine relationships.

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The utility of Cytochrome c Oxidase subunit I (COI) for species identification and phylogeny reconstruction within Cypriniformes (Actinopterygii; Teleostei)

Cytochrome-c-oxidase-subunit-I (COI) is a mitochondrial gene that appears to possess a greater range of genetic diversity and phylogenetic signal than many other mitochondrial genes, making it a potentially useful tool for phylogeny reconstruction and a barcoding locus. COI has been targeted for an international effort by the Barcoding Consortium for inventorying genetic diversity. This gene region (approximately 700 base pairs) has served as a useful molecular marker because it is easily amplified and sequenced, and has the potential for discrimination at the species level. Phylogenetic data have been obtained for this COI gene region from a broad range of cypriniform fishes for phylogeny reconstruction and its utility in species discrimination. The Cypriniformes is the largest order of freshwater fishes and includes many critically important fishes in many cultures as a food resource, are very important components to many aquatic communities, and include many invasive species that have had major impacts on their non-native communities. The use of genetic tools for identification of invasive species and in forensic efforts, as well as in phylogeny reconstruction has prompted the Cypriniformes Tree of Life (CToL) initiative to investigate the utility of COI as a useful genetic marker. Our preliminary analyses include a few hundred individuals and have focused on those species in the family Cyprinidae. Separate and combined phylogenetic analyses derived from COI and other genes will be provided, as well as comparative statistics as to the utility of this gene and others in species identification. This comparative approach will be used to infer the accuracy of COI for species identification and to determine how well the resulting phylogeny corresponds with previously published and concurrent representations of the same taxa using other gene regions. This study is part of an NSF REU initiative in Cypriniformes Tree of Life.

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Major histocompatibility complex (MHC) variation in the European fire-bellied toad (*Bombina orientalis*)

The Major Histocompatibility Complex (MHC) is part of the immune system of vertebrates and variation in the MHC-encoding genes has been found to be associated with parasite resistance and other measures of fitness. In recent years, determining the variability of this coding region has become a well-established

approach in population genetic studies of fish, birds, and mammals. However, MHC has been investigated in but a few species of amphibians. As part of a large population genetic study using neutral genetic markers, we have characterized a region of MHC II exon 2 in the fire-bellied toad using a combined genomic and cDNA approach. We examined the allelic variation in 45 individuals from nine populations from the Baltic region with different demographic histories. Whereas a few abundant alleles were found in many populations, other alleles were geographically restricted or found in only a single population. Loss of allelic variation was clearly identifiable in bottlenecked populations. We are comparing the level of genetic variation found in this coding region with that found at presumably neutral loci.

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The effectiveness of man-made populations in preserving genetic variation in the European fire-bellied toad (*Bombina orientalis*)

In order to preserve the genetic material of six of the remaining *Bombina* populations in Denmark, mirror populations from each of these have been established in Denmark over the last 25 years. In addition, four sites in Sweden, where *Bombina* had gone extinct in the 1960s, were stocked with *Bombina* in the 1990s. For the Swedish populations, toads were mixed from different Danish source populations. Using 17 microsatellite loci and mtDNA control region sequences, we found that in all translocation scenarios, except for one, there was no significant difference in the amount of genetic variation between source and man-made population. We found higher genetic variation in the Swedish populations of mixed Danish origin compared to the Danish mirror populations which had been stocked from only a single population. It also became apparent, that the Danish source populations contributed unequally to the current populations in Sweden. We will be discussing, how genetic diversity of these populations compares to their fitness measured as population growth and hatching success. We found that one Swedish population not only differs significantly from its source populations in respect to the nuclear markers, but that it also contains a mtDNA haplotype at high frequency which we did not find in any other Danish, German, or Northeastern European *Bombina* population we examined. These findings suggest that this population contains genetic material of very different origin and we propose that toads from outside Northeastern Europe have accidentally been released at this Swedish site.

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Field metabolic rate, stamina and survival of male lizards with alternative mating strategies

Male side-blotched lizards (*Uta stansburiana*) in Los Banos, CA exhibit three alternative mating strategies (ultra-dominant, mate guarding, and sneaking) that are genetically controlled and associated with throat color (orange, blue, and yellow, respectively). This variation in reproductive behavior can be expected to influence the lizards' energy needs and physiological performance in the field. During the breeding season, we measured maximum sprint speed and stamina of over 200 just-captured male *Uta* in the laboratory, and then injected them with doubly-labeled water and released them at their home territories to measure field metabolic rate (FMR) and water turnover. 89 lizards survived to be recaptured an average of 28 days later, and 48 of those survived to a second recapture another 19 days later. Lizards with higher stamina were more likely to survive; survivorship was not influenced by throat color or FMR. Mass-adjusted FMR and water turnover were higher during the first measurement period, and there was a slight but significant effect of throat color, with orange males having the lowest FMR and blue-yellow heterozygous males having the highest. FMR is therefore influenced by genotype (mating strategy) and may also be affected by the social environment in which the lizard is found.

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Differential thermoregulation in free-ranging cottonmouths *Agkistrodon piscivorus*

Body temperatures of snakes have been shown to affect such diverse physiological processes as digestion, immune response, and growth and development. However, little detailed information is available about the inactive season body temperature regimes of free-ranging snakes. In particular, differences in inactive season thermal profiles among individuals and between sexes are not well defined. Such information could be important in explaining characteristics such as annual energy allocation and patterns of mortality. I studied the thermoregulatory habits of the cottonmouth (*A. piscivorus*) in Tuskegee National Forest in eastern Alabama using a combination of several techniques including coelomically implanted temperature-sensitive radio transmitters and coelomically implanted semi-continuous temperature data loggers. I

located animals and recorded body and environmental temperatures through the late active season and inactive season 2005-2006. I observed significant differences in mean body temperature maintained by snakes both within and between sexes. Within sexes, some individuals exhibited relatively high mean temperatures while others exhibited relatively low mean body temperatures. Between sexes, males maintained lower mean body temperatures while females maintained higher mean body temperatures. In general, males exhibited body temperatures that were similar to the lowest available body temperatures while females exhibited body temperatures toward the upper range of available body temperatures. Additionally, females showed more precise thermoregulatory behavior exhibiting relatively low variation in body temperature as compared to males. I propose that observed intersexual and intrasexual differences in mean body temperature and thermoregulatory precision represent different strategies for energy allocation that may be dictated by differences in body condition, health, growth, and reproductive development.

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#### Water clarity and predator avoidance in reef fish

Human activities on land have multiple negative impacts on reef communities. Most attention has focused on the effects of excess sediment on the health of hermatypic corals. We investigated the possible impacts of altered water clarity on reef fishes in the field at Cabo Blanco, Costa Rica. We measured the tendency of a prey species, the flag cabrilla *Epinephelus labriformis*, to engage in predator avoidance behavior across a gradient of underwater visibility. We presented a known, frightening stimulus, the *face of death*, to cabrilla of different sizes and measured initial reaction and flight as the frightening image was moved closer to the prey species. We found that cabrilla reacted sooner to (at a greater distance from) the frightening image when water clarity was reduced. Younger fish were more sensitive than larger fish, reacting at a greater distance when water clarity was poorer. These results suggest that anthropogenic degradation of reef environments such as increased sediment inputs could impose costs on reef fishes in terms of lost energy and activity time.

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Serum levels of steroid hormones in captive adult male sand tiger sharks, *Carcharias taurus*, and their relation to sexual conflicts

Levels of the reproductively-related steroid hormones 17-estradiol (E<sub>2</sub>), progesterone (P<sub>4</sub>), testosterone (T), and 5- dihydrotestosterone (DHT) were determined via standard radioimmunoassay from sera obtained from captive male adult sand tiger sharks, *Carcharias taurus*. Results were obtained from samples collected twice yearly from 1988 to 2000 from male sharks at the National Aquarium in Baltimore (NAIB) and SeaWorld Orlando (SWO). These samples provided a reasonable comparison between a reproductively active (NAIB) and a reproductively inactive (SWO) captive population, especially during periods of overlap in sampling times, April, September, and November. Significant elevations were found in SWO males for T and DHT in November and in NAIB males for P<sub>4</sub> in April. Serial samples, collected from three male sharks at NAIB for 17 months in 2001-2002, yielded monthly variation in steroid levels as well as individual variation between male sharks involved in sexual conflicts within the dominance hierarchy. Mean levels of T peaked in November at  $19353.3 \pm 8399.7$  (SE) pg/ml declining to  $930.0 \pm 317.9$  (SE) pg/ml in May, and DHT followed this pattern peaking in October at  $803.3 \pm 328.4$  (SE) pg/ml and reaching its lowest level in June at  $10.0 \pm 0.0$  (SE) pg/ml. Mean levels of P<sub>4</sub> peaked in January at  $1343.0 \pm 637.6$  (SE) pg/ml, and declined to undetectable levels in August. Mean levels of E<sub>2</sub> peaked in January at  $6136.5 \pm 4197.3$  (SE) pg/ml and declined to its lowest levels in June to  $20.0 \pm 5.5$  (SE) pg/ml. Hormone concentrations at the individual shark level reflected both its place in the dominance hierarchy and specific behavioral characteristics associated with the sexual conflicts.

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Does size really matter? The effects of atrazine and competition on growth in the axolotl, *Ambystoma mexicanum*

We used the ambystomatid salamander *Ambystoma mexicanum* (the axolotl) to test the hypothesis that atrazine, in combination with density as an environmental stressor, affects growth, development and gene expression. Axolotl makes an excellent toxicological model system: they have high fecundity, have minimal housing

requirements relative to other model vertebrates, include genomic and bioinformatics resources, and are part of a group of lineages that are broadly distributed among North American habitats that are exposed to endocrine disrupting chemicals. We used density as a natural environmental stressor in combination with sub-lethal doses of atrazine. We analyzed growth data that was collected periodically throughout the 3 months of the experiment. Our experimental procedure and design consisted of 195 salamanders that were exposed to 9 treatments of varying densities and atrazine concentrations in 5 separate blocks, all contained within a single cooler to regulate environmental conditions. Atrazine treatments include a control, 1ppb, and 5 ppb; densities were 1, 4 or 8 salamanders per box. Increased density caused a significant decrease in growth. The effects of atrazine on growth were less dramatic than those induced by density variation. No interaction effects on growth were evident. Gene expression profiles were significantly different among all treatments.

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Can omnivores be dietary specialists? Adaptability of gut form and function in an omnivorous lizard.

Omnivory is often considered a jack-of-all-trades dietary strategy that allows some animals to exploit a variety of food items. However, the extent to which omnivores adaptively regulate gut form and function in response to different diets has not been widely investigated. When reared on specialist diets, do the digestive systems of omnivores respond like specialists, or are they constrained by the jack-of-all-trades/master-of-none paradigm? We raised 5-6 wk old omnivorous bearded dragons (*Pogona vitticeps*) for 20 wk on either a diet of ground alfalfa (herbivore), crickets (carnivore), or a 50/50 mix of both (omnivore). We compared aspects of gut form (histology, mass, surface area) and function (passage rate, apparent digestive efficiency, rates of nutrient transport) and used rates of growth as a measure of whole-animal digestive performance. After correcting for body size there was no effect of diet on surface-area measurements of gut sections or stomach mass. Herbivores had relatively smaller small intestines than both carnivores and omnivores, and smaller large intestines than carnivores, but not omnivores. Carnivores had longer intestinal villi than either herbivores or omnivores. Herbivores had higher rates of nutrient transport and total gut transport capacity for an amino acid and a sugar than carnivores, but similar rates as omnivores. Herbivores grew slower than omnivores, but had faster growth rates than carnivores. We show that increased nutrient uptake capacities translated into differences in growth rate among treatments. Although bearded dragons exhibited the physiological capacity to exploit both plant and animal foods, differences in growth rate indicate a selective advantage for omnivory. These results are counterintuitive because high-protein diets (i.e.,

carnivory) generally elicit the fastest rates of growth. Consequently, dietary generalists may be more specialized than previously considered.

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**\*HERZOG, DAVID P.; BARKO, VALERIE A.; HRABIK, ROBERT A.; OSTENDORF, DAVID E.**

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**The mini-Missouri trawl: A useful methodology for sampling small bodied fishes in small river systems**

Sampling has been conducted throughout the Midwest and southeastern United States to determine the usefulness of the mini-Missouri trawl designed to increase species detection of small-bodied fishes in small river systems. We modified the Missouri trawl, which is a 4.8 m standard two-seam slingshot balloon trawl covered with a small mesh cover, by reducing the size to a 2.44 m trawl and cover. The modified Missouri trawl (a.k.a. the mini-Missouri trawl) increased the number of species of small-bodied fishes captured over previously used gears in systems such as the Marais De Cygnes (MO), Osage (MO), St.Croix (MN), Minnesota (MN), Black (MO, AR, WI, MS), Platte (NE) and Pascagoula (MS) Rivers. For instance, Speckled Chubs (*Macrhybopsis hyostoma*) had only been captured in the St. Croix River of MN at three locations since 1960, yet we sampled them at 14 new locations in September, 2004 employing this methodology. Because of our success in small river systems throughout the Midwest and southeastern United States, we believe this is a useful methodology for sampling the benthic fish community in small river systems when other sampling methods are difficult to use because of high water depths and/or velocities.

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**HEUPEL, MICHELLE R.**

*Mote Marine Laboratory, Center for Shark Research, Sarasota, FL, 34236, USA*

**Shark tracker: An interactive aquarium display for public education**

Using state-of-the-art technology to study marine species results in an ever changing knowledge base among scientists and managers that may or may not reach the public. Mote Marine Laboratory and Aquarium have attempted to address this issue by building an interactive aquarium exhibit for public display and informal education. The exhibit is based on research conducted to monitor the long-term movement patterns of juvenile sharks inside a coastal nursery area in Florida. To demonstrate this research a live animal aquarium exhibit is being constructed to mimic shark monitoring efforts. Interactive animations of shark movements from the actual study are integrated into the exhibit and available on the internet for use by the public and school groups. Incorporating this simple, intuitive and interactive display into an aquarium exhibit enables learners of all levels to comprehend how

the project works and understand the results. This highly visual, interactive exhibit provides a unique and intuitive learning experience for school groups and adults who visit the Mote Marine Aquarium. The author encourages scientists to consider informal science education efforts via in house displays or on-line content to help educate the public on new advances in marine technology and to keep them interested in advances in coastal ecology and marine biology.

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Shark nursery areas: Concepts, definition, characterization and assumptions

The implications of defining critical habitat for fishes are becoming more widespread as coastal resources are increasingly impacted. Proper definition of these areas is critical to fostering a common understanding of what is meant by an ecological term. The term nursery area is one of the more ambiguous terms in fish habitat studies and has been the subject of several recent papers regarding the definition of these regions for teleost fishes. Often cited literature concerning shark nursery areas involve descriptions by authors such as Springer and Bass which may have not been intended to provide the definitive description of these regions. We examined the historical literature, current literature and potential definitions of nursery area currently published for elasmobranchs and teleosts. Based on this information we address some of the assumptions about the function of nursery areas and suggest criteria for assessing whether a region acts as a nursery. The importance of definition of shark nursery areas has increased in the last decade with the implementation of concepts such as Essential Fish Habitat. This trend is likely to continue, so providing a unified definition of what constitutes an elasmobranch nursery area will be critical for proper management and understanding of coastal species.

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A river runs: Examination of habitat use and response to freshwater flow by bull sharks

To examine the use of river areas by large, mobile predators we examined the residency and movement patterns of juvenile bull sharks within the lower reaches of the Caloosahatchee River. A series of 23 acoustic receivers was deployed within the Caloosahatchee River to define how much of this section of the river bull sharks used

and how use of the river changed through time. Sharks captured within the river were fitted with acoustic transmitters to allow their movement patterns to be tracked. Movement data were compared to environmental conditions within the river including water temperature, salinity and flow rate. A collaborative effort between the South Florida Water Management District and Mote Marine Laboratory scientists has provided a unique opportunity to examine the movements of mobile animals in response to freshwater releases into the river. Bull sharks are capable of tolerating full freshwater conditions and are physically able to swim the length of the river and/or leave the river system. Data collected from monitored sharks revealed that sharks stay within the river for extended periods of time and tend not to move into adjacent estuaries. Sharks have been monitored within the river for periods of 5 to 389 days. Sharks tended to use a small portion of the river during the course of a day with typically less than 5 km of the river used during a single day. Differences in the amount of the river used through time suggest small changes in habitat use, with sharks typically not moving larger distances from one day to the next. Examination of salinity within the river suggests that shark movements are correlated to river salinity level. Data from 2003 (a high freshwater flow year) and 2004 (a lower freshwater flow year) were compared to examine differences in river usage. Current data suggest that freshwater flow in the river has a direct effect on how bull sharks use the river and how much of the river they traverse.

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Your first stop for *Leptodactylus* (Amphibia: Leptodactylidae) literature searching

A bibliography of all published names of *Adenomera* and *Leptodactylus* species is being assembled and entered into the bibliography software program EndNote®. The starting point was a 3x5 inch card bibliography assembled by one of us (WRH) starting in 1966 that relied mostly on Zoological Record to obtain citations. We are processing bibliographies of papers containing *Adenomera* and *Leptodactylus* citations as the citations are entered into EndNote®. We started with about 2,000 3x5 inch card citations. We now have over 3500 references in EndNote®, which we think is well over half the total number of citations we should eventually obtain. At this point, there is enough information for researchers interested in literature on the frog genus *Leptodactylus* to begin their query using our database. We give an estimate of where we are in the process, provide examples of contributors with the most *Leptodactylus* publications, the most cited species, and the topics that have received the most published attention. We also provide information on how to access our database through the *Leptodactylus* website at <http://learning.richmond.edu/Leptodactylus/index.cfm>.

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## **HIBBITTS, TOBY J.**

*Texas Cooperative Wildlife Collections, Dept. of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX, 77843-2258, USA*

### Sexual selection in the Common Barking Gecko (*Ptenopus garrulus*)

The Common Barking Gecko (*Ptenopus garrulus*) is a medium sized, fossorial lizard found in the arid areas of western, southern Africa. They are best known for the distinctive clicking call that is made in the summer months at dusk. I studied two aspects of sexual selection in *P. garrulus*. First, I tested whether resident male geckos aggressively respond to a calling intruder of a known calling frequency in this experiment I played a standard recorded call to actively calling males. The behavioral and vocal responses of the resident male were recorded and examined in the context of body size, call frequency, and throat patch size. Second, I asked whether females bred with males that called at lower frequencies. Through field observations of a focal population of geckos, I determined the number of breeding occurrences for individual male geckos over a 2.5 month period. I discuss the features of males that successfully bred with females in comparison with a wider pool of unmated males.

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## **\*HICKERSON, CARI-ANN M.; ANTHONY, CARL D.; WALTON, B.M.**

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### Interactions among top-down regulators in forest-floor food webs: Preliminary results of a predator removal study

Red-backed salamanders, *Plethodon cinereus*, are small forest-floor predators that directly affect the density of invertebrates in detrital food webs. As a result of their large biomass, predation by individuals of *P. cinereus*, can have cascading effects throughout forest-floor food webs thus affecting rates of leaf litter decomposition. Recent behavioral studies suggest that *P. cinereus*, may also interact with large predacious invertebrate guild members through competition and intraguild predation (IGP). The synergistic relationship between competition and IGP among forest floor predators as a driving force in terrestrial trophic cascades within detrital food webs has not been investigated. Our research was conducted to explore how removal of focal predators from open field plots influences densities of competitors and of organisms at lower trophic levels. 288 artificial cover objects (ACOs) were divided into eight replicated blocks containing three removal treatment groups: salamander removal (SR), centipede removal (CR) and all predator removal (PR) and one control group: no animals removed (NR). The ACOs were placed in the Cuyahoga Valley National Park (NE Ohio, USA) and the site was visited every two weeks for 2-years. To date we have removed 801 individuals of *P. cinereus*, 558 spiders, 309 centipedes and 190 predatory beetles. Measured abiotic variables do not

appear to differ among treatments, and so are unlikely to contribute to differences in predator density among treatments. Preliminary data analyses suggest that there are more salamanders in CR plots than in the other plots and during year one there was a significant treatment effect on spiders. There were more spiders in control (NR) plots compared to predator removal (PR) plots. These data suggest that the method of treatment manipulations is effective and removals are working. An overview of the first 2 years of data collection will be presented.

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(PLF) *Dept. of Palaeontology, The Natural History Museum, Cromwell Rd., London, SW7 5BD, United Kingdom*

### Fossil marine arowanas and the biogeography of the family Osteoglossidae

The biogeography of the basal teleostean group Osteoglossomorpha is thought to be intimately tied to Earth history since all extant members are primary freshwater fishes found on Gondwanan continents. In this presentation we will describe two new fossils representing marine members of the family Osteoglossidae (one from the Paleocene of Saudi Arabia and one from the Eocene of England), as well as new records of known marine fossil taxa. We will then critically review the taxonomic placement of all putative fossil osteoglossid genera to conservatively establish minimum ages of the family and the crown members of the subfamilies Arapaiminae and Osteoglossinae. Fossil crown group osteoglossines are not reliably known. Crown group arapaimines can be dated reliably to the Paleocene, but the lineage must be at least as old as Campanian, the age of the oldest stem osteoglossine (*Cretophareodus*). Several marine taxa probably belong to the osteoglossine lineage and since these do not form a monophyletic group it is possible that the distribution of *Scleropages* and *Osteoglossum* involved a marine phase. The family Osteoglossidae must be at least as old as Cenomanian (based on the oldest notopteroid, *Palaeonotopterus*) and there may be stem representatives known as far back as Early Cretaceous but more evidence is needed. The minimum ages calculated for the various key cladogenetic events of osteoglossid history are considerably younger than those proposed in a recent molecular study.

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A very easy technique to remove stomach contents without killing frogs

Stomach contents of anurans can be easily extracted by forced regurgitation with forceps. This method is called "stomach reversing". We will introduce this new technique to extract stomach contents from living anurans and demonstrate how easy this technique is. Dissection should not be done from the perspective of anuran conservation. Stomach flushing has been used to collect stomach contents from anurans. Stomach flushing is a reliable technique but really troublesome. The technique we originally devised is much easier than stomach flushing, and can quickly remove stomach contents from an individual anuran within just several seconds. A weak point is that the technique needs craftsmanship: it requires some time to learn. If this weak point is overcome, anyone can easily collect a large number of anuran diet samples. So far, we have collected diet samples from more than 5000 individual anurans. This technique will be a major breakthrough in dietary studies of anurans. The diffusion of this technique will facilitate diet analysis and accordingly contribute to expanding our knowledge of anuran food habits.

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**HIRT, M. VINCENT**

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Formation of the transverse plate in the Weberian apparatus in white suckers, *Catostomus commersoni*

The Weberian apparatus, composed of modified bony elements of the first four vertebrae, is the defining character of otophysan fishes, a highly successful clade of freshwater fishes. Suckers (Family Catostomidae) have evolved an additional large, bony element called the transverse plate. The adult form of the plate has been well documented but the formation of the plate has not. This study investigates the formation of the Weberian apparatus, especially the transverse plate, in relation to the surrounding tissues in *Catostomus commersoni*. Larvae and juveniles were collected from the field during the spring and summer of 2005. Whole specimens were cleared and double-stained for cartilage and bone and other specimens were serially sectioned for histological evaluation. The critical size in Weberian apparatus formation in *Catostomus commersoni* is between 13mm and 16mm SL. During this period a paravertebral space which is continuous with the intracranial space forms, enlarges, and fills with mesenchyme. The myosepta of the surrounding muscles play important role in the formation of some of the bony elements of the Weberian apparatus. This is especially noticeable with the transverse process on the second vertebra which forms within connective tissue of the horizontal septum. The transverse process also undergoes a reorientation during formation from a horizontal

to a more upturned orientation. The face of the transverse plate runs perpendicular to the length of the vertebral column dorsal to the fourth vertebra with processes extending dorsally to the second and fourth vertebra. Ossifications of condensed mesenchyme between the medial margin of the hypaxial muscle and the lateral margin of the pronephric kidney form the ventral portions of the transverse plate.

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**\*HOEINGHAUS, DAVID J.; WINEMILLER, KIRK O.; AGOSTINHO, ANGELO A.**

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**Structure of diverse tropical river food webs: Landscape determinants, introduced species and ecological efficiency of exploited systems**

Multiple factors may influence food web properties, and the relative importance of each likely differs among ecosystems. Few food web studies and even fewer mathematical models used to develop food web theory have addressed biologically diverse systems. Here we report findings from our research on diverse food webs of the Paraná River basin, Brazil. Stable isotopes were used to construct energy flow webs in different habitat types across the basin. A suite of landscape factors was used to examine variation in maximum food chain length and the relative importance of basal carbon sources among webs. Trophic positions of dominant fish species were examined for trends among native, dispersed (from elsewhere in the basin), and exotic species. Species trophic positions, commercial values and fisheries catch data were used to examine ecological and economic efficiency of these commercially exploited food webs. Food web structure was in large part determined by habitat type. Reservoirs were characterized by longer food chains leading to top predators that are exotic species. Food webs of high-gradient rivers are more strongly based on allochthonous carbon sources, but differ little in food chain length from low-gradient river food webs. Dispersed and exotic species were not generally established in high-gradient rivers, and when present in low-gradient rivers, occupied lower trophic positions than in reservoir food webs. Exotic species of low commercial value and high trophic position are important components of commercial fisheries of reservoirs, reflecting both low ecological and economic efficiency. Our results suggest that river impoundment in this diverse Neotropical basin has dramatically affected food web properties such as food chain length and ecological efficiency, and at the same time reduced the economic efficiency of these exploited webs. These patterns may be attributable in part to the relative ease of exotic species to colonize and become established in reservoirs.

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**HOESE, DOUG F.**

## Relationships of gobioid fishes living in association with alpheid shrimps

Approximately 100 species of gobioid fishes live in association with alpheid shrimps. The shrimps dig the burrow and the gobies provide sentry duty. Little is known of the evolution of the association or whether all genera of gobioid fishes involved evolved from a common ancestor. Three distinct monophyletic groups are recognizable in the Indo-Pacific and one in the western Atlantic. Evidence does not support monophyly with the Atlantic group, but no previous studies have been carried out to determine the interrelations of the Indo-Pacific genera. The three groups from the Indo-Pacific are distinctive in several morphological features, including papillae and osteology. The groups also show ecological differences. The largest group, the *Cryptocentrus* group includes 6 genera; the *Amblyeleotris* group 3 genera; and the *Flabelligobius* group with one genus. In all three groups, the genera are not well defined.

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**\*HOFFMAYER, ERIC R.; GRAY, GARY J.; SHELLEY, JOHN P.**

*Center for Fisheries Research and Development, Gulf Coast Research Laboratory, The University of Southern Mississippi, Ocean Springs, MS, 39564, USA*

## Preliminary assessment of short-term movement patterns of young bull sharks in Davis Bayou, Mississippi, and notes on their concentration in Mississippi bayous as a result of Hurricane Katrina

Young-of-the-year bull sharks, *Carcharhinus leucas*, are common inhabitants of the bay and bayou systems along the Mississippi coast and rarely venture into higher salinity waters (>15 ppt). Since little information is available on how these shark utilize this low salinity habitat, the objective of this study was to investigate the short-term movement patterns of young-of-the-year bull sharks within this habitat. Acoustic telemetry was used to manually track the movements of five bull sharks in Davis Bayou, Mississippi continuously for four to eight hour periods totaling 21.5 hours. Mean straight line swimming speed was  $1.81 \pm 0.17$  km h<sup>-1</sup>, with a maximum observed swimming speed of 4.8 km h<sup>-1</sup>. Sharks spent 98 % of their time within the bayou, and the majority of their movements were within 5-10 m of the coastline. Two sharks utilized small sloughs, which were not previous thought of as available habitat for this species, and one shark was observed resting on the bottom for nearly two hours, which is not characteristic of this species. As a result of Hurricane Katrina (29 August 2005), young bull sharks concentrated in the bayou systems along the Mississippi coast during the months of September and October. This concentration may have been the result of Katrina-related low dissolved oxygen levels in coastal rivers, which possibly reduced the shark's access to the rivers. By the end of October, dissolved oxygen levels increased in coastal river systems and bull shark concentration diminished in the bayou systems.

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### Juvenile fishes associated with *Sargassum* in the north central Gulf of Mexico: Observations from a remotely operated vehicle

*Sargassum*, a pelagic brown algae, is considered critical habitat for the larvae and juveniles of several commercially and recreationally important fish species in the north central Gulf of Mexico (GOM). The species composition of juvenile fishes associated with *Sargassum* has been under-represented in past studies because gear bias towards smaller sizes. Underwater video recordings from a remotely operated vehicle (ROV) were used to assess the relative abundance of juvenile fishes under *Sargassum* and to compare the species composition associated with two *Sargassum* aggregates, windrows and isolated mats. From May 2000 to September 2002, 12 video surveys were conducted under *Sargassum* (6 windrows, 6 mats) in the north central GOM. The video data were analyzed using the Visual Fast Count (VFC) species-time method modified from coral reef surveys. Ten-minute intervals of videotape were analyzed, and fish were identified to the lowest possible taxon. Eighteen fish species representing 6 families were identified. Carangids (jacks) were the most abundant family represented (65.8 %), with the blue runner, *Caranx crysos*, as the most dominant species (41.3%). A significant difference in fish species composition was observed between *Sargassum* windrows and isolated mats. Typically, pelagic species (e.g. *Caranx*, *Seriola*, and *Elegatis*) were associated with windrows, whereas species more commonly associated with hard structure (e.g. *Balistes*, *Monochanthus*, and *Canthidermis*) were associated with mats. Windrows of *Sargassum* contained a larger number of species and higher species diversity compared to mats, but numbers of fishes were four times greater at mats. The use of the ROV provided valuable information on the abundance and diversity of juvenile fishes associated with *Sargassum* in the north central GOM.

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### A new look at the molecular phylogenetics of the surgeonfishes and their allies (Perciformes: Acanthuroidei)

Since the earliest considerations of percomorph interrelationships, acanthuroids and tetraodontiforms were thought to share a close relationship. However, following Rosen's proposal that tetraodontiforms are closely related to the zeiforms and caproids, both morphological and molecular investigations of acanthuroid

relationships were conducted without the inclusion of tetraodontiform representatives. Recent molecular analyses have resurrected the hypothesis that acanthuroids and tetraodontiforms may share a close relationship to one another. The goal of the present study is to determine whether hypotheses of acanthuroid interrelationships change as a result of the inclusion of tetraodontiform outgroups. Data were collected from portions of the nuclear genes RAG1, Tmo-4c4, and MLL and analyzed using parsimony and Bayesian methods. Preliminary results indicate that Luvaridae, Zanclidae, and Acanthuridae form a well-supported monophyletic group. Inclusion of tetraodontiform representatives appears to destabilize the relationships among the Luvaridae + Zanclidae + Acanthuridae clade and the remaining acanthuroid families. Ephippidae is recovered with weak support as the sister group of the Luvaridae + Zanclidae + Acanthuridae clade. Siganiidae and Scatophagidae appear to be allied, again with weak support, with more distant outgroups.

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**\*HOLLAND, REEF; ROUTMAN, ERIC**

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Phylogeography of *Cryptobranchus alleganienis alleganienis*

The hellbenders, *Cryptobranchus alleganienis alleganienis* and *C. a. bishopi*, are large aquatic salamanders living in streams in the Appalachian Mountains and Ozark Plateau. Because this species is a candidate for listing under the Endangered Species Act, it is important to know the relationships among these populations. Work on mtDNA variation has revealed very high levels of population subdivision and shown the subspecies to be paraphyletic. However, since mtDNA is occasionally misleading due to the sorting of ancestral polymorphism, introgression tendencies, and sex-limited dispersal, it is important to use autosomal genes to check the accuracy of the mtDNA tree. We will use autosomal gene intron sequence (Fibrinogen, RAG, etc) to test the population relationships and degree of subdivision estimated from mtDNA.

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**\*HOMAN, REBECCA N.; WRIGHT, CHRISTIAN; WALKER, DAWN**

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Correlates of location and movement of spotted salamanders (*Ambystoma maculatum*) in the breeding pond

We wanted to understand where spotted salamanders (*Ambystoma maculatum*) are located in and around the breeding pond habitat throughout their life stages, and whether the location and movement of one life stage influences the location and movements of the next. We tracked the pattern of breeding adult entry into and exit from the breeding pond. Following breeding, we located and marked all visible egg masses (n = 130) within the pond. Throughout the period of larval development, we broke the pond into quadrants and using transect lines within each quadrant,

quantified larval abundance, abundance of potential prey and predators, and abiotic factors such as water depth, temperature, dissolved oxygen, and pH. We then followed the paths of juveniles out of the pond. We found that adults entered and exited the pond in a non-random pattern ( $p < 0.001$ ), apparently preferring the habitat adjacent to pond quadrant 3. Eggs and larvae were unevenly distributed within the pond ( $p < 0.001$  for both), preferring quadrants 3 and 4. The quadrants with a greater abundance of eggs and larvae were significantly deeper than the less populated quadrants ( $p < 0.0001$ ). Juveniles left the pond in an uneven distribution ( $p < 0.001$ ), preferring to exit from an area of the pond that was deep, but not as densely populated with larvae. When considering adult movement only out of the pond, there was a nearly significant correspondence between the locations and movements of each life stage, with juveniles exhibiting the most different pattern of movement ( $p = 0.054$ ). We suspect that egg laying locations were chosen by adults based on a combination of adult entry location and water depth, that larval densities were influenced in part by the location of the egg mass and water depth, and that juvenile dispersal may have been influenced by some other unmeasured factor.

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**\*HOPKEN, MATT. W.; DOUGLAS, MARLIS R.; DOUGLAS, MICHAEL E.**  
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#### Introgressive hybridization in Rio Grande Cutthroat Trout (*Oncorhynchus clarki virginalis*): Environmental, geographic, and historic considerations

Introduction of alien species is increasingly recognized as a serious threat because of their unanticipated and deleterious effects on indigenous species assemblages. Predation is most visible and apparent because impacts are immediate and often severe. Competition can also lead to decline of indigenous species, particularly when realized niches of native and exotic overlap considerably. Further, exotics can gradually eliminate indigenous species through introgressive hybridization. While the latter occurs slowly and over longer periods, it is equally as devastating as predation and competition. Both competition and introgression are especially germane to loss of native trout in western North America. For example, non-native trout have replaced Rio Grande Cutthroat Trout (RGCT; *Oncorhynchus clarki virginalis*) in 90-95 percent of its historic distribution. Recovery efforts now focus on maintenance of genetically pure populations. To facilitate this, we evaluated 39 RGCT populations (15-30 individuals per population) across their range by analyzing PINEs (Paired Interspersed Nuclear Elements) so as to determine percent-introgression. We also employed sequence analysis of two fast-evolving mitochondrial (mt) DNA genes (ATPase 6 and 8) based on 8 individuals per population to derive an hypothesis of phylogeographic relationships among populations. Locality information and environmental parameters were used to derive ecological and geographical hypotheses of distribution among populations. We then evaluated the association between levels of introgressive hybridization vs environmental, geographic, and historical divergence using Mantel tests. We also

utilized three-way Mantel tests to tease apart associations that were significant across multiple associations. These results are discussed.

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**HORSTKOTTE, JOACHIM**

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Trophic segregation by habitat selection within a species-flock of genus *Cyprinodon* (Cyprinodontidae, Teleostei) - An experimental approach

Analysis of gut content of six syntopic *Cyprinodon* of the species flock from Laguna Chichancanab, Yucatan, Mexico revealed that only one species (*C. beltrani*) feeds in the typical *Cyprinodon* way on detritus. All other species developed specific preferences for different benthic invertebrates. Laboratory experiments with three of the *Cyprinodon*-species point to opportunistic non-specific feeding of casually found prey. But they seem to differ in preference of habitat and strategy of tracking prey. In an aquarium four different substrates (sand, gravel, plastic plant and blank bottom) were offered to the species. *C. beltrani* made the most feeding attempts in small grained sand, *C. labiosus* preferred coarse gravel. F1-Hybrids of both species show no difference between sandy and gravelled sediments. *C. maya* shows no preference for any bottom substrate too, but was the only one making feeding attempts on the plastic plant. Furthermore it was observed that all species specifically differ in the way feeding attempts were made. As all specimens were hatched from aquarium in same conditions, the specific preferences as the feeding behaviour appear to be genetically fixed. These observations lead to the conclusion that habitat segregation within the *Cyprinodon*-species flock took place.

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**\*HOWELL, J. HEATH; KUHAJDA, BERNARD R.**

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Geographic influences on life history traits: The Alabama Darter (*Etheostoma ramseyi*) species complex

The Alabama Darter (*Etheostoma ramseyi*) is a widespread and common species endemic to the Mobile Basin in Alabama. It is found in tributaries of the Cahaba and Alabama river systems, as well as direct tributaries of Mobile Bay. It is a member of the subgenus *Ulocentra* which contains small (65 mm standard length), colorful, snubnose darters. Populations sampled for life history study include one above the fall line in the Valley and Ridge geographic province at Little Schultz Creek and one below the fall line in the Coastal Plain at Blue Girth Creek. Specimens from Blue Girth Creek were collected from July 1987 to April 1989, with additional collections from March 1974, April 1993, and May to December of 2005. Specimens from Little Schultz Creek were collected from Summer 2005 to Spring 2006. Alabama Darters collected in Blue Girth Creek were often found in slow current over sand and detritus while those in Little Schultz Creek were found in moderate current over bedrock,

cobble, and gravel. Standard length was significantly correlated with body mass ( $R^2=0.9724$ ). Sex ratio was 1.25 females for 1 male. Length frequency distribution revealed four different age classes. Enumeration of otolith annuli was used to verify these age classes. Gross examination of gonads indicates that spawning occurs from March to May. Weight of gonads with respect to body weight (gonadosomatic index) was used to support these findings. Analysis of stomach contents revealed that the Alabama Darter has a diet consistent with other snubnose darters which includes larvae of flies, stoneflies, mayflies, and caddisflies.

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**\*HOWEY, CHRISTOPHER A.; DINKELACKER, STEPHEN A.**

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Population demographics of the alligator snapping turtle (*Macrochelys temminckii*): Evidence for past overexploitation and present recovery

Prior to gaining protection in 1993, alligator snapping turtles (*Macrochelys temminckii*) were an economically important species in Arkansas. However, data concerning basic demographic characteristics for the species are still largely unknown. Therefore, we initiated a mark-recapture study in 2005 to determine the status and potential recovery of a population suspected to have been previously exploited. Turtles were trapped in Cadron Creek, which is a slow-moving stream in central Arkansas. We marked each turtle and recorded morphometrics, mass, age, and growth. Turtles were sexually dimorphic, with males reaching larger sizes. Size distribution of the population shows a noticeable lack of large adult turtles. In fact, most of the turtles have just reached sexual maturity within recent years. Sex ratios were female biased (7:1), and the ratio of adults to juveniles was 2:1. Collectively, our data suggest this population was previously exploited, but recovery is occurring. The consequences of exploitation include a lack of older, large turtles and an abundance of females in the population. Future research should examine the genetic impacts of this altered population structure.

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Preliminary studies of the biology of white sharks at Guadalupe Island, Mexico

Guadalupe Island is home to a large population of great white sharks (*Carcharodon carcharias*). The few Mexican notes on the biology of white sharks are based on dead specimens, and therefore provide little insight into the behavior and ecology of these sharks. We have initiated a collaborative research program on the white sharks at Guadalupe Island, providing information that will be essential in the development of future management and conservation plans for this species in Mexico. To date we have tracked four white sharks carrying ultrasonic transmitters. Preliminary results from this study suggest that these sharks: 1) spend a considerable amount of time in the waters adjacent to northern elephant seals and Guadalupe fur seal colonies, 2) swim with yo-yo-like vertical oscillations from the surface to almost 90 m, 3) maintain a stomach temperature 7 °C higher than the surrounding water (25–26 °C). Additionally we have collected tissue samples from white sharks for both genetic and stable isotope analyses, and from their prey species for stable isotope analyses.

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### Mechanical factors involved in the evolution of chondrichthyan jaw suspension mechanisms

The elegant interplay between musculoskeletal elements in vertebrate feeding mechanisms has long been studied because of the wealth of information these systems possess regarding organismal evolution and ecology. Aquatic feeding mechanisms are particularly known for their extensive kinesis, the anatomical basis and functional consequences of which have been established by innumerable empirical studies. Despite decades of research dedicated to understanding form-function relationships in aquatic feeding mechanisms, the evolutionary processes by which the forms that afford substantial cranial kinesis (jaw suspension) came to be have largely been ignored. Jaw suspension, the manner in which the jaws articulate with the cranium, varies greatly among gnathostomes, perhaps nowhere so much as in the chondrichthyan fishes. Chondrichthyan jaw suspension mechanisms range from complete fusion of the upper jaw to the cranium (autostyly) to indirect articulation between the jaws and the cranium via a pair of mobile hyomandibular cartilages (euhyostyly). Through biomechanical modeling of the feeding mechanisms of chondrichthyan fishes with divergent feeding mechanisms we have begun to understand the role that cranial force distributions associated with prey capture have had on the evolution of chondrichthyan jaw suspensions. Evidence from several species suggests that changes in jaw suspensions associated with enhanced upper jaw kinesis (protrusion) involved a reduction in anterior palato-cranial loading and a transition from tensile to compressive posterior palato-cranial loading. These findings have provided a glimpse of the mechanics of evolutionary change, with a more complete story yet to come.

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A herpetofaunal survey of Bayou Macon Wildlife Management area in northeastern Louisiana

Bayou Macon Wildlife Management Area (BMWMA), located in East Carroll Parish, is owned and managed by the Louisiana Department of Wildlife and Fisheries. BMWMA is a forested island in a highly fragmented, agricultural landscape located within the Mississippi Alluvial Plain. It is the largest tract of bottomland hardwood forest in a four county/parish area of northeastern Louisiana and southeastern Arkansas. The vegetation type is dominated by hackberry-American elm-green ash, with overcup oak-water hickory and water oak-sweetgum present also. The terrain at Bayou Macon is basically flat, and the soil type is predominantly Sharkey clay. Fifteen 500-meter transects have been randomly placed within the 14 management compartments. Drift fence arrays have been used to sample the herpetofauna with a combination of funnel and pitfall traps as well as time-constrained visual encounter surveys. Anurans call surveys have also been conducted. Drift fence and visual encounter surveys conducted from September 2004 to November 2005 resulted in a sample of 422 individuals of 21 species. Incidental sightings have also been recorded, bringing the total species richness to 33 species, including nine anuran, one salamander, four turtle, three lizard, 15 snakes and one crocodylian species. This study was supported by funds provided by LDWF and USFWS, Division of Federal Aid, through the State Wildlife Grants Program.

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Phorid fly predation of red-eyed treefrog eggs: Do maggots induce hatching?

Eggs of many species exhibit plasticity in hatching time in response to predation. Red-eyed treefrogs, *Agalychnis callidryas*, lay arboreal egg clutches that are susceptible to predation by snakes and wasps as well as infection by a pathogenic fungus. Embryos hatch up to 30% prematurely to escape from these risks. Phorid flies infest the arboreal egg clutches of ten species of frogs, and have been recorded from *A. callidryas* clutches in Nicaragua. We investigated the effects of larval fly infestation on hatching time and survival *A. callidryas* embryos in Gamboa, Panama, during the summer of 2005. We collected clutches from Ocelot Pond and brought them to an open-air laboratory for monitoring. We inspected clutches for presence of fly larvae and matched groups of fly-infested clutches with equal-age uninfested controls. Each clutch was affixed to a plastic card set in a cup with water to catch hatched tadpoles. We monitored 35 infested and 23 control clutches. We assessed clutch condition and recorded mortality and hatching every six hours until all eggs either hatched or died. Two species of flies infest *A. callidryas* clutches. Phorid larvae were present on all

infested clutches, whereas psychodid larvae were observed on only three clutches. Survival for infested clutches was 20% lower than controls. Phorid larvae consumed eggs that were developing normally only hours before. Average hatching time was 22 hours earlier for infested clutches. Inoculation experiments planned for 2006 will test larval fly ability to successfully infest healthy clutches and isolate fly effects on frog survival and hatching from any confounding factors that may attract flies to frog clutches. Future research will address interactions among consumers commonly encountered upon red-eyed treefrog clutches – phorid flies, pathogenic fungi, and wasps – as well as the effects of multiple enemies on hatching time and survival of red-eyed treefrog embryos.

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#### Adaptations for molluscivory in the cichlid pharyngeal jaw

The pharyngeal jaw of cichlids may represent a key innovation that facilitated their extensive exploitation of durable prey such as mollusks. To examine characteristics of the lower pharyngeal jaw that may enhance the ability of cichlids to exploit durable prey, 3D computed microtomography (micro-CT) scans were used to examine the external and internal structure of the lower pharyngeal jaw of 11 Heroine cichlids from Central America. We CT-scanned the LPJ in both the molluskivorous and non-molluskivorous alternative morphotypes in the polymorphic cichlid *Herichthys minckleyi*. We also examined the LPJ in five independent evolutionary contrasts between species that differ in the extent to which they crush mollusks. Differences in the extent of internal suturing, size of the horns that serve as muscular attachment sites, keel size, erupted tooth size, replacement tooth size, and depth of tooth crypts will all be discussed using these contrasts. Finally, we assessed the extent of convergence as well as the contribution of these morphological elements to resisting forces encountered during mollusk crushing.

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#### Dorsal pattern variation in *Sonora semiannulata* in New Mexico

The ground snake, *Sonora semiannulata*, exhibits a variety of dorsal patterns throughout its range. Three color morphs occur in New Mexico: a plain morph, characterized by solid red dorsal coloration; a striped morph with a single dark longitudinal dorsal strip on a red background; and a banded morph, which has numerous dark crossbands that partially or completely encircle the body. We investigated the hypothesis that the frequency of different morphs varies

geographically. To address this question, 154 snakes from 14 counties in New Mexico were examined, and the frequency of each morph recorded. The results of a chi-square test show that the frequency of different morphs varied significantly between counties. However, a lack of collecting effort in some counties rendered it difficult to discern a general pattern in the distribution of different morphs. We suggest that this data warrants further investigation.

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**HUTCHINSON, DEBORAH A.**

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Sequestration and maternal provisioning of defensive toxins in the asian snake *Rhabdophis tigrinus*

*Rhabdophis tigrinus* (Colubridae: Natricinae) is an oviparous, bufophagous (toad-eating) snake from eastern Asia that possesses defensive integumentary glands on the neck known as nuchal glands. These glands are used in defensive displays and typically contain bufadienolide toxins. Whereas toads are known to synthesize bufadienolide steroids from cholesterol precursors, chemically undefended *Rhabdophis* must sequester bufadienolides from ingested toads in order to exhibit these compounds in their nuchal glands. Chemically defended females are capable of provisioning their embryos with these toxins so that their unfed hatchlings are chemically defended prior to consuming toads themselves. All of the hatchling *Rhabdophis* from an island with a dense population of toads were chemically defended regardless of their diet in the laboratory. In contrast, none of the hatchlings from an island lacking toads possessed bufadienolides in their nuchal glands until after they consumed bufonid prey. Recent <sup>1</sup>H-NMR and HPLC analyses demonstrate that newly acquired bufadienolides from ingested toads can be transferred from the dam to the embryos as late as 12 days prior to oviposition, suggesting that at least some transport of toxins occurs within the oviduct. Although the hatchlings are provisioned with the same bufadienolides possessed by the dam, there is significant chemical selectivity to this process. In a recent feeding experiment with 12 gravid *Rhabdophis* from various localities, 10 clutches had been provisioned with moderate to large quantities of bufadienolides. In these 10 provisioned clutches, the most abundant bufadienolide in the unfed hatchlings was almost always the same compound, although it generally was not the most abundant bufadienolide in the dam. *Rhabdophis tigrinus* is the first amniote vertebrate known to have evolved specialized defensive structures dependent on sequestered dietary compounds, either obtained directly from prey or provisioned by the dam.

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### Reproductive characteristics of the Ornate Wobbegong Shark (*Orectolobus ornatus*) for population assessment

Three species of wobbegongs can be found in temperate eastern Australia (New South Wales, NSW). Two are already described (*Orectolobus ornatus*, *O. maculatus*) and a new species previously thought to be a subspecies of *O. ornatus* has recently been described. All three species are targeted by commercial fishers. Their catch rates have declined dramatically, circa 50%, over the last decade. This reduction has led to wobbegongs being listed as vulnerable in NSW on the IUCN Red List of Threatened Species. We are investigating the reproduction of the *O. ornatus* which reaches sexual maturity at total lengths of 796-875 mm and 799-889 mm for males and females, respectively. The decline of male gonadosomatic index (July-August) prior to female ovulation (November-December) potentially suggests mating 2-3 months before ovulation and possible sperm storage by the females. Parturition occurs between September and October after a gestation period of approximately 12 months. Litter size is 4-16 ( $8.8 \pm 0.46$ ,  $n = 28$ ). Ovulation occurs when follicles are at  $43.3 \pm 1.36$  mm diameter ( $n = 24$ ). Size at birth is  $21.7 \pm 0.07$  mm ( $n = 57$ ). Sex ratio at birth does not differ from unity ( $\text{Chi-square}_{1df}$ ,  $P > 0.05$ ). The reproductive cycle is most likely to be triennial. This reproductive information is crucial for fisheries assessments in order to determine the resilience of each species to fishing pressure and to make recommendations for the future management of the fishery.

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### Importance of predator-predator interactions in ecosystem-based management models

Increasingly the conservation of species and ecosystems has been aided by ecosystem-based management including the analysis of food web structure and dynamics. Food web models are very sensitive to the structure and parameterization of the many interactions and processes that link species. Typical food web models ignore interactions among predators. Recent theoretical studies suggest that omitting these important interactions may lead to mismanagement of fisheries. In this presentation, it is demonstrated how interference competition and antagonistic/synergistic interactions influence food web dynamics influencing management decisions concerning harvest. In general, omitting these interactions can result in overharvesting by several orders of magnitude in just five years. These results suggest that more information regarding the basic biology and ecology of aquatic predators is greatly needed.

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The search for paedomorphic traits in the development of a dwarf *Corydoras* species

Throughout the years, the speciose catfish genus *Corydoras* has been the subject of various studies, the majority dealing with the diversity and complex taxonomy of the genus. In one of these studies, the three dwarf species of the genus (*C. pygmaeus*, *C. hastatus* and *C. australe*) were isolated into a separate genus, a statement which was later contradicted by morphological, morphometric as well as molecular data. Nevertheless, the matter remains that these species are, next to being smaller, also more streamlined and laterally compressed than their congeners. In fact, their external morphology is that different from other *Corydoras* species that even mimicry with characins has at one time been suggested. The above mentioned study on *Corydoras* morphometrics, however, did find that adults of the pygmy species lay well within the normal patterns of variation of the genus, indicating that evolutionary changes in *Corydoras* morphology were the result of subtle, perhaps heterochronic changes. This hypothesis fitted our findings when comparing the growth curves of both a dwarf *Corydoras* species (*C. pygmaeus*) with a 'typical' *Corydoras* species (*C. aeneus*), since differences found also hinted towards heterochronic mechanisms like progenesis and neoteny. Given this we examined a cleared and stained ontogenetic series of both *C. pygmaeus* and *C. aeneus*, comparing the timing of the different developmental stages, changes in external morphology (appearance of fins, pigmentation, etc.), the development of the cartilaginous skeleton and the sequence of ossification in the cranial region. As a result, the combination of all these developmental traits allowed us to test the paedomorphic hypothesis.

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Home range, movements, and survival of the threatened Eastern Indigo Snake (*Drymarchon couperi*) in southeastern Georgia

The Eastern Indigo Snake (*Drymarchon couperi*), the largest North American snake species, was federally listed as threatened in 1978 because of populations declines caused primarily by habitat loss and degradation. These threats remain the primary obstacles to the persistence of this southeastern species, with required habitats such as the longleaf pine forests rapidly declining in quality and area due to development, fire suppression, and agriculture. We conducted a radiotelemetry study on 32 *D.*

*couperi* (19 M, 13 F) from 2002-2004 at sites on and adjacent to Fort Stewart to examine the movement ecology and survival of the species in southeastern Georgia. We determined home ranges using two estimates (minimum convex polygons and kernel density) at 3 temporal scales: cumulative (total radiolocations), annual, and seasonal. We analyzed intraspecific differences in annual home range size through a series of a priori hypotheses, using repeated measures regression analysis, evaluated with an information theoretic approach. We used known-fate modeling to estimate survival over time and as related to individual covariates. Annual home ranges were large ( male = 510 ha; female = 101 ha). Models for annual home range size estimates suggested a positive correlation with body size, negative influence of sex (being female), and negative home range size association with habitat undergoing restoration opposed to areas used for commercial timber production. Annual survival in 2003 was 0.890 (SE = 0.074, n = 25) and 0.723 (SE = 0.088; n = 27) in 2004. Survival analysis suggested the effect of size, as standardized by sex, as the strongest predictor of adult *D. couperi* survival with larger males and larger females more at risk than smaller adults of each sex.

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### **IKEUCHI, ISAMI**

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What time should a diurnal gecko (*Lygodactylus tolampyae*) wake up to avoid predation?

Because animals are vulnerable to predators while sleeping, one of the most important factors hypothesized to influence the selection of sleeping sites is predator avoidance. Several authors have proposed that diurnal arboreal lizards use branches and leaves as sleeping sites to avoid nocturnal predators, such as arthropods and snakes, that do not detect prey using visual cues. On the other hand, these same sleeping sites may make lizards vulnerable to visually oriented diurnal predators, such as birds, because the lizards perching on branches and leaves are exposed. We hypothesized that the time when diurnal arboreal lizards leave their sleeping sites should have evolved to decrease the risk from both nocturnal and diurnal predators. *Lygodactylus* is a diurnal genus within which most species are arboreal. To test the hypothesis that sleeping site selection evolved to reduce predation risk, we investigated spatial usage by a Madagascan gecko, *Lygodactylus tolampyae*, during day and night, and recorded the start timing of activity in geckos and bird predators in the early morning. Most geckos perched on tree trunks during the day, whereas they slept on the tips of branches and leaves with their heads away from the trunks. We recorded the behavior of 10 geckos leaving their sleeping sites both during the rainy and dry seasons. The number of bird songs, indices of bird activity, air temperature, and illumination were recorded simultaneously. Geckos turned their perching directions toward the trunks of tree before bird song started, left for tree trunks when bird started singing, and all of geckos went out of visual range before sunrise. These gecko behaviors did not differ between the rainy and dry seasons even

though the air temperatures differed seasonally. These results suggest that *L. tolampyae* leaves its sleeping site before the onset of bird activity to avoid bird predation.

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### Foraging ecology of juvenile lemon sharks in Bimini, Bahamas: Utilizing ultrasonic accelerometry to monitor feeding

A new ultrasonic accelerometer transmitter will be used to telemeter foraging behavior of juvenile lemon sharks (*Negaprion brevirostris*) by signaling lunges at prey. The accelerometer transmitter emits a coded pulse to allow trackers to recognize the shark, and emits a fast alarm pulse whenever it detects a change in acceleration greater than or equal to 1.5 g ( $1g = 9.8 \text{ m/s}^2$ ). The objectives of this study are to investigate the utility of this new technology for studying shark foraging, gain direct evidence of juvenile lemon shark foraging in the wild, determine the physical locations of foraging events within the Bimini nurseries, and examine diel patterns of foraging. In order to gain quantitative and qualitative information about the accelerations juvenile lemon sharks make, captive trials will be conducted. During these trials, the total number and time of acceleration events will be recorded. Visual observations as well as stomach content analysis will be used to determine whether accelerations were associated with successful versus unsuccessful feeding events or other non-foraging behaviors. In addition to both pre- and post-consumptive observations, individual sharks will undergo trials with live teleost prey. Since it is unlikely that a shark will be able to chase, capture and consume live prey without the transmitter producing acceleration alarms, the following hypothesis will be tested: the number of prey pursued, attacked and consumed by each shark will be positively correlated with the number of acceleration alarms. Preliminary observations show a positive transmitter response during prey capture and handling, but also show acceleration alarms when sharks make sharp turns. The transmitter sensitivity will be adjusted as needed to reduce non-foraging acceleration alarms. Results of captive trials, preliminary results of field tracks, and future research directions will be presented, including the potential utility of this technology for other elasmobranch foraging studies.

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**JAWS! Heterochrony and the control of metamorphosis in the carnivorous tadpole *Lepidobatrachus laevis***

The carnivorous larva of *Lepidobatrachus laevis* features what may be the most bizarre chondrocranial morphology among anuran tadpoles. Most striking of these features are the enlarged jaws that the tadpole uses to capture and consume prey whole. These, along with a functional gut and well-developed visual system, are key components of this highly derived feeding mode and have been hypothesized to represent the early expression of adult features. I am interested in studying both the embryological origins of this extreme morphology and its integration into the adult form at metamorphosis. Here I present studies of the latter on the control of metamorphosis and the conversion of larval tissues, focusing on the remodeling of the lower jaw and the activity of deiodinase enzymes. This group of enzymes is essential for the control and coordination of local levels of active thyroid hormone that drives metamorphosis in anurans. It is hypothesized that these enzymes play a vital role in evolution of morphological diversity and adaptations in both the larval and adult stage by mediating the transition between life history stages. Using enzyme activity assays and organ culture, I show that the deiodinases are key in the coordination of metamorphosis in *L. laevis*. I also address the role of heterochrony in the generation of the unique larval morphology of *L. laevis*.

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**Plasticity and natural selection in lizards**

Plasticity and natural selection can both alter the mean and variance of traits, but few studies have examined the roles of both on morphology and performance in natural populations. Lizards are ideal model systems for this issue because of the ease of collection and the fact that many show distinct seasonal patterns that may correlate with plasticity. We have conducted extensive field and laboratory studies documenting the relative roles of plasticity and selection on both bite force and sprint speed in green anoles (*Anolis carolinensis*) and tree lizards (*Urosaurus ornatus*). Our work shows substantial seasonal plasticity in bite force and associated morphological variables, as well as significant selection on performance in at least one system (tree lizards). We advocate an integrative approach that takes into account both plasticity and selection simultaneously when examining the evolution of performance.

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### Preliminary data on the phylogeny of the gobiidae

The family Gobiidae comprises of some 2000 small teleost fishes commonly known as gobies. A recent faunistic survey of this group carried out in Singapore, Peninsular Malaysia and Southern Thailand yielded some 120 species and made apparent taxonomic problems still inherent at all levels within this group. Using preliminary data set of mitochondrial genes, a phylogenetic tree is constructed in the attempt to elucidate taxonomic inconsistencies. In particular, the placement of species from the sub-family Gobiinae will be discussed.

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### Phylogenetic relationships of the endemic New Zealand diplodactylid gecko radiation

The geckos in New Zealand include both nocturnal (genus *Hoplodactylus*) and diurnal species (genus *Naultinus*) and are almost unique among gekkotan lineages in being viviparous. They occupy a wide variety of habitats ranging from near-subtropical coastal bush to high altitude talus slopes, to cool temperate insular ecosystems. Previous hypotheses of relationship based on morphology, allozymes, and limited mitochondrial DNA sequence data have supported the monophyly of the New Zealand taxa as a whole and that of *Naultinus*, whereas *Hoplodactylus* has been hypothesized to be paraphyletic. In addition, previous systematic work has suggested the existence of many cryptic taxa, particularly within *Hoplodactylus*. A combination of different data sets were examined including both nuclear data (Rag1 DNA sequence and allozymes) and mitochondrial DNA sequences for all major lineages of all species of New Zealand geckos. The geckos of New Zealand are the sister group to those of New Caledonia. The new DNA sequence data corroborates the existing phylogenetic hypotheses and provides robust support for the recognition of many new species with restricted distributions within New Zealand. A revised picture of the systematics of these geckos reinforces existing views regarding extreme levels of endemism in New Zealand and reveals unexpectedly high species diversity for such a temperate region. The DNA-based phylogeny of geckos is consistent with data from other taxa that suggests that the diversification of much of the New Zealand biota occurred after the Oligocene marine transgression.

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### Morphological phylogeny of montane and jumping pitvipers (genus *Cerrophidion* and *Atropoides*)

The *Porthidium* group includes terrestrial pitvipers in the genera *Atropoides*, *Cerrophidion*, and *Porthidium*. Species of *Cerrophidion* and *Atropoides* have similar distributions from southern and eastern Mexico to western Panama. *Cerrophidion* species inhabit highland regions while *Atropoides* occurs at low to moderate elevations. The most recent phylogenetic analyses of molecular data (Castoe et al., 2005) suggest a sister relationship between *Cerrophidion* and *Porthidium* to the exclusion of *Atropoides*. Separate analyses of *Atropoides* and *Cerrophidion* were conducted incorporating all species of each. A preliminary analysis of the *Porthidium* group was also conducted by combining data sets of *Atropoides* and *Cerrophidion* with two species of *Porthidium* (*P. nasutum* and *P. ophryomegas*). In this study, characters of scalation, bones, and hemipenes were examined. Several OTUs were included for the wide-ranging species *C. godmani*, *A. mexicanus*, *A. nummifer*, and *A. occiduus*. Data for *C. petlalcalensis* were available from literature. Our analyses suggest a sister relationship between *C. tzotzilorum* and a monophyletic *C. godmani* complex. The monophyly of *Atropoides* is strongly supported by morphological data, although recent molecular analyses continue to find only weak support for this clade owing to the problematic placement of *A. picadoi*. Ongoing work includes incorporation of additional *C. godmani* OTUs and all other species of *Porthidium*.

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**\*JAFFARIAN, THOMAS; OLIVEIRA, KENNETH**

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### Changes in the digestive tract of maturing American eels

We examined histological and apoptotic changes in the digestive tract of yellow and silver phase American eels at different stages of the yellow-silver metamorphosis. It is thought that upon migration, a silver eel stops feeding and reabsorbs its digestive system. Eels forced to delay their migration would be unable to maintain energy reserves necessary to complete the spawning migration at a later date. Migrating silver eels were collected and held in the laboratory for 10 months, divided into fed and non-fed groups, and individuals sampled at one-month intervals to examine changes in their digestive tracts. Preliminary data indicate that, similar to previous studies, the overall digestive tract size was reduced as the silver metamorphosis progressed, but complete loss of the digestive tract was not observed. In addition, silver eels presented food maintained feeding throughout the experiment. Apoptotic cells were evident in silver eel samples, suggesting that the intestinal changes are developmental and not atrophic.

## **JANOVETZ, JEFF**

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### **Kinematics of prey capture in the creek chub, *Semotilus atromaculatus***

The ostariophysian order Cypriniformes is one of the most species-rich groups of bony fishes, comprising well over 3,000 species. This taxonomic diversity is reflected in both a wide dietary diversity and broad range of feeding patterns despite a synapomorphy of great trophic significance; all cypriniformes lack teeth in the oral jaws. Additionally, the group possesses a highly protrusible upper jaw that has been independently evolved from the acanthopterygian mechanism. Despite the uniqueness of the cypriniform trophic apparatus and the ecological importance of this group to the freshwater faunas of North America and Eurasia, the functional morphology of feeding behavior in the group has rarely been investigated. This project examined the feeding kinematics of a representative cyprinid, the creek chub, *Semotilus atromaculatus*, on three different prey; small fishes, large terrestrial insects, and small terrestrial insects. These prey were chosen to represent common prey in the natural diet of these minnows and to test whether the kinematics of prey capture were modulated according to the elusiveness and size of the prey item. Strikes on elusive fishes showed greater displacement of skull elements and were faster than strikes on non-elusive insects, consistent with the behavioral responses in other fishes when capturing prey capable of rapid escape behaviors. Extensive upper jaw protrusion occurred only during fish captures and hyoid depression was also much greater during fish strikes.

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### **\*JANZEN, FREDRIC J.; GIBBONS, J. WHITFIELD; GREENE, JUDITH L.; IVERSON, JOHN B.; TUCKER, JOHN K.**

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### **Climate change and temporal variation in nesting biology of North American turtles**

Altered phenology of reproductive events has been noted as a particularly key indicator of biotic response to contemporary climate change. However, most research has focused on a single population of a given taxon (oftentimes at the edge of its geographic range), yet meta-analyses use such data as a proxy for the entire species. Moreover, few sufficiently long-term studies of phenology in reptilian taxa have been published. We address the possibility of climate-altered reproductive phenology with long-term (>10 years) data on nesting behavior in multiple populations of each of four genera of North American turtles (*Kinosternon*, *Chelydra*, *Chrysemys*, and *Trachemys*). We find that initiation of the nesting season has advanced significantly only in populations at the northern edge of the geographic range of a species. Populations located farther south within the geographic range of a species exhibited

less marked temporal changes in nesting behavior. Our results appear to provide one explanation for the outcomes of meta-analyses that purport to exemplify the biotic impacts of climate change. We are now exploring what climatological variables explain the nesting patterns we observe in these turtles as well as testing whether the significant temporal shifts in phenology in populations at the northern edge of the range reflect phenotypic plasticity or adaptive evolutionary changes.

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Reproductive morphology of *Pseudocorynopoma doriae* (Characidae: Stevardiinae), including description of longest sperm nuclei among Teleostei

Dragonfin Tetras, *Pseudocorynopoma doriae* Perugia, 1891, are relatively small fish (maximum standard length about 62 mm) that usually inhabit interior and coastal streams from Rio Grande do Sul State in southern Brazil to Uruguay and parts of northeastern Argentina. This species, like other stevardiine characids, exhibits insemination, sexual dimorphism, and complex mating behaviors. These behaviors may be mediated by secretions from the base of the caudal fin. We conducted microscopic studies of cells and tissues that may play a role in the reproduction of *P. doriae*. The testis is divided into an anterior spermatogenic region that contains cells in the various stages of spermatogenesis and a posterior aspermatogenic region lined with a simple cuboidal epithelium. Produced in the testis are spermatozoa with nuclei of extraordinary length. The mean nuclear length is at least 32  $\mu$ m, the longest known for a teleost fish. These measurements are larger than previous estimates and based on images from light and electron microscopes. The spermatozoon also contains accessory microtubules, an elongate "binding collar" that contains the flagellum, and greatly elongate mitochondria. Inseminated females lack any apparent structure for storage of spermatozoa. Rather, spermatozoa are found in the ovarian lumen. Males lack an obvious intromittent organ, but one particular aspect of the mating behavior probably accounts for transferal of spermatozoa to the female. Although distinct sperm packets are not evident, males may release mucilaginous clumps of sperm, as evidenced by PAS+ secretions. *Pseudocorynopoma heterandria* Eigenmann, 1914, the sister taxon of *P. doriae*, produces spermatozoa with nuclei that are also elongate (i.e., not spherical) but shorter than those of *P. doriae*.

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### Anthropogenic effects of large-scale resort development on juvenile lemon shark (*Negaprion brevirostris*) populations of Bimini

The shallow waters around the islands of Bimini (25°43.70'N, 79°18.00'W) provide an ideal nursery location for the lemon shark (*Negaprion brevirostris*), but this habitat is under threat from a large tourist development known as the Bimini Bay Resort, which has been carrying out dredging operations and removing mangroves in and around the North Sound lagoon. The effects of the development so far were investigated by studying the growth rates of juvenile lemon sharks in the North Sound, Sharkland and South Bimini nursery areas using before-after, control-impact analysis; the first-year survival rates of neonate lemon sharks in the North Sound and Sharkland between 1995-2005; and a comparison of habitat structures in the North Sound and off South Bimini in 2003 and 2005. The results from this study found no statistically significant interaction term between the growth rates of juvenile lemon sharks in the three nursery areas before and after March 2001, which was when the largest dredging operation to date was initiated. Statistical significance in the first-year survival rates of neonate lemon sharks in the North Sound ( $F = 9.058$ ,  $p < 0.05$ ), and the North Sound and Sharkland combined ( $F = 8.358$ ,  $p < 0.05$ ) before and after March 2001 was found however. Some significant differences were also found between the habitat structure of the North Sound in 2003 and 2005, the most obvious being a reduction in the mean percentage cover of the seagrass *Thalassia testudinum* by 17.68 percent since 2003, and in the location closest to the dredging it had been reduced by 46.5 percent. The results obtained suggest that the development so far has had a negative effect on both the first-year survival rates of neonate lemon sharks and the habitat of the North Sound, and to avoid further damage the extent of the development should be reduced.

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Early fish larvae assemblages in the oceanic region off Baja California: Winter and fall 1999

Fish larvae assemblages were analyzed to determine differences on larvae assemblages formed by the integrated fish larvae community and those formed only by the early larvae in preflexion stage, relating these assemblages with sea surface parameters that define their distribution. The fish larvae analyzed came from two oceanographic cruises, one in winter and one in fall, made in 1999 in the oceanic region off Baja California Peninsula, Mexico. Samples were collected in zooplankton oblique-tows using Bongo nets. CTD casts were made in each sampling station recording sea surface parameters like temperature, salinity and dynamic heights. Community and group analysis were applied to define fish larvae assemblages, and canonical correlation analysis was used to compute the interrelationships between the fish larvae and sea surface parameters. Data showed the formation of groups composed of larvae of temperate, subtropical, and tropical species. Assemblages formed by the integrated fish larvae community and the preflexion larvae are different in terms of the species that constituted them. Preflexion larvae assemblages are more coherent with their adult habitat and distribution, and correlate better than the assemblages formed by the integrated fish larvae community with sea surface parameters inherent to the distribution of fish larvae. Funded by IMECOCAL Program, CONACYT, IPN-CGPI and IPN-COFAA.

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A remarkable rib/swimbladder association in the moonfish, *Mene maculata* (Perciformes: Menidae)

The moonfish, *Mene maculata* (Perciformes: Menidae), is distributed in deeper coastal waters of the tropical Indo-Pacific. Distinctive features include a highly compressed, disc-like body, highly protrusible upper jaws, elongate second pelvic ray, and extremely truncated, embedded anal soft rays. The osteology of *Mene* is known almost exclusively from descriptions of fossils, particularly those from the Eocene deposits of Monte Bolca, Italy. These fossils are primarily two dimensional, and details of the posterior portion of the braincase and anterior portions of the axial

skeleton below the midline are almost always obscured by the opercle and pectoral girdle. As a consequence, remarkable modifications of the anterior vertebrae and first two ribs of this relatively common Indo-Pacific fish have gone unrecognized since its original description over 200 years ago. Most striking of these are the hypertrophied first ribs, which have medial and lateral expansions embracing paired, thin-walled anterior ducts of the swimbladder that attach to the first centrum and basioccipital. The large first ribs are braced by expansions of the second ribs and strut-like, anteriorly inclined parapophyses of the fifth vertebra. The moveable first vertebra has an autogenous neural spine and paired transverse processes giving rise to stout ligaments that expand to cover the lateral walls of the swimbladder ducts and insert on the first ribs. We illustrate these skeletal modifications with wet and dry skeletal preparations and high-resolution X-ray computed tomography. We are still in the process of investigating the soft tissue aspects of this complex, and can only speculate at this time that its function is related to sound reception and/or production.

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A comparison of fine-scale genetic variation within two morphologically and behaviorally distinct amphibian taxa

The maintenance of connections among populations is important for limiting the risk of regional extinction. But in increasingly urbanized and modified landscapes the capacity for natural dispersal and gene flow may be limited. Dispersal movements among distant sites are difficult to detect with direct methods (e.g., mark-recapture), and estimates of gene flow can provide information regarding the frequency and scale of inter-pond dispersal events. We used microsatellite loci to estimate the degree of population differentiation and scale of population structure of the gray treefrog (*Hyla versicolor*), and the spotted salamander (*Ambystoma maculatum*). Individuals from each species were sampled from 20 natural breeding locations in central Missouri separated by distances ranging from 0.1 to 73 km. We hypothesized that the scale of dispersal events (as reflected by pairwise estimates of genetic differentiation [ $F_{st}$ ]) would differ due to increased mobility of gray treefrogs resulting from an arboreal lifestyle compared to the fossorial habits of spotted salamanders. Overall, our results demonstrate a positive correlation between geographic and genetic distances among sites. As predicted, the spatial scale of population structure was greater for treefrogs than for salamanders, suggesting that treefrogs have a greater capacity for long-distance movements or greater ability to cope with altered habitat. We discuss the effects of habitat fragmentation and conversion on natural dispersal movements and regional-scale population dynamics of these two amphibian taxa.

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Acoustic telemetry offers new insight into the hunting behaviour of white sharks at a Seal Island

Between June 2001 and December 2005 we attached 98 RCODE acoustic transmitters to white sharks at Mossel Bay, South Africa. During this period we monitored their presence and absence at Seal Island by means of two underwater VR2 listening stations. During 2005, a further three sharks were fitted with continuous acoustic pingers and manually tracked for 605 hours in and around Mossel Bay. Information on spatial and temporal trends in predatory activity was garnished by photographic surveys of shark bitten seals residing at Seal Island and direct observation of attacks. Multiple day tracks of patrolling sharks offer new insights into the feeding periodicity, patrolling behaviour, and behavioural plasticity of individual white sharks at Seal Island. Inter and intra annual patterns of habitat use reveal that the white shark is a seasonal hunter of Cape fur seals that concentrate their hunting activity in the winter period. The seasonal reduction in hunting activity results from change in pinniped availability and accessibility during the mating and pupping season. Diel patterns of hunting confirm that activity is essentially crepuscular with hunting effort concentrated in the early morning and late afternoon and evening. However, speculation that white sharks are obligatory diurnal hunters of pinnipeds is incorrect, as a night time attacks was documented. At this location, high behavioural flexibility by white sharks appears paramount to successfully exploit a pinniped resource whose accessibility can vary dramatically in relation to time, space and anti-predatory strategies.

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Using acoustic telemetry to monitor and track the behaviour of white sharks (*Carcharodon carcharias*) at Mosselbaai, South Africa

Between June 2001 and December 2005 an underwater array of 10 VR2 acoustic listening stations was in continuous operation at Mosselbaai, South Africa. Receiver placement covered coastal swimming beaches, the near shore seal island, coastal

reefs, river mouths, offshore areas, and commercial dive spots. Whilst the array was in operation 98 white sharks (*Carcharodon carcharias*) were fitted with RCODE acoustic transmitters at Mosselbaai. Spatial and temporal trends in site fidelity, habitat use were monitored. In addition, during 2005 a further three sharks were fitted with continuous acoustic pingers which enabled manual tracking possible. These three sharks were tracked for a total of 605 hours, including a 103 hour continuous track. This data was used to investigate fine scale movements of white sharks within and around the bay. Acoustic telemetry produced further insight into the white sharks degree of sociality, hunting behaviour, rate of movement, and response to chumming vessels. The high degree of residency and newly demonstrated patterns of habitat use offers new insight into the white sharks life history. Results give management the opportunity to effectively mitigate the impact of consumptive (incidental fishing) and non-consumptive (cage diving activities) exploitation of white sharks in South Africa, as well as offering new means for humans to avoid shark attacks.

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#### Geographic variation in the diet of ring-necked snakes in Minnesota

Ring-necked snakes (*Diadophis punctatus*) occupy two different habitats in Minnesota: forested areas in the northeastern portion of the state and deciduous forests and prairie remnants in the southeastern part of the state. Research on ring-necked snake diet from the upper peninsula of Michigan has shown they eat primarily salamanders and earthworms. Because there are no small salamanders in southeastern Minnesota we hypothesized that earthworms would make up a larger portion of the diet compared to snakes that occur in sympatry with small salamander species. We analyzed the stomach contents of over 35 ring-necked snakes from southeastern Minnesota and found that earthworms made up the majority of the diet. Observations regarding morphological variation and reproduction will also be discussed.

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**JORDAN, LAURA K.**

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#### Stingray mechanosensory and electrosensory ecomorphology: implications for near field prey detection (Elasmobranchii: Batoidea)

Elasmobranch fishes (sharks, skates, and rays) demonstrate remarkable sensory capabilities which are used for a variety of purposes including locating and capturing

prey. This study compares the sensory anatomy of the mechanosensory lateral line system and the electrosensory system in benthic, benthopelagic, and pelagic rays. These systems allow elasmobranchs to locate prey through detecting water movements and electric fields respectively. Morphometric measurements and detailed maps of the sensory anatomy were constructed and analyzed using high resolution images for each species. Striking differences exist in distributions and densities of both lateral line and electrosensory pores. *Urobatis halleri* is a benthic ray feeding primarily on small epifaunal benthic invertebrate prey. The lateral line of this species shows a high proportion of non-pored ventral canals while the electrosensory pores are concentrated ventrally around the mouth. *Myliobatis californica* is a benthopelagic ray, capable of utilizing both the benthic and pelagic environment, and feeds primarily on deeply buried infaunal benthic invertebrates as well as some more mobile invertebrates and fishes. The lateral line system is highly branched with a large number of pores per branch which may help it locate water jets from the siphons of buried prey. The electrosensory system shows the highest pore number of these three species and is highly concentrated anteriorly. *Dasyatis* or *Pteroplatytrygon violacea* is a pelagic ray typically caught in the upper 100m in coastal waters. *D. violacea* feeds on highly mobile fishes and invertebrates, primarily squid. The lateral line branching and ratio of pored to non-pored canals is intermediate in this species while the electrosensory pore number is greatly reduced. Relationships between the ecology of these species, sensory morphology, and potential differences in detection capabilities are explored.

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**Pattern and process of genetic structuring among populations of Galápagos lava lizards**

The geography of islands shapes the evolutionary trajectory of organisms. While this phenomenon has been well documented for reptiles in the Galápagos Islands and other archipelagos, few studies have investigated the role of changes in sea level following the Pleistocene. As sea levels rose in Galápagos, loss of connection to larger land masses created new islands that are currently inhabited by populations of Galápagos lava lizards (*Microlophus* spp.). Although it is possible that populations were established by vicariance, subsequent colonization and gene flow via periodic over water dispersal may play a principle role in shaping genetic variation among populations. The recent development of statistical approaches based on coalescent models, rather than  $F_{ST}$ , now allow a test between these two demographic scenarios. We determined genetic variation in 17 populations from Isla Santa Cruz and its associated islets using 12 microsatellite markers. Strong genetic differentiation is found among populations. Allelic diversity is highest among individuals sampled from three geographically isolated sites within Santa Cruz. Increasing distance from

Santa Cruz is correlated with decreasing genetic variation among populations. We will also present a preliminary analysis that uses coalescent modeling. The method works by developing models that assume: 1) fragmentation of populations has led to divergence by genetic drift alone, or 2) an equilibrium exists between genetic drift and gene flow. Because the probability functions of allele frequencies produced by each model are distinct, it is possible to assess which scenario has the higher likelihood. Our study provides an example of how genetic markers can be used not only to describe patterns of genetic variation among populations but also the processes that have led to them.

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Interspecific female choice in a Lake Malawi cichlid fish

The cichlid fishes of the East African great lakes provide an excellent opportunity to study rapid species diversification. Sexual selection on male nuptial coloration has been noted as being particularly important to the reproductive isolation amongst closely related groups. Female haplochromine cichlids have been shown to mate assortatively with males of particular color morphs and in certain circumstances visual cues alone were sufficient for females to make consistent choices. If sexual selection were indeed a facilitator of species diversification amongst haplochromine cichlids, one would expect color to be particularly important to interspecific mate choice. I sought to further understand interspecific female choice by investigating associative behavior in a single species of Lake Malawi cichlid fish, *Metriaclima zebra*. I tested the hypothesis that females would spend more time associating with heterospecific males most similar to conspecifics in coloration and that this association would be evident even when these heterospecifics were more distantly related than differently colored heterospecifics. I found that females exhibited increased associative behavior with heterospecific males colored like *M. zebra* males than with males that were not. These results are discussed in the broader context of both the adaptive and non-adaptive mechanisms that have been suggested to be important to the radiation of this group.

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**JORGENSEN, MICHAEL E.**

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Developmental plasticity in larval American toads, *Bufo americanus*

If one considers the substantial amount of information that exists about phenotypic plasticity in amphibians, it is surprising that few researchers have examined the abiotic factors that are responsible for shaping phenotype. Phenotypic change and stability are artifacts of organisms that bear significant relevance to evolution within

and among taxonomic groups. Moreover, morphological and developmental characters of organisms often are used by systematists to infer phylogeny. The apparent high degree of morphological and developmental variation in amphibian species presents a unique opportunity to quantify and describe major patterns of shape change affected by incubation temperature and temperature regimes through early ontogeny. Herein, I examine development as a phenotypically plastic aspect of larval anurans. With the use of hormone injections to induce ovulation and spermiation, eggs of the American Toad (*Bufo americanus*) were obtained from specimens representing multiple populations. Tadpoles were distributed equally among four temperature treatments (constant average, constant high, constant low, and fluctuating-daily), and developmental series were collected from each temperature treatment. Larvae were cleared and double-stained to permit photography of the chondrocranium under a stereomicroscope. More than a dozen landmarks were placed on digital images of chondrocrania. Landmark-based geometric morphometrics was used to facilitate examination of differences in overall shape change of the larval chondrocranium through ontogeny, as a result of developmental temperature regime. These results, along with apparent differences among major structural regions of the chondrocranium, are presented.

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The white shark cafe: Seasonal offshore migration of adult white sharks to the central northeast Pacific

The white shark *Carcharodon carcharias*, an important apex predator, is a species of conservation concern yet their ecology remains poorly understood. We identified an offshore region of the subtropical eastern Pacific consistently utilized by adult white sharks migrating from the coast of central California. We tagged 58 adults with pop-up satellite archival tags in coastal waters of northern California, and have retrieved 20 records to date. 28 tags remain on white sharks and are due to pop up in 2006. Adult white sharks resided near pinniped colonies and were observed feeding during fall and early winter. Movements offshore occurred over a long time period, some sharks left the coast by the end of November while others did not leave until late February. Over the five years of the study, most sharks moved to the same

oligotrophic region of the central north Pacific gyre and remained there throughout the spring and summer. Sharks appeared to make directed movements between the coastal and offshore regions. Some hypotheses about the nature of these migrations are discussed.

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### Egg mass translocations and the colonization of an artificial wetland by amphibians in Rocky Gap State Park, Maryland, USA

We described the initial colonization of a small (0.2 ha), artificial wetland by amphibians and attempted to enhance amphibian colonization by translocating egg masses of two amphibian species that were native to the region (western Maryland), but absent from within 16km of the artificial wetland. This wetland was created in the summer of 1997 in a small valley below a newly constructed golf course and consisted of a series of seven ponds. Ponds were graded to depths of either < 35 cm or > 40 cm deep to offer a variety of drying regimes, and all ponds contained shallow, vegetated shelves. Five anuran and one salamander species naturally colonized these ponds within one year of their creation. The translocations of fewer than 700 *Pseudacris triseriata feriarum* (upland chorus frog) eggs in 1997 and 1998 resulted in the return of several adults in 1998 and 1999 that deposited egg masses. Fewer than 800 *Ambystoma jeffersonianum* (Jefferson salamander) eggs were translocated in both 1996 and 1997. At least 14.8% and 1.4% of all *A. jeffersonianum* embryos completed metamorphosis in 1996 and 1997, respectively, while a small number of *A. jeffersonianum* egg masses were found in one pond when the wetland was visited in 2004.

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The effects of chronic pesticide exposure on larval amphibians

Egg masses and larvae of amphibians were exposed to three different insecticides (carbaryl, chlorpyrifos, imidacloprid), fungicides (mancozeb, fosetyl-al, and chlorothalonil), and herbicides (glyphosate, prodiamine, dimethylamine) in a series of chronic exposure egg mass and larval trials whose exposure levels were expressed relative to bioassay estimated LC<sub>50</sub> values. *Bufo americanus* (American Toad) eggs and larvae were exposed to insecticides and herbicides, while egg masses and larvae from *Rana sylvatica* (Wood Frog) were exposed to the fungicides. For each insecticide, *B. americanus* larvae failed to survive when exposure levels were 0.5xLC<sub>50</sub>, while exposure levels equivalent to 0.1xLC<sub>50</sub> did not appear to affect larval survival. Exposure levels of 0.1xLC<sub>50</sub> did, however, increase time to metamorphosis and reduce larval growth compared to controls. The herbicides glyphosate and prodiamine reduced *B. americanus* hatching success at exposure levels as low as 0.25xLC<sub>50</sub>, while prodiamine began to affect larval survival at levels equivalent to 0.1xLC<sub>50</sub>. In *R. sylvatica*, the fungicide mancozeb reduced hatching success and increased the percent of hatchlings with deformities at 0.1xLC<sub>50</sub>, while reducing larval survival at levels as low as 0.01xLC<sub>50</sub>.

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**JUTERBOCK, J. ERIC**

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A preliminary look at climbing behavior in southern Appalachian plethodontid salamanders

Although the arboreal nature of western North American species of *Aneides* has been long accepted, controversy existed over the significance of arboreal behavior in Green Salamanders until publication of recent work in South Carolina. For other plethodontids occurring in the southern Appalachian Mountains, few details are known of their climbing behavior, in spite of the number of researchers and the volume of work done there. The one study of climbing behavior, involving Red-backed Salamanders in the Shenandoah Mountains of Virginia, found that they did so only when it rained and they did so to feed. References in several books about salamanders or all amphibians published over the past decade note the climbing behavior of several species of three genera of plethodontids, but little else. I have begun a study to quantify aspects of this behavior among plethodontid assemblages

at several sites in the southern Appalachians. Ascending trees, shrubs or forbs occurs widely among dusky salamanders, species of the *Plethodon jordani* complex and *Eurycea wilderae*. Climbing is more common during, but does not require, rainy weather. Although all surface terrestrial activity was much reduced in dry weather, *jordani*-complex salamanders were not only active at ground level, but a few were climbing more than two weeks post-rain. There may be a seasonal relationship to the frequency of climbing behavior among these plethodontids, with it becoming less frequent later in the active season. *Desmognathus ocoee* may more frequently be above ground than on the surface during wet weather.

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### Olfactory responses and crypsis of natural prey metabolites to juvenile hammerhead sharks

Hammerhead sharks have a unique neurocranium morphology formed by lateral expansion of the olfactory capsules. Their correspondingly widely separated, enlarged and elongated olfactory organs are hypothesized to confer enhanced sensitivity, detection and localization of prey. Whereas a few studies have examined the response to amino acid stimuli in elasmobranchs, none have empirically tested the ability to detect the metabolites from their natural prey. This study employed an electro-olfactogram technique to quantify the response of juvenile scalloped hammerhead sharks, *Sphyrna lewini*, to the six most common prey items in their diet: three teleost and three crustacean species. Metabolites from all prey items evoked responses from the shark olfactory epithelium, but those from teleosts generally elicited a greater response than did those from crustaceans. Commensal shrimp/goby pairs live in a shared burrow excavated by the shrimp and are the primary prey items in the diet of juvenile sharks in Kaneohe Bay, Oahu. Whereas the response of the shark to the burrowing shrimp did not differ significantly from the other crustaceans, the commensal goby elicited the greatest magnitude response of all species. However, when the metabolites from the burrowing shrimp were combined with its commensal goby, the response was of lower magnitude than that to metabolites of the goby alone. Additionally, water from shrimp/goby burrows did not elicit a response that differed from adjacent seawater indicating that the chemical inhibition of the metabolites from the two species was effective at masking the odor signature of the burrow inhabitants. This represents the first report of differential olfactory sensitivity to natural prey in a shark, and the first example of possible olfactory crypsis between commensal prey species.

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Egg feeding behavior of a rhacophorid tree frog (*Chirixalus eiffingeri*) from  
subtropical Taiwan

We used an infrared digital camera to record the feeding behavior of *Chirixalus eiffingeri* female frogs in the field. Females of *C. eiffingeri* deposit fertilized eggs above the waterline on the inner walls of bamboo stumps. Upon hatching, tadpoles drop into the pool of water where they grow and develop until metamorphosis. Female frogs visit and feed tadpoles at night at intervals of about 8 days. Tadpoles are obligatorily oophagous, and the length of larval period is 40 to 60 days. Results showed that the feeding behavior was uniparental care in that male frogs did not involve during the whole behavioral sequences. As a female returned to her nest, she usually crawled up the bamboo stump slowly and stop couples times on her way to the opening. During her ascent, tadpoles in the water pool remained immobile. As soon as the female reached the rim of the stump, she jumped into the pool. The tadpoles immediately became extremely excited and started to aggregate around her. Each tadpole stiffened its tail and began vibrating vigorously and nipping at the skin around her cloaca, thighs, and body. During the process, females stretched her body and allowed the tadpoles to touch her body. The movement of tadpoles became faster and more vigorous as the encounter progressed; this behavior was fastest and most vigorous moments before eggs were deposited in the pool. The egg-begging behavior lasted about 15 min and females began to lay trophic eggs, a few at a time. As soon as the eggs are laid, the tadpoles swallowed the eggs immediately. The video on the egg feeding of females will be showed during the presentation.

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The ecology and conservation of bullsnakes (*Pituophis catenifer sayi*) in upper  
Midwestern prairies

Bullsnakes (*Pituophis catenifer sayi*) are the largest snakes native to the Upper Midwest, and appear to be experiencing significant population declines. Unfortunately, little ecological research, especially regarding their habitat preferences, has been conducted in this region. The objectives of this study were to determine: (1) habitat utilization and preferences, (2) home range sizes and movement rates, and (3) sources of mortality. Radio telemetry equipment was used to track 20 snakes during typical seasonal activity periods from 2003 to 2005. During weekly telemetry surveys, the geographic position of each snake and several structural habitat and environmental parameters were recorded. Later, Geographical

Information Systems (GIS) were used to analyze snake location and habitat data. Chi-squared analyses determined that snakes were not found in habitats based on the proportion in which they were available. Bonferroni confidence intervals showed that snakes were found to prefer two habitat types (open bluff faces and oak savannah), and seemed to avoid two others (closed canopy bluffside forest and row crops). Differences in the size of the home ranges and movement rates between male and female snakes will be discussed. Throughout the study coyotes (*Canis latrans*) and agricultural equipment posed the most significant sources of mortality to adult snakes. It is hoped that these data will help habitat managers within the region make sound conservation decisions regarding bullsnakes and their preferred habitats.

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Molecular phylogenetics in the garter snakes of northern New England:

*Thamnophis sirtalis sirtalis* L. 1758, and *T. s. pallidulus* Allen 1899

The common garter snake, *Thamnophis sirtalis*, is one of most-studied reptiles worldwide. Due to differences primarily in color and stripe morphologies, twelve subspecies are described for *T. sirtalis* across its range in North America. Two of these twelve subspecies exist in northern New England: the eastern garter snake, *T. s. sirtalis* L. 1758, and the maritime garter snake, *T. s. pallidulus* Allen 1899. Most field guides and other published literature on these snakes place a boundary between the two subspecies, which runs diagonally from southeastern New Hampshire through northwestern Vermont; *T. s. pallidulus* exists north and east of this boundary, and *T. s. sirtalis* exists south and west of this boundary. This study uses a molecular phylogenetic perspective to explore the geographic variation within *T. sirtalis* populations from northern New England, and to address the null hypothesis that the subspecies classification of *T. s. pallidulus* is invalid. Snakes were collected from five field sites on a North-South transect from northern New Hampshire, through central Massachusetts. Ventral scale clippings were taken from these garter snakes, and standard DNA extraction, polymerase chain reaction, and sequencing methods were employed to acquire cytochrome B, ND4, and ND2 mitochondrial sequence data. Phylogenetic trees were created using divergence data from these mitochondrial regions, to show relationships between and among regional *T. sirtalis* populations existing across this subspecies cline.

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Hybridization and introgression in *Nothonotus* darters (Percidae)

Hybridization has the potential to be an important factor in speciation and lineage diversification. Many recent studies of hybridization have focused on hybrid zones and the mechanisms of reproductive isolation. Hybrids are known to occur in *Nothonotus* darters, a monophyletic group of 20 described species, of which 17 species are sympatric with at least one other *Nothonotus* species. Most species in *Nothonotus* exhibit no parental care, but a monophyletic group of 5 species exhibits parental care through male nest guarding. We wanted to determine if male guarding had an effect on the frequency of hybridization among *Nothonotus* species. We searched museum specimens for putative F1 hybrids between *Nothonotus* species and found 88 individuals. Of these, 82% involve *Nothonotus rufilineatum* as a parental species, 80% involve *N. chlorbranchium*, 30% involve *N. camurum*, and only 8% involve species that exhibit male nest guarding parental care. We also used mitochondrial and nuclear DNA sequence data to determine if there is a pattern of introgression among *Nothonotus* species. We discuss both sets of results in relation to the potential mechanisms of reproductive isolation, as well as the difficulties that may arise when attempting to interpret *Nothonotus* phylogeny from sets of conflicting gene trees.

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Selective tidal stream transport and rheotactic orientation by green sturgeon, *Acipenser medirostris*, in the San Francisco Bay Estuary, California

Fishes moving within tidal environments continuously interact with water currents. These currents can make travel energetically expensive; however, some fishes use selective tidal stream transport, migrating vertically to be carried by favorable tides, thus reducing energetic costs. We report on the role of currents in the movements of green sturgeon (*Acipenser medirostris*) tracked within the San Francisco Estuary. Six fish (101-153 cm TL) were implanted with depth-sensing acoustic transmitters and tracked for approximately 95 hours, yielding 35 hours of directional movements. The observed movements were bi-modally distributed with 57.3% of movements recorded near the surface and 42.7% near the bottom. Total movement vectors (bearing and speed) at five minute intervals were calculated, and current vectors for each interval were estimated using modeling software. Vector math was used to subtract the current from the total movement, revealing the fish's vector at each interval. The average sturgeon swimming speed did not differ (surface = 0.50 m/s, bottom = 0.51 m/s); however, surface movements had a higher total speed (0.85 m/s,

0.54 m/s) and occurred at higher current speed (0.62 m/s, 0.28 m/s). The mean angle of the fish to the current was positively rheotactic at the surface (mean angle = 33°) and negatively rheotactic at the bottom (mean angle = 210°). When fish vectors were calculated with currents reversed, swimming speed increased minimally for bottom movement (0.71 m/s), but tripled for surface movements (1.43 m/s). Sturgeon apparently suffer low costs opposing slower currents, and do so near the substrate; however, the costs of opposing swift currents are substantial, and they instead travel at the surface swimming with the current. Our observations indicate that green sturgeon must be able to determine the direction of flow and actively move in that direction, increasing the efficiency of travel in the estuarine environment.

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Molecular phylogenetics of *Patagonotothen* (Notothenioidei: Nototheniidae)

*Patagonotothen* contains 14 species distributed in marine habitats of Tierra del Fuego, the Falkland Islands, the Burwood Banks, South Georgia, and Shag Rocks. The clade is thought to represent a radiation of secondarily non-Antarctic nototheniid species. Previous taxonomic studies have relied exclusively on external morphological features. These surveys indicate that there is slight morphological distinction among many *Patagonotothen* species. Limited molecular phylogenetic analyses indicate that *Patagonotothen* is nested within *Lepidonotothen*, and the most recent common ancestor of *Patagonotothen* has a recent origin. We examined *Patagonotothen* relationships through phylogenetic analysis of the mtDNA ND2 gene sampled from 37 individuals across ten species. We provide the first phylogenetic hypothesis for *Patagonotothen* species and discuss tempo of speciation in the clade and Antarctic marine biogeography.

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Seasonality in shark long-line catches at Bimini, Bahamas

A bi-monthly long-line regime conducted at Bimini, Bahamas (25°44N, 79°16W) since July 2003 was designed to sample the resident and nomadic shark populations for structure, growth, movements and seasonality. Every 24hr-fishing period, five bottom lines, each approximately 400m in length with 15 baited gangions interspersed by surface floats, are set and checked every three-five hours. Captured

specimens are secured to the boat, measured (pre-caudal, fork and total length) and individuals over 140cm fitted with a NOAA/NMFS M-type dart tag. All lemon sharks (*Negaprion brevirostris*) receive a PIT tag and a DNA sample is taken. Catch per unit effort (CPUE) shows little seasonal variation other than a drop in February and March to 0.1, but recovers to the highest rate in April at 0.37. *Carcharhinus acronotus* catches are too infrequent and sparsely distributed to conclude anything on seasonality. *C.leucas* catches are also infrequent but CPUE is highest in April (0.04) and present from June to August, which is contrary to the period of most local sightings in the winter months. *Rhizoprionodon porosus* catches are again infrequent and seasonal with highest CPUE in April (0.08) and May (0.03). *C.limbatus* CPUE peaks at 0.1 in the summer months (August/September), with fresh mating scars observed at this time. This species is absent from the catches during the month of February when they are likely birthing over the flats. *Ginglymostoma cirratum* CPUE also peaks in the summer months at 0.15 and drops off to absent in the February and March. *Galeocerdo cuvier* is the only species represented by catches year round, with neonates caught throughout, suggesting the absence of a defined pupping season. *N.brevirostris* CPUE peaks at 0.07 in the early summer (April/May/ June), which coincides with their know parturition period at Bimini. This species is completely absent from catches in February and March.

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### Comparative study of life histories of the endangered Vermilion Darter (*Etheostoma chermocki*) and its sister species, the Warrior Darter (*E. bellator*)

The federally endangered vermilion darter (*Etheostoma chermocki*) is endemic to a single stream in the Black Warrior River system in the Mobile Basin in Alabama. Examination of preserved specimens provided useful information on life history characteristics of this species but was insufficient in critical details, such as the length of spawning seasons. Thus, a surrogate species was employed in order to attain a better understanding of the autecology of this endangered species. The warrior darter (*E. bellator*) represents an ideal surrogate for the vermilion darter because it is the sister species and it inhabits the system adjacent to the endangered vermilion darter. Life history characteristics of these two species were comparable. The sex ratio was close to 2 to 1 in favor of females. Larger individuals tended to be more fecund than do smaller individuals. The population included four age classes (0+, 1+, 2+, and 3+) with the majority in the first and second year of age. Both species were opportunistic feeding on aquatic invertebrates, such as larval chironomids, mayflies, and caddisflies. Diet breadth (prey richness) was greatest during warmer months and least during colder months although the diet of *E. bellator* appeared to be more diverse than that of *E. chermocki*. These similarities probably indicate few changes since they diverged from the ancestral species. Thus, it may be assumed that the missing information on life history characteristics of *E. chermocki* can be completed by

using the life history characteristics of *E. bellator*, such as the spawning season for *E. bellator* (March to June) is likely the same for *E. chermocki*.

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### Isotopic evidence for dietary shift in historical and modern white sharks off the coast of California

White sharks (*Carcharodon carcharias*) are top-level opportunistic predators that have been observed to prey on marine mammals off the coast of California. However, California pinniped populations were in decline until 1970s. Populations began to rebound after enactment of the Marine Mammal Protection Act in 1972. We used stable isotope analysis to determine feeding patterns of white sharks from 1955 through present as marine mammal populations fluctuated off California. Stable isotope ratios of carbon ( $^{13}\text{C}/^{12}\text{C}$ ) and nitrogen ( $^{15}\text{N}/^{14}\text{N}$ ) can be utilized as tracers for ecological studies. Carbon isotopes vary at the base of the food web with primary productivity, onshore versus offshore location, and latitude. Nitrogen isotopes are strongly sorted by trophic level, with greater  $^{15}\text{N}$ -enrichment at higher trophic levels. The life history of a white shark may be recorded in its concentrically accreted vertebrae, assuming subsequent turnover does not overprint earlier events. To track the diet of a shark through its lifetime, we determined the  $^{13}\text{C}$  and  $^{15}\text{N}$  values of organic matter extracted from individual vertebral growth rings. Our preliminary results indicate that white sharks fed at a high trophic level in the 1950 and 1960s, when pinniped populations off California were not high. Isotopic data suggest that white shark diets consisted of pinnipeds from higher latitude or migratory populations and perhaps baleen whales. In addition, ontogenetic dietary shifts are discernable within vertebral centra. A controlled feeding study is needed to verify diet-to-tissue fractionation factors and remodeling dynamics of vertebral centra. Additional samples from historic and archaeological sites will also help define the trends of white shark feeding habits through time.

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Estimating detection probabilities and site occupancy rates in three anuran species using call surveys

We monitored the distribution of three anuran species based on large-scale volunteer call surveys. Detection probabilities and site occupancy rates were estimated from repeated visits of each 2 X 2 km<sup>2</sup> survey plot within an administrative district, Haenam Kun, Junnam Province, Korea. Five-minute surveys on whether the species are present or not were conducted 30 minutes after sunset or later on rice fields in 2005. We obtained detection probabilities from four models with three covariates: temperature, humidity, and the amount of water on the field. Monitoring was carried out at seven to 28 sites with average 10.3 to 10.7 visits depending on the species. Site occupancy rates of the three species were all high over 0.80 while model averages of detection probability were low of 0.32 (Narrow-mouthed toads, *Kaloula borealis*) to 0.59 (Three-striped pond frogs, *Rana nigromaculata*). Model selection was not clear in Three-striped pond frogs and Narrow-mouthed toads, while Bullfrogs (*Rana catesbeiana*) were well explained with a model including the amount of water.

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**KING, RICHARD B.; QUERAL-REGIL, ALEJANDRO; \*STANFORD, KRISTIN M.**

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Population size and recovery criterion of the threatened lake erie watersnake: Integrating multiple methods of population estimation

Quantitative estimates of abundance are central to management of threatened and endangered species but may be difficult to obtain for rare secretive organisms. Estimates of adult population size for the federally threatened Lake Erie watersnake were computed using mark-recapture data from area-constrained searches of 21 study sites on 9 islands encompassing >25 km of shoreline and spanning 25 years. Watersnakes were hand captured and marked by scale clipping (1980-1992) or PIT tags (1996-2000), providing data on 5441 captures of 4168 adults. Population estimates were generated using Pollock's 'robust design' from a combination of secondary (within-year) and primary (among-year) population censuses. Closed population methods (Lincoln-Petersen, Schumacher's) were used for within-year censuses and open population methods (Jolly-Seber, Bailey's triple-catch) were used for among-year censuses, providing 121 point estimates. Paired t-tests comparing alternative methods were consistently non-significant, suggesting that the no-recruitment assumption of closed population methods was met. At 11 sites encompassing 15.8 km of shoreline for which recent (2000-2004) mark-recapture

estimates were available, population density was highly correlated with capture rate ( $r = 0.90$ ). The regression relationship between density and capture rate was thus used to estimate population size at 19 additional sites (19.6 km of shoreline) based on capture rate alone. Together, mark-recapture and capture rate estimates totaled more than 6500 adults, exceeding the overall number (5555 adults) specified in the *Population Persistence* criterion of the Lake Erie Watersnake Recovery Plan. Actions related to other criteria (*Habitat Protection and Management, Reduction of Human-induced Mortality*) and a capacity for rapid population growth make recovery and eventual delisting of the Lake Erie watersnake a real possibility.

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#### Endocrinological evidence for differences in the annual reproductive cycles of two sympatric skate species from the Gulf of Maine

The smooth skate, *Malacoraja senta*, and thorny skate, *Amblyraja radiata*, are two sympatric batoids whose stocks are at or below threshold levels within the Gulf of Maine. During the past five years, a large life history study was conducted in an attempt to accurately describe important biological life history parameters previously lacking for these species. As part of that project, the goal of the current study was to gain insight into the reproductive biology of these species. Plasma samples were obtained from mature smooth and thorny skates of both sexes captured all months of the year, and the Estradiol ( $E_2$ ), Testosterone (T), and Progesterone ( $P_4$ ) concentrations were determined using radioimmunoassay (RIA). The respective steroid hormone concentrations were averaged, compared to morphological reproductive parameters, and plotted to examine any monthly trends. Based on morphological parameters, each species exhibited an annual reproductive pattern. Furthermore, preliminary analysis indicated that  $E_2$  concentrations in females may be different between the two skate species over the course of their reproductive cycles. Analyses of the other steroid hormones in female and male smooth and thorny skates are currently underway so that we can compare the respective plasma profiles during their reproductive cycles.

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The potential effects of climate change on insular species distributions: An example using Caribbean *Anolis* lizards

Global climate change is now a commonly accepted phenomenon which will potentially have dramatic effects on the Earth's biodiversity and ecosystems. Although the environmental changes associated with this climatic variability have been predicted in detail, their effects on species distributions and biodiversity are not well understood. Over long periods of time, species have been able to respond to gradual climatic changes, but the current rapid changes in these conditions and their impact on species distributions is of significant concern. To assess the potential effects of climate change on insular species, I assembled a dataset including 8,587 individual localities from 76 species of Caribbean *Anolis* lizards. Using these data, GIS data representing current and future climate predictions, and the GARP ecological niche modeling algorithm, I predicted the potential shifts in species distributions for *Anolis* lizards on the major islands of the Greater Antilles. Results indicate that several species will experience dramatic reductions in available habitat. As predicted by previous work on continental systems, species richness will likely increase at higher elevations while species richness will tend to decrease at lower elevations. Additionally, Cuba will apparently experience the greatest decreases in species richness followed by Hispaniola, Jamaica, and Puerto Rico. Recent morphological work suggests that Caribbean anoles have adapted to local temperature and precipitation levels. Consequently, results from the climate change predictions appear to have relevance to local population processes.

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Seasonal occurrence, residency patterns and habitat use of white sharks at Seal Island, South Africa

South Africa is a centre of white shark (*Carcharodon carcharias*) abundance and the first country to protect this apex predator. White sharks are listed as Vulnerable on the IUCN's Red List of Threatened Species and on CITES Appendix II, but vital information required on this species' ecology, including occurrence, residency patterns, site-fidelity, identification of critical habitats and habitat utilisation, are still limited. This information is crucial when trying to ensure that protection and

management measures are adequate. As a result, a telemetry study aimed at addressing these ecological issues was initiated in May 2004 at Seal Island, False Bay, the largest island Cape fur seal (*Arctocephalus pusillus pusillus*) breeding colony in South Africa and one of the areas along the South African coast where shark tourism activities (shark cage diving and viewing) are a regular occurrence. Vemco VR2 acoustic listening stations (2 – 6) have been deployed on the seafloor around the island, and 40 white sharks of both sexes, ranging in size from 200 – 500 cm, have been tagged with a combination of Vemco V16 and V16P acoustic transmitters. White sharks are seasonally present at Seal Island during the southern hemisphere's winter months, actively preying on young of the year Cape fur seals. Residency times are highly variable among individuals and range from a few days to up to 6 months, having important ecological consequences. Spatial and temporal activity patterns are correlated to seal availability. We discuss these preliminary results, their ecological implications and future research objectives.

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Presentation time affects memory of conspecifics in red-backed salamanders  
*Plethodon cinereus*

Memory is defined as the capacity to store, retain, and retrieve information from a past. One important aspect that can affect memory is presentation time. We investigated whether presentation time would affect individual recognition memory in male red-backed salamanders, *Plethodon cinereus*. We conducted two experiments that tested the hypotheses that individual recognition memory would be weak after a short presentation time (15 min) and strong after a long presentation time (5 d). After 15 min presentations, focal males differed significantly in aggressive behavior across the treatments. Post-hoc comparisons showed that focal salamanders spent more time threatening both familiar and unfamiliar intruders compared to the controls. There were no significant differences in chemodetection (i.e. number of nose taps) across the treatments for nose taps. After 5 d presentations, focal males spent significantly more time threatening unfamiliar intruders than familiar intruders, and significantly more time nose tapping in front of unfamiliar intruders than familiar intruders. The results from the first experiment suggest that 15 min was not enough time for a salamander to remember an individual it had seen five days earlier. The results from the second experiment suggest that 5 d was enough time to remember an individual seen five days earlier. Thus, these results support the hypothesis that presentation time affects individual recognition in red-backed salamanders.

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**KONINGS, ADRIANUS; \*STAUFFER, JAY**

*Cichlid Press, El Paso, TX 79913 School of Forest Resources, Penn State University, University Park, PA, 16802, USA*

Variability in some species of *Metriaclima* (Cichlidae) from Lake Malawi

The genus *Metriaclima* was diagnosed to accommodate the *Pseudotropheus zebra* complex. The main characters that delimit members of *Metriaclima* from other complexes in *Pseudotropheus* are a moderately-sloped ethmo-vomerine block with a swollen rostral tip. Morphological characteristics of the feeding apparatus reflect the manner in which these fishes browse from the substrate and we include characters of feeding behavior in the diagnosis of *Metriaclima*. In this paper, we compare various neighboring populations of *M. zebra* in the Lake Malawi National Park leading to a widening of the diagnosis to allow inclusion of a non-barred population at Maleri islands. We further describe a new taxon, with populations that vary in morphology as well as in coloration. The populations around two of the Maleri islands (Nakantenga and Maleri) are morphologically very similar but differ slightly in male breeding coloration, while one distant population (Chidunga Rocks) differs in morphology but not in breeding coloration when compared to that from Maleri Island. An additional distant population (Thumbi West Island) differs both in morphology and coloration from the others. Underwater observations indicate that all populations are behaviorally similar, which leads us to believe that they are conspecific.

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**KONOW, NICOLAI**

*Hofstra University, Dept. Biology, Hempstead, NY, 11549, USA*

Functional disparity and ecological diversification in marine angelfishes, f. Pomacanthidae

I examined structural and functional disparity in a complete regional assemblage of marine angelfishes (Family Pomacanthidae) to evaluate the functional and evolutionary basis of biting in reef fishes. Molecular evidence provided a phylogenetic framework allowing comparisons of the ecomorphological characteristics governing biting to the more intensely studied ram-suction feeding mode of reef fishes. Variations in angelfish feeding morphology are restricted to two shared derived traits, an intramandibular joint permitting closure of the protruded jaws and pronounced suspensorial flexion augmenting mandible protrusibility. Analyses of prey-capture kinematics demonstrated restricted functional disparity in angelfishes: while phylogenetic mapping of informative gut character traits delineated ecologically divergent feeding guilds, these guilds are governed by a single novel kinematic pattern to dislodge attached prey. Disparity principally occurs among the "pygmy" angel subgenera while a pronounced kinematic uniformity characterizes the generalized, large-bodied taxa. The novel feeding apparatus traits, a high-velocity jaw retraction and pronounced body-size differences provide the

functional basis that permits angelfishes to negotiate 'ecological thresholds' posed by sturdily attached prey. Despite limited structural and functional disparity, functional innovations in the angelfish feeding apparatus have played an overriding role in the evolution of considerable ecological diversification.

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**KONOW, NICOLAI; \*SANFORD, CHRISTOPHER P. J.**

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### Motor-pattern variation during feeding in tongue-biting teleosts

Patterns of change in muscle activity that result in novel feeding behaviors have rarely been quantified in lower vertebrates. The kinematic differences in prey-capture (strike) and processing (raking) in a previously studied salmonid suggest a possible mechanism by which diverging motor-patterns (MPs) are responsible for a new feeding behavior using the tongue-biting apparatus. We tested for differences in the MPs characterizing striking and raking in the rainbow trout, *Oncorhynchus mykiss* using electromyography (EMG) of five cranial muscles used during feeding. Five muscle activity variables were analyzed (onset & offset timing, duration, mean amplitude and mean integrated area). A principal components analysis revealed significant differences between MPs, predominately driven by recruitment variability of the *m. protractor hyoideus* and *m. adductor mandibulae* among feeding behaviors. We also compare the rake EMG of *Oncorhynchus mykiss* to that of a more basal, tongue-biting osteoglossomorph. This avenue of research investigates whether the morphological similarity of tongue-biting apparatus found in evolutionarily distinct teleost lineages translates into convergent or divergent tongue biting motor patterns. Supported

by NSF IOB-0444891

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**\*KONSTANTINIDIS, PETER; BRITZ, RALF**

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### Development of the hyopalatine arch in tetraodontids: Fixation of the ethmopalatine articulation

We describe the development of the ethmopalatine articulation in representatives of the teleost family Tetraodontidae and compare it with that of a morphologically less modified percomorph *Dicentrarchus*. We use cleared and double-stained specimens and serial transverse sections of different developmental stages of the two tetraodontids *Monotretu leiurus* and *Carinotetraodon travancoricus* and the moronid *Dicentrarchus labrax*. In the earliest stages of tetraodontids available to us, the cartilaginous hyopalatine arch is fully formed and comprises the hyosymplectic and palatoquadrate cartilages. As in *Dicentrarchus* and most other teleosts, the pars

autopalatina of the palatoquadrate articulates anteriorly with the ethmoid plate in tetraodontids; posteriorly the hyopalatine arch articulates with the otic capsule via the pars hyomandibularis of the hyosymplectic cartilage. Subsequently, however, the ethmoid plate in tetraodontids develops anterolaterally projecting paired processes that are covered ventrally by the developing bilobate vomer, which articulates with the ossifying autopalatine. The perichondral autopalatine develops a posteriorly directed lamina of membrane bone that covers the vomer dorsally and later in development forms a strong interdigitating suture with the vomer through development of additional posterior membrane processes. This results in the immobilisation of the ethmoidpalatine joint and concomitantly in an almost complete restriction of the lateral movement of the hyopalatine arch, a situation very unlike that in *Dicentrarchus*, which retains a mobile ethmopalatine articulation. The fixation of the ethmopalatine joint is most likely correlated with the durophagous feeding habits of puffers to which a suite of additional modifications like the fusion of individual jaw teeth into the tetraodontid beak and the strong interdigitation between left and right jaws can be attributed.

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#### A regional perspective on the phylogeography of the *Fundulus notatus* species complex

The *Fundulus notatus* species complex is comprised of the Blackstripe Topminnow (*F. notatus*) the Blackspotted Topminnow (*F. olivaceus*) and the Broadstripe Topminnow (*F. euryzonus*). *Fundulus notatus* and *F. olivaceus* are both widely distributed, while *F. euryzonus* is endemic to the Lake Pontchartrain drainage of Louisiana and Mississippi. The systematic relationships among these three species remains unresolved and may be further complicated by geographic variation (*e.g.*, the chromosomal race of *F. notatus* in the Tombigbee River). Here we report on the use of mitochondrial (cytochrome *b* and ND2) and nuclear (S7 intron) sequence data to characterize the geographic patterns of intraspecific genetic variation in members of the complex and to assess the phylogenetic relationships among these taxa. Our study emphasizes the drainages of the Lower Mississippi River and the Gulf of Mexico including 88 *F. olivaceus* from 11 drainages, 33 *F. notatus* from 6 drainages and 5 *F. euryzonus* from 2 drainages. Phylogenetic analyses of the combined mitochondrial and nuclear datasets refute the prior hypothesis of a sister relationship between *F. euryzonus* and *F. olivaceus*. Furthermore, the overall tree topology illustrates a rich biogeographic history along the Gulf Coastal Plain, highlights potential areas of unrecognized taxonomic diversity and supports previous observations of hybridization among members of the complex.

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**\*KRIGER, KERRY M.; HERO, JEAN-MARC; PEREOGLOU, FELICIA**

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Seasonal and latitudinal variation in the prevalence of chytridiomycosis in *Litoria lesueuri*

Chytridiomycosis is an emerging infectious disease of amphibians associated with mass mortalities and population declines worldwide. Previous chytridiomycosis field studies have yielded limited information on the ecology of the disease because survey methodologies were generally limited to opportunistic sampling across a broad range of species, age classes, altitudes, latitudes, habitat types, seasons, and years. Thus, it has been difficult to disentangle or quantify the relative effects of these individual parameters. We conducted chytridiomycosis surveys in Southeast Queensland to determine the magnitude of seasonal variation in disease levels in a single population of *Litoria lesueuri*. A strong seasonal effect of the disease was evident, with disease prevalence peaking at nearly 60% in early spring, and dropping to 0% by late summer. These results highlight the need for researchers to account for the seasonal dynamics of chytridiomycosis when conducting disease surveys and designing experiments. We also conducted disease surveys at 31 lowland sites distributed north-south along 2344km of the Australian east coast and encompassing 20.8 degrees of latitude. A total of 863 adult male *Litoria lesueuri* were sampled, and the overall prevalence of chytridiomycosis was 27%. Prevalence at one site, Currowan Creek, NSW, was 70%, the highest prevalence yet reported for any native frog population anywhere in the world. Chytrid infections were found at 77% of the sites, including sites at the northern and southern limits of the latitudinal transect, but frogs further from the equator were significantly more likely to be infected. Climatic variables affecting the distribution of the disease will be discussed.

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**\*KUCH, ULRICH; LAWSON, ROBIN; MEBS, DIETRICH**

*(UK, DM) Institute of Forensic Medicine, Zentrum der Rechtsmedizin, Johann Wolfgang Goethe University, Kennedyallee 104, 60596 Frankfurt am Main, Germany; (UK) Sektion Herpetologie, Forschungsinstitut und Naturmuseum Senckenberg, Senckenberganlage 25, 60325 Frankfurt am Main, Germany; (RL) Osher Foundation Laboratory for Molecular Systematics and Department of Herpetology, California Academy of Sciences, San Francisco, CA, 94103, USA*

Phylogeny and toxinology of kraits (Elapidae: *Bungarus*): taxonomic and medical implications

Kraits (*Bungarus*) are one of the major groups of terrestrial elapids in Asia, where neurotoxic envenomation by snakebite is a serious public health problem. With individual snakes producing more than 40 different toxins, krait venoms are complex and subject to considerable quantitative variation. While a few toxins are conserved across populations and species, the intra- and interspecific variability of others is pronounced. Traditionally, only three species of kraits have been regarded as

medically significant and used for the production of antivenoms. However, phylogenetic analyses of molecular characters and morphological evidence support the recognition of three well-differentiated clades of kraits comprising at least 18 species. Eleven of these are known to have caused fatal envenomation, and kraits that were previously assumed to be rare continue to emerge as species of epidemiological concern from those clinical studies that address the identity of biting snakes. The implications of the unveiled cryptic diversity of kraits for the management of snakebite in South and Southeast Asia are challenging, and in most regions complicated by the sympatry of 2-4 morphologically similar species. Antivenom has frequently been reported to have little or no apparent influence on the severity of neuromuscular paralysis in krait envenomation. The late admission of bite victims to hospitals and the modes of action of toxins that irreversibly bind to acetylcholine receptors or destroy the nerve terminals are generally thought to be responsible for this problem. Our studies highlight the neglected possibility that antivenom may be ineffective because many bites are caused by species whose venoms are not included in antivenom production, and whose toxins are not recognized by paraspecific antivenom. Comprehensive efforts involving awareness campaigns, clinical use of molecular markers and immunodiagnosis for species identification, trials of existing antivenoms, and the development of new products are required to ameliorate this situation.

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**KUHAJDA, BERNARD R.**

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**Conservation of the imperiled Rush Darter (*Etheostoma phytophilum*) in Alabama: A multifaceted approach**

The Rush Darter, *Etheostoma phytophilum*, is a recently-described species in the subgenus *Fuscatellum*. It is a candidate species for federal listing as endangered. Rush Darters are restricted to two disjunct populations in the Black Warrior River drainage above the Fall Line in north-central Alabama, including Clear Creek sites in the Sipsey Fork system in Winston County and sites in Turkey and Little Cove Creek in the Locust Fork system in Jefferson and Etowah counties. A proposed subdivision development upstream of known sites for the Rush Darter in the Turkey Creek watershed in Jefferson County prompted a single collection effort in 2005 that yielded a record 57 specimens. Utilizing expertise and membership support from two scientific societies as part of a presentation to the Jefferson County Zoning Board lead to a permit requiring six BMPs to be used in the construction and design of the subdivision. The Little Cove Creek population in Etowah County, which has been represented by a single specimen collected in 1975, was considered extirpated until a specimen was collected in 2005. Rush Darters are typically collected sporadically and in low numbers, therefore diligent efforts are required in appropriate habitats to accurately define current distributions. Populations in Locust Fork occupy the Valley and Ridge Province, while those in Sipsey Fork lie within the Appalachian Plateaus

Province. Management of this imperiled species needs to consider differences in habitats and life histories between these disjunct populations.

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**KUHNZ, L.A.; \*BIZZARRO, J.J.; CHANEY, L.; EBERT, D.A.**

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*In situ* observations of deep-living skates and rays in the central and eastern North Pacific

We studied more than 2,000 deep-living skates and rays using *in situ* video observations from the Monterey Bay Aquarium Research Institute's (MBARI) Video Annotation and Reference System (VARS). This database includes annotations for more than 16,000 videotapes recorded with the remotely operated vehicles (ROVs) *Ventana* and *Tiburon* since 1988. Observations were at depths below 200 m and primarily from the Monterey submarine canyon. Records also include the Pacific Northwest, southern California basins, central California seamounts, northern California, Hawaii, and the Gulf of California. We reviewed each observation, identifying animals to the lowest possible taxon, and noting gender when appropriate. We also recorded parameters such as geographic location, temperature, salinity, and oxygen content of the water, micro- and macrohabitat characters, and specific behaviors. Twelve species were observed. These video records extend the depth range of *Amblyraja badia* to 3,167 m, making it the deepest known skate species.

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**\*KULKA, DAVID W; MIRI, CAROLYN M; SIMPSON, MARK R.**

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Biogeography, growth and maturity of the skate complex on the Grand Banks, northeast Newfoundland and Labrador Shelf

There is a paucity of information on species of skate that occur on the Grand Banks and Labrador Shelf of Atlantic Canada. Data collected during Department of Fisheries and Oceans Canada (DFO) research surveys during 1971-2005 were used to describe the biogeography of about 14 species occurring there. Distribution and abundance changes are mapped and variation in distribution in relation to depth/temperature examined. Relative importance of each of the species within the ecosystem is discussed. Growth rates and size at maturity of selected species is compared over a gradient of about 20 degrees of latitude. External characteristics of onset of maturity for all skate species, specifically an abrupt increase in male clasper lengths and female oviducal (shell) gland widths is compared to condition of the gonads over a range of sizes. Vertebrae and spines will be examined to determine

best approach to aging for each of the species.

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**\* KUME, GEN; YAMAGUCHI, ATSUKO**

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Age, growth and maturity of fanray *Platyrrhina sinensis* in Ariake Bay, Japan

Fanray *Platyrrhina sinensis* is distributed widely in Northwest Pacific, which is the most abundant species of any elasmobranchs in Ariake Bay, Japan. As the top predator of the benthic ecosystem in Ariake Bay, *P. sinensis* could greatly affect the dynamics of any other sympatric species including many commercially important species in Ariake Bay fishery. Accordingly, it is important to understand the ecology of *P. sinensis* on the purpose of the proper fisheries management in Ariake Bay. In this study, age, growth and age at sexual maturity of *P. sinensis* in Ariake Bay were examined. From May 2002 to February 2006, a total of 285 specimens (male: 142, female: 143) were sampled by small trawl fisheries and gill nets in the middle part of Ariake Bay. Age determination was practiced by centrum analysis using soft x-radiography. Based on seasonal centrum edge analysis, the dark ring was formed right after the parturition and thereafter once a year. The dark ring was formed mostly in November, when is the most active spawning season. Age can be calculated by subtracting 1 from the number of the dark rings, because its formation completed at the spawning season. Great differences were observed between sexes in the growth pattern of this species. The von Bertalanffy growth equations were described as follows, male:  $L_t = 438(1 - \exp(-0.428(t + 1.08)))$ , female:  $L_t = 697(1 - \exp(-0.118(t + 3.03)))$ , where  $L_t$  is total length in mm and  $t$  is age in years. The maximum age was 5 years old for males and 12 years old for females. The growth over 5 years females trend to growth larger than males. Age at sexual maturity was assumed to be 3 years for male and 5 years for female, based on the hardness of clasper and the occurrence of eggs in uterus, respectively.

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**\*LABONTE, JOHN P.; WELCH, KENNETH**

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Effects of venom components on digestive performance in neonatal Southern Pacific Rattlesnake (*Crotalus oreganus helleri*)

In Viperidae, venom is a complex mixture of enzymatic and toxic compounds generally falling into two broad categories: neurotoxins and proteolytic enzymes. Proteolytic components degrade structural and functional proteins and likely enhance digestion. This digestive function has been prevalent in discussions on the evolution of venom, ontogeny, and diet in rattlesnakes, however has received limited experimental attention. Specifically lacking are experiments to determine whether neonatal snakes, with limited venom capacity, can attain digestive benefits from

proteolytic components in venom. We examined the effects of venom components on digestive efficiency in neonatal Southern Pacific rattlesnakes (*Crotalus oreganus helleri*) collected in Santa Barbara County, California. This population has previously been shown to undergo an ontogenetic shift in venom. Neonates have dramatically higher proportions of neurotoxic constituents in their venom than adults, whereas adult venom is primarily composed of proteolytic enzymes. This shift in venom is correlated with a shift in diet from lizard prey to rodent prey, suggesting a significant role for the functional properties of venom components on the acquisition and digestion of different prey types. We tested for differences in digestive performance in neonates that were force-fed rodent prey artificially injected with either neonate or adult venom. We assessed digestive performance by comparing specific dynamic action (SDA), peak rate of oxygen consumption ( $VO_2$ ) and length of metabolic response between our treatment groups. Groups were tested at 22°C and 30°C to determine whether effects are amplified at lower temperatures. A small subset of snakes from each treatment group were sacrificed to quantify gut passage rates. There were no significant differences in digestive performance at 30°C. At 22°C, gut passage rates, time to defecation, and length of elevated metabolic response were slightly longer for the neonate venom treatment, however SDA and peak  $VO_2$  were not different. Final results will be presented.

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#### **LADUC, TRAVIS J.**

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#### The use of museum collections to evaluate change in species distribution and community structure: A west Texas case study

The Texas Natural History Collections (TNHC) have over 63,000 preserved reptile and amphibian specimens, with over 33,000 Texas specimens. Many Texas specimens in these collections were the result of 4-6 week intensive vertebrate surveys in several counties in western Texas conducted between 1945-1965. These invaluable historical collections provide a fantastic opportunity to investigate historical trends in habitat use and local climate change and their affects on species community composition. An example of these collections is the series of specimens taken from the Sierra Vieja Mountain range and the vicinity of C. E. Miller Ranch in Presidio County (over 1300 herpetological specimens). The Miller Ranch specimens are especially intriguing because they represent the collecting efforts of Dr. Frank Blair and 22 of his students during a single 37-day span in 1948. These collections represent a unique slice in time and are an accurate representation of species diversity and community membership in west Texas 50 years ago. Based on voucher specimens at the TNHC, several papers were written on the reptiles and amphibians, birds, mammals, and vegetation of the ranch at the conclusion of this 1948 expedition and serve as our snapshot of life on Miller Ranch in 1948. Focusing on the herpetofauna, we have returned to Miller Ranch for 7-10 days each of the past three years, initiating a new long-term survey at this site. Fifty-one species were found in 1948; 39 species have been found in the first

two years (including 2 new species) and we will discuss our recent results from May-June 2006. We will detail our methodology and goals for this and future surveys around the state.

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**\*LAFLEUR, GARY J., JR.; POOLE, DANIEL; FAUCHEUX, STUART;  
BROUSSARD, NICOLE**

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Garfish ichthyotoxin extracted from oocytes, eggs, and larvae is lethal to crustaceans but not to teleosts

We report a preliminary characterization of the unique strategy used by Garfish to incorporate a toxin into oocytes, eggs, and larvae. Garfish roe has been previously reported to be toxic to tetrapods including humans, mice, and chickens, as well as crustaceans; oddly however, it does not appear to influence other ray-finned fishes. We have developed a bioassay to characterize the toxic effects of egg homogenates isolated from Spotted gar (*Lepisosteus oculatus*). For negative controls we injected Locke's saline carrier alone or the egg homogenates of another Holostean fish, the Choupique (*Amia calva*). We tested several animals that may act as predators on garfish eggs including Crawfish (*Procambrus clarkii*), Grass shrimp (*Penaeus pugio*), Fiddler crabs (*Uca longisignalis*), Sailfin mollies (*Poecilia latipinna*), and Gulf killifish (*Fundulus grandis*). Crawfish, Grass shrimp, and Fiddler crabs injected with egg extract immediately become listless, lose their balance, splay their legs, and display rigid paralysis within one minute of injection. Teleosts injected with the egg extract show no apparent signs of stress, nor changes in behavior. Twenty-four hours after egg extract injections, less than 50% of the crustaceans survived, while 100% of both Sailfin mollies and Gulf killifish survived. This response suggests that the Garfish egg extract contains a neurotoxin that specifically affects crustaceans and not teleosts. Similar results were found whether injections contained extract of oocytes, fertilized eggs, or hatched larvae, suggesting that the toxicity does not rely on an intact chorion, but rather is associated with the cytosol. The distinct biochemical entity responsible for Garfish egg toxicity has not yet been identified, nor had the toxin's mechanism of action been elucidated. Future studies include testing specific cytosolic fractions with whole cell recording of crustacean neurons to identify whether ion channel function is being disrupted. Supported by the NIH COBRE program in collaboration with LSU Neuroscience Center.

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## LA MARCA, ENRIQUE

*Universidad de Los Andes, Escuela de Geografía, Laboratorio de Biogeografía, Mérida 5101, Venezuela*

### Differential altitudinal declines in Venezuelan Andean dendrobatid frogs

We assessed the conservation status of the four dendrobatid genera (*Aromobates*, *Colostethus*, *Mannophryne* and *Nephelobates*) that occur in the Venezuelan Andes. A high percentage (55.6%) of the species showed population declines, 22% have relatively stable populations, while 22% had inconclusive data. None of the species showed population increases. The highest percentage (70%) of species in decline were members of the genus *Nephelobates*, while *Mannophryne* and *Colostethus* had 25 to 33% of species in decline. The monotypic *Aromobates* had its only species in decline and is probably extinct. There is an emerging pattern showing that population declines increase with altitude. The low-elevation sub-Andean forests had its only dendrobatid frog species with stable populations. The semi-deciduous montane forests had 67% of species with declines. The highest percentages of species in decline were found in cloud forests (67%), evergreen dry montane forests and paramos (each with 100%). Among the causes hypothesized to drive declines are the fungal pathogen disease *Batrachochytrium dendrobatidis* and regional climatic changes in temperature and precipitation. Some cases revealed high degree of chemical pollution as well as habitat destruction.

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### \*LAMB, TRIP; BAUER, AARON M.

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### On the monophyly of *Typhlosaurus* and its phylogenetic status among Africa's acontine skinks

The skink subfamily Acontinae comprises some 18 legless, fossorial species partitioned among three genera in southern Africa. Traditional interpretations of generic relationships have suggested that *Acontias* (with movable eyelids) is the most primitive genus, with *Acontophiops* (immovable, semi-transparent eyelids) being intermediate to a derived *Typhlosaurus* (lidless, vestigial eyes). A recent analysis of mitochondrial DNA sequences provided a different phylogenetic hypothesis, recovering a basal *Typhlosaurus* that was sister to the monotypic *Acontophiops* + *Acontias*. However, only two of nine species of *Typhlosaurus* were included in this survey. Here we revisit acontine relationships, presenting a phylogenetic hypothesis based on data from four mitochondrial genes and 37 morphological characters, with complete taxon sampling. Our results reveal that *Typhlosaurus* is polyphyletic, consisting of a basal clade (5 spp.) that is sister to *Acontias*, *Acontophiops*, and the remaining *Typhlosaurus* (a derived subclade of 4 spp.). Furthermore, *Acontophiops* and the derived subclade of *Typhlosaurus* are imbedded within *Acontias*, each falling in a

different, well-supported clade. We offer a taxonomic revision of the Acontinae that reflects these newfound relationships.

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**LANG, NICHOLAS J.**

*Department of Biology, Saint Louis University, 3507 Laclede Ave., MW128, St. Louis, MO, 63103, USA*

Systematics of the *Etheostoma spectabile* species group (Teleostei: Percidae) based on a nuclear locus (first intron of S7), with an examination of hybridization involving group members.

Preliminary investigations into the phylogeography of the *Etheostoma spectabile* species group and the systematics of its subgenus *Oligocephalus* based on the mitochondrial ND2 gene revealed several instances of hypothesized hybridization among the *E. spectabile* species group and other species groups within the subgenus. As part of a study initialized to test the mtDNA-based phylogeographic hypotheses with a nuclear locus, all hypothesized hybrid individuals, along with additional specimens from sympatric populations of both proposed parental species, will also be sequenced for both ND2 and the first intron of S7. Preliminary studies on *Etheostoma uniporum*, a member of the *E. spectabile* species group have revealed what appears to be complete introgression of *E. caeruleum* (a member of the *E. asprigene* species group) mtDNA, but no apparent hybridization at the S7 intron. Hypothesized hybridization events to be tested are geographically widespread west of the Mississippi River and also involve multiple members of the *E. whipplei* species group (subgenus *Oligocephalus*).

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**LANG, NICHOLAS J.**

*Department of Biology, Saint Louis University, 3507 Laclede Ave., MW 128, St. Louis, MO, 63103, USA*

Systematics of the genus *Etheostoma* (Teleostei: Percidae) based on complete taxonomic sampling of both mitochondrial (ND2) and nuclear (S7) loci.

Hypotheses regarding relationships within the genus *Etheostoma* have been in flux since the beginning of North American ichthyology. Several important studies involving characters related to morphology and behavior have failed to reach a consensus of relationships. Published DNA sequence-based studies on the higher-level taxonomy of this genus have been limited to mitochondrial loci and have utilized only a small proportion of the recognized diversity. I present a data set inclusive of all extant, currently recognized species composed of complete sequences of both mitochondrial and nuclear loci. Parsimony and Bayesian analyses were performed on ND2, S7, and combined datasets using non-darter percids as outgroups. All analyses failed to clearly resolve basal relationships within *Etheostoma*, although several well-supported clades are found across resulting phylogenies. These

clades generally correspond to either subgenera or species groups that had been previously hypothesized based on morphological or behavioral data. Several well-supported clades unite members of currently distinct subgenera. As with previous studies based on mitochondrial data, the subgenera *Allohistium* and *Nothonotus* are resolved outside of a clade containing the remaining members of the genus *Etheostoma* in the ND2 and combined data sets. Preliminary analyses of the S7 intron, however, resolve members of both of these subgenera deep within a clade corresponding to the current genus *Etheostoma*. Discussion will focus on the congruence among analyses and its potential impact on darter taxonomy.

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**\*LANGSTON, ROSS C.; PEYTON, K; SPALDING, H.L.; FUKUNAGA, A.; PENCE, D.**

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#### Preliminary information on the fish fauna associated with deep-water seagrass and macroalgal meadows in Hawaii

Seagrass and macroalgal meadows play an important role in the life-cycle of many shallow-water tropical marine fish species. However, little is known of the biota and ecology of deep-water algal meadows. In this study, we investigate the fish-fauna associated with deep-water (10-50 m) meadows of the green macroalgae *Halimeda kanaloana*, *Avrainvillea amadelpha*, and the seagrass *Halophila decipiens* in the nearshore waters of Oahu and Maui (Hawaiian Islands). We used open-circuit and closed-circuit decompression diving to survey the deep-water meadows and surrounding soft- and hard-bottom habitats. We sampled the fish fauna associated with these habitats using visual and photographic censuses as well as collections made with spears, traps, and clove oil anesthetic. To date, we have conducted a total of 24 fish surveys and have identified 66 species from 25 fish families which are associated with *Halophila*, *Avrainvillea*, and *Halimeda* meadows or adjacent habitats. Wrasses (family Labridae) were the most diverse group of fishes in both *Halimeda* and *Halophila* meadows. Wrasses were also the most abundant (number of individuals) family in *Halophila* meadows, whereas dragonettes (family Callionymidae) and gobys (family Gobiidae) were most abundant in *Halimeda* meadows. Some species were found in only one habitat type. Among these, the razorfish *Cymolutes praetextatus*, appears to be found exclusively in *H. kanaloana* meadows. This species was previously known from East Africa and the Society Islands, and is a new record for Hawaii. Other species prefer sandy areas adjacent to meadows (e.g., blow-outs or sandy meadow perimeters), and are found around both *H. kanaloana* and *Halophila* meadows (e.g. *Bothus pantherinus* and *Parapercis schauinslandii*). Recreationally or commercially important fish species were rarely encountered in deep-water meadows, indicating that these habitats play a limited role in near-shore fisheries.

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## Thermoregulatory efficiency of two sibling *Sceloporus* species with different reproductive mode

The lizards viviparity evolution has been explained through the cold-climate hypothesis. According to this model, viviparity evolved at high altitudes and latitudes, where viviparous pregnant females may provide optimal temperatures to the embryos by thermoregulatory behavior, unlike oviparous females whose eggs are exposed to fluctuating temperatures. Therefore, thermoregulatory ability of lizards limits their altitudinal distribution. *Sceloporus aeneus* is an oviparous lizard that occurs from 2400 to 3200 m. It is replaced at elevations above 3000 m by its viviparous sibling species, *S. bicanthalis*, whose elevation range extends up to 4250 m. This study evaluated the thermoregulatory efficiency of one population of each species at the volcano Nevado de Toluca in Mexico at their highest elevation distribution. Mean field body temperatures of *S. aeneus* and *S. bicanthalis* were 30.27 and 26.97 °C, respectively, whereas selected body temperatures at the laboratory were 35.5 and 34.9 °C, respectively. Thermal quality of the environment offers different conditions to each species. Viviparous species are able to colonize cold climates due to an efficient thermal behavior that compensates for environment deficiency. In contrast, the environment occupied by the oviparous population provides better thermal quality that allows organisms to obtain optimal temperatures with minimum effort. Results show that both lizards species have similar thermal requirements, suggesting that limited altitudinal distribution of oviparous species is not due to adults thermoregulation, but thermal requirements of nesting eggs, according to other studies. This study support that thermoregulation of viviparity pregnant females is an efficient mechanism to invade highest elevations.

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## Effects of provisioning ecotourism activity on the behavior of white sharks, *Carcharodon carcharias*

Ecotourism operations which provide food to large predators have the potential to impact negatively on their target species, by conditioning them to associate humans with food, or by generally altering their behavioural patterns at the individual or population level. This latter effect could potentially have detrimental consequences

for the predator's ecosystem, as any behavioural changes could impact on the species with which they interact. Here we present the results of a study examining the effects of provisioning ecotourism operation on the behaviour of white sharks around a small island seal colony in South Africa. Although ecotourism activity had an effect on the behaviour of some sharks (without which this ecotourism industry would not be viable), this was relatively mild, and the majority of sharks showed very little interest in the food rewards being presented. It is unlikely that conditioning would occur from the amount of ecotourism activity tested, as even those identified sharks which supplied most of the data presented here (which may possess a stronger predisposition towards conditioning, as their persistence around the boat is what allowed them to be identified) showed a nearly ubiquitous trend of decreasing response with time. Further, those sharks which succeeded in acquiring food rewards more than others demonstrated a clear ability to ignore ecotourism offerings, and typically stopped responding after several interactions. Consequently, moderate levels of ecotourism probably have only a minor impact on the behaviour of white sharks, and therefore are unlikely to create behavioural effects at the ecosystem level.

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The Maugean Skate (*Zearaja* sp.) – a micro-endemic, Gondwanan relict from Tasmanian estuaries

A new species of rajin skate is described on the basis of specimens from two estuaries in remote southwestern Tasmania. The species, known locally as the Maugean Skate, has a conservation status of Endangered based on its rarity and very narrow geographic range. It is also one of the few skates worldwide occurring mainly in brackish water. The Maugean Skate belongs to a group of anatomically conservative, *Dipturus*-like skates conforming to the currently unrecognized genus *Zearaja* (Whitley). This ancient group, with a Gondwanan lineage possibly dating back to the Cretaceous, contains at least two other species: *Z. nasuta* from New Zealand and *Z. chilensis* from South America. The skeletal morphologies of the *Zearaja* species are compared with typical *Dipturus* skates and their phylogenetic position discussed.

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### Response of upland herpetofauna to Carolina bay restoration

Of the 34 species of amphibians reported from Carolina bays on the Savannah River Site, near Aiken, South Carolina, 31 are terrestrial for some portion of their life cycle. Many reptile species also move between Carolina bays and the adjacent uplands, utilizing the wetlands for forage or cover. In 2000 and 2001, the Department of Energy implemented a wetland mitigation and banking program by restoring sixteen formerly ditched and drained Carolina bays on the Savannah River Site, near Aiken, South Carolina. Hardwoods were removed from the margins of eight of the restored bays with the ultimate objective of creating fire-maintained pine savannahs in the 100 m upland buffers. From 2002 to 2005, we used paired drift fence arrays 50 m from the edge of the bays including pitfall and funnel traps, cover boards, and PVC refugia to monitor herpetofauna at twelve Carolina bays: six restored bays, three reference bays that had never been drained, and three control bays that have not yet been restored. Traps were checked continuously from February through July each year. We recorded 45,952 individual amphibians representing 27 species, and 1,453 individual reptiles representing 41 species. Preliminary analysis indicates that reference bays which had never been drained maintained the highest species richness in both taxa, while control bays support the lowest species richness.

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### Tetrodotoxin and egg predation in the rough-skinned newt, *Taricha granulosa*

Anti-predator defenses include behaviors to evade capture, physical structures to deter predation, and noxious or toxic chemicals aimed at predators. While adults are often well protected, early life history stages (e.g., eggs) often are more vulnerable. In these cases, parents may provide defenses either through their behavior or through chemicals provided to the embryo. Nest defense behaviors have been well studied, but relatively little is known about chemical defenses in eggs. Studying the defenses of early life history stages is particularly interesting because of the influence early survivorship can have on population growth rates. Rough-skinned newts, *Taricha granulosa*, possess tetrodotoxin (TTX), a neurotoxin that inhibits the propagation of nerve signals, leading to paralysis and potentially death in most organisms that ingest it. TTX acts as a chemical defense against predatory garter snakes in adults, and is also present in newt eggs. Because adults do not defend eggs, TTX represent eggs' only defense against predation. My fieldwork has demonstrated that caddisfly larvae prey heavily upon newt eggs, despite the presence of TTX. Further a strong correlation exists between the toxicity of newt eggs and the abundance of caddisfly

larvae, suggesting that egg predation has the potential to influence the evolution of toxicity in *T. granulosa*. It was previously unknown to what degree caddisfly larvae consume eggs of varying toxicity and how TTX affects them. Here I report the results of several studies, including field studies of predation, susceptibility of caddisfly larvae TTX, caddisfly choice of food items with or without TTX, and the influence of predator cues on developing newt embryos. The relationship between newt eggs and their caddisfly predators, the effects of TTX on this relationship, and the potential for co-evolutionary interactions in this system will be discussed.

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Mitogenomics or nuclear phylogenomics for deep phylogeny?

Using a single locus or a few loci to infer phylogeny often results in low resolution and incongruence among gene trees, which may be caused by sampling errors or systematic errors (inconsistency). Collection of sequence data from many loci can substantially improve the resolution by increasing the signal to noise ratio. Two alternative strategies were explored to recover better phylogenetic signal: DNA sequence generated from the mitochondrial genome and multiple nuclear loci. Using universal primers or shotgun sequencing, mitochondrial genome sequences can be collected in a relative short time. Mitochondrial loci have some advantages as phylogenetic markers, in that homologs are easily identified, and the small effective population size results in fewer instances of deep coalescence among taxa. However, mitochondrial loci also showed problems, such as high mutation rates (low signal to noise ratios) and linkage of all loci (non-independence) in vertebrates. Some unorthodox phylogenies have resulted from the use of only mitochondrial genome data. Genome-scale nuclear genes were proposed as an alternative or complement to mitochondrial data for phylogenetic inference, because they have appropriate substitution rates and are better representation of the history of the whole genome. The technical barriers for using genome-scale nuclear genes include the difficulties in identifying homologs and the paucity of well-known nuclear markers. With our newly developed single copy nuclear gene markers, the performance of the mitogenome and multi-locus nuclear gene data in phylogenetic inference were compared. Possible explanations for discrepancies between results from mitochondrial and nuclear gene data were also examined.

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Conservation genetics of the Plains Topminnow (*Fundulus sciadicus*)

The plains topminnow is a freshwater killifish endemic to the Great Plains region. It inhabits three disjunct areas, two in Missouri and one primarily in Nebraska. Recent ichthyological surveys of freshwater fishes from Nebraska documented a paucity of plains topminnow in habitats where it was historically common, suggesting a marked population decline. Surveys of this species in Missouri also suggest range declines. Preliminary results based on mtDNA sequence data show remarkably low genetic variation within Nebraska even though some populations are isolated by as many as 1300 river km. Additional analyses of Missouri populations show moderately higher variation with very shallow structure. These results are consistent with a recent colonization of Nebraska streams from refugia in Missouri. To better understand recent finescale population structure and to estimate population divergence time, we developed a battery of hypervariable microsatellite markers for genotyping of populations in all three disjunct areas. The results of this work will enable an appropriate strategy for conservation of this at-risk species.

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Development of genome-scale nuclear gene markers for the tree of life

Using many independent nuclear genes to infer phylogeny has been shown as one of the essential ways to resolve the tree of life. However, the lack of widely-amplifiable nuclear gene markers has resulted in a dilemma for phylogeneticists in that either many genes can be used for the few taxa for which genome sequences are available, or a few well-known genes can be sequenced for the many taxa of interest. Finding new nuclear gene markers useful for a wide variety of taxa is a high priority for assembling the tree of life. Here, we developed a simple approach to identify novel gene markers that are single copy nuclear loci, containing large exon and conserved across widely distributed taxonomic groups. Using ray-finned fishes as a case study, we identified 126 candidate markers by comparing genome sequences of two model organisms, *Danio rerio* and *Takifugu rubripus* and 5 additional fish species for which partial genome sequences are available. We tested 15 candidate markers experimentally in 13 species representing the major lineages of ray-finned fish. Phylogenetic analyses using the sequences of these markers suggested the usefulness

of new markers and the success of our marker-developing strategy. The new gene markers we have developed will facilitate the recovery of the phylogeny of ray-finned fishes. The strategy employed here can be used to effectively and efficiently develop phylogenetic markers in other taxonomic groups. Our results have important implications for construction of the tree of life.

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Phylogeography of the Chatham Islands skink (*Oligosoma nigriplantare nigriplantare*)

The Chatham Islands (43 S, 176 E) are situated 800 kilometres east of the South Island of New Zealand. The only inhabiting reptile of the island group is the endemic Chatham Islands skink (*Oligosoma nigriplantare nigriplantare*), a recognised sub species of the mainland New Zealand common skink (*Oligosoma nigriplantare*). The intriguing geography and geological history of the Chatham Islands present a unique opportunity for microevolutionary study, for which the Chatham Islands skink is an ideal model species. In this study Chatham Island skink samples were taken from all the main islands of the Chathams group, representing the extent of the species distribution. An intraspecific phylogeny was built using the mitochondrial genes, ND2 (550 bp) and ND4 (773 bp). Samples of the mainland New Zealand sub species, *Oligosoma nigriplantare polychroma* were included to determine the taxonomic relationships within this New Zealand common skink species complex. Subsequently a haplotype network was used to reveal any phylogeographic pattern within the Chatham Island group. The Chatham Island skink was found to be more divergent (10%) from the New Zealand common skink than previously reported, challenging its subspecific status. Within the islands of the Chatham group genetic divergences were found to be insignificant taxonomically. However, all but two closely associated islands of the group were found to contain only unique haplotypes. These findings provide insight into the colonisation and historical association between islands of the Chathams group, and to mainland New Zealand. This research also has implications for the taxonomy and future conservation of the Chatham Islands skink.

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Reintroduction of a declining amphibian: Determining an ecologically feasible approach through analysis of decline factors, genetic structure, and habitat associations

Species reintroductions provide a model for integrating practical and theoretical aspects of conservation biology. Combining pre-reintroduction research on ecology, genetics, and causative factors of declines with experimental reintroductions and rigorous monitoring, offers an approach that should increase reintroduction success rates. Amphibians present challenges as reintroduction subjects due to characteristics such as biphasic life cycles, low mobility, and patchy distributions. This study focused on a stream-dwelling, declining amphibian in California and Oregon, the foothill yellow-legged frog (*Rana boylei*), and included three components: (1) determining primary causes of decline, (2) describing range-wide genetic variation, and (3) quantifying habitat associations. For decline factors, the analysis approach was to spatially relate the current status of *R. boylei* at historic localities to: topography, land uses, wind-borne toxins, climatic variables, and proximity and size of dams. Climatic variables showed strong influence in multivariate models. There was also evidence for interactions, especially that negative effects of dams appeared to be exacerbated in areas with low precipitation. For genetic analyses, I used sequences of two mtDNA fragments for 77 individuals from 34 localities. Phylogenetic analyses recovered several well-supported, geographically congruent clades. Genetic variation was low among populations in the largest, most inclusive clade, but individuals from several localities showed substantial divergence. Hydrologic regions, which represent likely dispersal corridors for *R. boylei*, show promise in explaining patterns of genetic variation. The habitat associations component focused on microhabitat scale oviposition site selection coupled with larger scale evaluations of occurrence and relative abundance at breeding areas. Oviposition microhabitat characteristics such as water depth, water velocity, and stream substrate showed narrow ranges among study localities suggesting strong habitat selection. I discuss the application of these results to potential reintroductions of *R. boylei* and propose a conceptual model for integrating this and other information into reintroduction programs.

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Nocturnal vertical position in the Panamanian golden frog, *Atelopus zeteki*

The Panamanian golden frog, *Atelopus zeteki*, is a stream dweller of middle elevation rain forests of the Panamanian isthmus. Once locally abundant, this species has undergone dramatic declines due to numerous anthropogenic pressures. In order to better understand this species for conservation, the authors set out to determine the nocturnal whereabouts of this diurnally active animal. Investigators expected that adult males and juveniles might occupy different nocturnal microhabitats based on differences in size and ontogenetic coloration and patterning. Findings presented here demonstrate that adult males climb significantly higher than juveniles at night and that movement distances to final resting positions also significantly differed. This change in diurnal and nocturnal position in adult males may be related to predator avoidance, mate attraction, and/or territorial vigilance. Lastly, this study demonstrated that individual rain forest amphibians can be successfully tracked over short to moderate distances in humid to wet environments using fluorescent pigments.

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Amphibian distributions in isolated wetlands within a longleaf pine dominated landscape

Isolated wetlands are a common feature of the landscape of the Coastal Plain of the southeastern U.S. However, these wetlands are also highly threatened habitats, which receive little legislative protection and are subject to intense development pressure. Furthermore, isolated wetlands are variable in size, vegetation type and a number of other factors which may affect the ability of amphibian species to successfully colonize or breed within them. Understanding how these factors influence amphibian and other wildlife communities is essential in forming wetland mitigation and restoration strategies. We examined the relationship between wetland habitat variables and the distribution of amphibian species in 29 relatively undisturbed isolated wetlands in southwestern Georgia, USA. Wetlands were sampled for amphibians in the winter, spring, and summer using aquatic traps,

dipnetting, PVC pipe refugia, and automated frog call recording devices (frogloggers). Mean amphibian species richness among study wetlands was  $12.7 \pm 2.7$  species (range 7-18). Distributions of 6 amphibian species were associated with wetland type, a designation based on wetland vegetation and soil characteristics. Distributions of 3 species were negatively impacted by predatory fish presence based on Fisher's exact tests. A detrended correspondence analysis of amphibian species compositions revealed that one wetland type, cypress-gum wetlands, supported a different amphibian assemblage than cypress savannas or marshes. A principal components analysis revealed strong correlations between wetland types and wetland and upland habitat variables suggesting that wetland types varied fundamentally in hydroperiod, size, depth, numbers of amphibian predators, densities of surrounding paved roads, percentage of surrounding forest, and wetland isolation. Our research highlights the importance of wetland variation in promoting amphibian diversity in the region. Future wetland monitoring and restoration efforts in Georgia should account for both wetland type and fish presence before making assumptions about potential amphibian assemblages.

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### Emerging infectious disease and the loss of biodiversity in a Neotropical amphibian community

We report the first unambiguous link between the arrival of a chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*), into a naive amphibian community at El Copè, Panama, and subsequent mass mortality and loss of amphibian biodiversity. *Bd* was absent in 1,566 amphibian samples collected over 4 years, but quickly increased in prevalence (10-50%) following the first detection in September 2004. The first dead amphibian was found on October 4, 2004 and subsequent mortality was high (>3 dead located/d) through January when most populations had declined. We found 346 dead anurans and 5 dead salamanders between October 2004 and February 2005 on terrestrial and riparian transects. Dead frogs were from 38 species (57% of the amphibian fauna) and all 7 families found at El Copè. All but 3 of the 249 dead amphibians examined were infected with *Bd*. Amphibian density and species richness increased during 6 years of surveys until September 2004 when both declined abruptly in diurnal and nocturnal riparian amphibian communities 1 mo before we first detected *Bd*. Density and species richness of terrestrial transects did

not decline significantly although numbers were reduced. Several amphibian species have not been seen for several months, and abundance continues to decline. We found no evidence that ranavirus, chemical contamination, climatic anomalies, exotic species, land use change, or overharvesting contributed to mortality or declines. Our data support chytridiomycosis as the cause of mortality and subsequent population declines, and support a model in which *Bd* has spread southward through Central America at 30 km/yr. We propose *Bd*-induced chytridiomycosis as the primary cause of other enigmatic amphibian declines worldwide. *Bd*'s lethality and broad host range make this emerging pathogen a threat to an entire vertebrate class; under these circumstances it is no longer correct to speak of Global Amphibian Declines, but more appropriately of Global Amphibian Extinctions.

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#### Visual ecology of the sandbar shark, *Carcharhinus plumbeus*

Elasmobranchs rely heavily on a rich diversity of sensory input to identify prey, navigate, reproduce and interact within their environment. The role vision plays in these behaviours remains unknown for many species. This study examines the visual ecology of the sandbar shark, *Carcharhinus plumbeus*, a species which inhabits a diversity of visual environments, ranging from clear water fringing reef habitats to turbid water estuarine habitats. Here the visual ecology of the sandbar shark is assessed throughout ontogenetic development to identify visual strategies of this species in different visual environments. Using anatomical and electrophysiological techniques, key capabilities such as sensitivity to light, spatial and temporal resolution, as well as spatial and temporal summation are assessed. Topographic distributions of photoreceptor and retinal ganglion cells revealed a region of higher cell density in the centro-temporal retina, slightly ventral of the horizontal meridian. This specialisation would afford improved visual resolution in the lateral and frontal visual field with a peak spatial resolution of 5-6 cycles per degree recorded in the adult sandbar shark. Electroretinograms are used to record sensitivity to light and temporal resolution, determined by the flicker fusion frequency (FFF), at different intensities and frequencies of light stimulus. Peak light sensitivity was recorded at relatively low light intensities, indicating a high sensitivity to dim light as compared to a tuna, for instance. Peak FFF values recorded ranged between 35 to 40 Hz. Variations in temporal resolution between habitats will be discussed. This study provides insights into the visual physiology of sharks and identifies thresholds of the sandbar shark's visual sense. This knowledge could aid our understanding of the underlying mechanisms of diurnal and nocturnal activity patterns, reproductive behaviour and predator-prey interactions in this species.

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## Distribution, abundance and feeding of skates in western African waters and adjacent submarine mounts

The skates of North African (22°N-36°N) and central African (7°N-11°N) shelf and slope and adjacent submarine mounts were analyzed with respect to diet composition, standard depths occurrence and distribution patterns. There were used data from 1225 trawl hauls and 371 stomachs in total. There were observed 18 skate species in northern zone and 22 in the central one. The most abundant northern species was *Raja montagui*, it dominated between all the elasmobranchs, sharks included, on the depths 25-200 m. It consumed 47 food items in total, the most important were cephalopods, then crustaceans and fish. Another relatively abundant species were *T. marmorata*, *R. miraletus*, *R. straeleni*, *R. clavata*, *D. pastinaca*. The relative importance of *R. maderensis*, *R. asterias*, *Leucoraja circularis* and *L. fullonica* was much higher on the submarine mount Conception comparing continental shelf and slope. On the submarine banks southward Azores were observed *R. clavata*, *T. nobiliana* and *R. maderensis*. The most abundant elasmobranch species in the central zone were *Dasyatis margarita* (at 10 and 25 m) and *Raja miraletus* (at 75 and 100 m). *R. miraletus* fed mainly on bottom crustaceans (15 items), fish (7 items), and cephalopods being less important (1 item). In the northern zone bottom crustaceans were also very important for this species (13 items), crustaceans and fish being of the minor significance (two items for each). As a whole, skates of both zones fed mainly on crustaceans and fish, cephalopods were not important, but abundant *R. montagui*, which preferred cephalopods. The preys were bottom, near-bottom and pelagic species. There was the pronounced correlation between the body disc shape and share of pelagic items in the food composition of *Raja spp.* *Dasyatis pastinaca* in northern zone and *D. hastata* in central zone demonstrated high percentage of polychaets in food comparing other skates. There were revealed some distribution patterns in both zones: *R. montagui* have not ever been observed northward 34°N, as some other shark species; *Z. schoenleinii* was quite rare southward 8°N, *Rh. rhinobatos* was found there in May-April only. Such gaps inside species ranges are suggested to be boundaries between stock units.

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## Sex differences in longevity in the Spotted Turtle (*Clemmys guttata*)

Turtles are in decline world-wide, and few studies have collected the long-term, age-specific demographic data needed to identify species-specific life history stages critical to population viability and conservation. Here I report estimates of birth and death rates, survivorship, and longevity of Spotted Turtles (*Clemmys guttata*) using modified logarithmic decay equations and 24 years of mark-recapture data collected

from a population at the northern extreme of the species' range. The recruitment rate was more than twice the mortality rate. Spotted Turtle survivorship and longevity estimates are among the highest values reported for any animal species, and females are significantly more long-lived than males. Minimum annual adult female survivorship is 96.5%, maximum longevity is 110 years, and age at maturity is 12 years. Minimum male survivorship is 94.2%, maximum longevity is 65 years, and age at maturity is 11 years. This ongoing study is the longest-running on Spotted Turtles, yet insufficient age-specific data have been gathered to construct a life table, particularly because egg and hatchling survival rates remain unknown; future work should specifically focus on gathering such data. The results of the current study have important management implications when considering which life history stages to protect for maintenance of population viability of long-lived vertebrates.

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Diel variation in the stomach contents of *Plethodon cinereus* (Caudata: Plethodontidae): Implications for dietary analyses

Stomach content analysis reveals important information pertaining to a species' resource use and potential for competition with other species. Since (1) terrestrial Plethodontid salamanders forage primarily at and immediately after dusk and (2) prey with a high chitin content digest more slowly – the time of day that stomach contents are sampled may have an impact on what prey items are found in the stomach. We hypothesized that *Plethodon cinereus* stomach contents collected in the evening (i.e., within 3 hours prior to sunset) would have a greater proportion of chitinous prey than samples collected in the morning (i.e., within 3 hours after sunrise). We sampled 116 *P. cinereus* stomachs (66 morning samples, 50 evening samples) at the Ritchie Ledges region of the Cuyahoga Valley National Park in northeastern Ohio. Prey items were identified to family, categorized as chitinous or non-chitinous, and the proportion of chitinous to non-chitinous prey was calculated by number of prey and volume of prey for each sample. The proportion of chitinous prey in the evening samples was significantly greater than the morning samples for both number ( $U = 1180.0$ ,  $p = 0.005$ ) and volume ( $U = 1066.0$ ,  $p < 0.001$ ) of prey. Additionally, based on a coding scale from 1 (poor condition) to 3 (excellent condition), prey items in evening samples were in significantly poorer condition ( $U = 140322.0$ ,  $p < 0.001$ ). These results suggest that researchers must consider the time of day that they collect stomach content samples while designing experimental protocols and during the subsequent data interpretation.

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**LOEFER, JOSHUA K.; \*SEDBERRY, GEORGE R.; GEDDINGS,  
JONATHAN**

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USA*

**Additional satellite tagging of sharks and billfishes off the southeastern  
United States**

In 2005 we tagged 46 oceanic sharks and billfishes with satellite pop-up tags. Sharks (*Carcharhinus falciformis*, *C. signatus* and *Sphyrna lewini*) and billfishes (*Istiophorus albicans*, *Makaira nigricans*, *Tetrapturus albidus* and *Xiphias gladius*) were tagged in the Gulf Stream off South Carolina. The tagging area encompasses a rugged bottom feature and upwelling area that may be an important feeding and spawning area (for billfishes). Many of the fishes were resident in the tagging area during the tag retention period; however most moved considerable distances away from the tagging site, generally moving northeastward as surface waters warmed in spring. Most species undertook diel vertical migrations, but some remained in warm surface waters. Results for the 2005 tagging effort, combined with our previous satellite tagging, indicate that bottom features and thermal fronts along the Gulf Stream and its eddies are important habitats for large highly migratory pelagic fishes.

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**LOFTUS, WILLIAM F.**

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**Inland ichthyofauna of St. John, U.S. Virgin Islands**

The United States National Park Service supported the first, island-wide survey of fishes on St. John, U.S.V.I. in non-marine habitats, from 2001-04. Project objectives were to 1) provide geo-referenced information on fish-species composition, richness, and distribution in four major aquatic habitats: intermittent stream channels (guts), coastal ponds, saline ponds, and freshwater ponds; 2) measure the physical characteristics of inland aquatic habitats; and 3) compare the species composition of the inland ichthyofauna of St. John with nearby islands. I sampled repeatedly at 59 locations during five trips. Freshwater habitats were rare, and mainly represented by gut pools and constructed ponds. Fish species richness was highest in mesohaline to slightly hypersaline ponds, particularly if inlets or low berms allowed tidal connections. High salinities and lack of marine access combined to exclude fishes from many coastal ponds. I identified 40 species during this inventory, with six additional taxa observed that could not be positively identified to species. The taxa belonged to 23 families, with families Gerreidae, Eleotridae, and Gobiidae most speciose. Most species were either tropical peripheral-freshwater species or marine colonists. First island records included *Kryptolebias marmoratus*, *Centropomus ensiferus*, *Dormitator maculatus*, *Erotelis smaragdus*, and *Sicydium plumieri*. The most widespread species in freshwater and oligohaline habitats were *Agonostomus monticola*, *Eleotris*

*perniger*, and *Anguilla rostrata*. *K. marmoratus*, *Gerres cinereus*, and *Megalops atlanticus* were widely distributed in mangrove habitats. Coastal habitats were nurseries for several marine species. An unusually heavy rain event in November 2003 produced over 50 cm of rainfall, and connected inland aquatic habitats with the sea. Subsequently, I collected two additional species in freshwater and two in coastal ponds. Only two non-indigenous fishes were found: *Poecilia reticulata* and *Oreochromis mossambicus*. The ichthyofauna of St. John is similar to those of neighboring Puerto Rico and St. Croix, U.S.V.I., but has fewer species as a result of its smaller area and lack of aquatic-habitat diversity.

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Prehistoric exploitation of bonefish (*Albula*) in Hawaii

We report for the first time that bonefish form a large portion of fish remains recovered from a prehistoric cultural site in the Pacific. Controlled excavation on the Waimanalo plain of Oahu, Hawaii yielded the largest fish bone collection yet recovered from the area. A layer containing <sup>14</sup>C evidence of Hawaiian activity as early as 1628 AD contained 19,043 osteichthyan remains representing 12 families. These, along with other faunal remains, fishhooks, hook-working tools and oven stones suggest food preparation and consumption were primary activities at the site. Because most fish parts were highly fragmented, only 12.3% could be identified to at least family level. Scarids, labrids, monacanthids and albulids comprise 98% of the identified remains. Of these, *Albula* were represented by 244 otoliths, or 11.1%. These otoliths represent at least 127 individuals. These results are noteworthy because, although *Albula* species are popular food fish in Hawaii and common on sandy flats adjacent to the site, their remains are rarely identified in archaeological excavations. Previously, albulids were known only from a single bone found on the Waimanalo plain; 9 otoliths recovered from 3 sites on Molokai, Hawaii; and 7 otoliths found at a single site from New Caledonia. Analysis of vertebral diameter and the prevalence of small fishhooks at the Waimanalo site suggest the total fish catch was composed mostly of individuals weighing less than 225 g. We are describing the relationship between otolith and fish size for Hawaiian albulids to more accurately reconstruct bonefish catch at this site.

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Effect of drought on the dispersion pattern of rainforest *Eleutherodactylus*:  
Implications for vulnerability to chytridiomycosis

We have focused on the study of climate change and disease as potential causes of amphibian declines in the island. We suspect a synergistic interaction between drought and the pathological effect of the chytrid fungus. We tested the hypothesis that rainforest *Eleutherodactylus* (coqui frogs) that become stressed because of lack of rain, tend to change their dispersion pattern from random to clumped. We designed a controlled experiment with six terraria in which the number of refugia, food, light and temperature remained constant. Water was applied to the soil on only one half and later to one fourth of the experimental terrariums, while controls received water throughout the entire surface. The use of retreat sites by the frogs was monitored daily. Frog dispersion within the terraria changed significantly as a result of the water treatments (ANOVA,  $F_{1,35} = 13.6$ ;  $P = 0.001$ ). In the experimental terrariums, frogs moved from dry to humid sides within 3 days of drought resulting in clumping at retreat sites. In control terraria, frogs used refuges on both sides. We hypothesize that at times of drought frogs will clump in humid patches where the fungus is more likely to occur. As a consequence there is a situation of frogs that are immunologically deprived in an area where the fungus is potentially abundant, thus, generating an epidemic that may result in declines.

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**\*LOPEZ, PAMELA T.; RYND, LORI S. ; GOLLER, JOSHUA B.**  
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Correlates between age, body size and mating success in the Rough-skinned  
Newt (*Taricha granulosa*)

The significance of such morphological attributes as snout-to-vent length, tail length, and tail crest height to male mating success in urodele amphibians has been investigated to a limited extent, primarily in European species of newts. Additionally, correlates between age and body size have been examined in only a few species of urodeles. The Rough-skinned Newt (*Taricha granulosa*) is extremely common throughout its range, however there have been few studies of its reproductive behavior and ecology. Using both field surveys and skeletochronological techniques we addressed the following questions concerning this species: (1) Is age associated with male body size?, (2) Does body size influence male mating success?, and (3) Does age influence male mating success? Due to our inability to track male mating success across the breeding season, we examined this variable on a daily basis. Males captured while in amplexus were designated as mated and all others as nonmated. Mean age for all newts included in the skeletochronological analysis (n=63) was 4.41 years (range: 2-7). Age was

significantly correlated with snout-to-vent length, tail length and head width for all males. There was no significant difference between mean age of mated versus nonmated males. Mean tail length, tail crest height and body mass were significantly greater in mated males than nonmated males. These results suggest that while age is correlated with several size attributes it is not a critical factor to mating success (as defined in this study) in male rough-skinned newts.

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### Thermal biology in three species of viviparous lizards of *Sceloporus torquatus* group

Viviparous lizards predominate at high altitudes. The cold climate hypothesis suggests that viviparity evolved in reptiles at these environments due to the capacity of pregnant females to regulate body temperatures. Thirteen species of the *Sceloporus torquatus* group inhabit mainly high elevations. However pregnant females prefer lower temperatures than those of non-reproductive females, to avoid damage to embryos. *Sceloporus mucronatus aureolus* inhabits high altitude at which occurs viviparous species. *S. macdougalli* and *S. serrifer*, inhabit warm environments should offer thermal heterogeneity that allows to keep temperatures similar to high elevation locations occupy by their relatives. To evaluate this idea, was determined the thermoregulatory behavior that allow both species to live in the warm climate without negative effects to their descendants. We recorded and compared preferred body temperatures in the field and in the laboratory for both, pregnant and nonpregnant females, of the mentioned species. We also estimated their thermoregulatory precision and thermal quality of habitat. Body temperatures of pregnant and nonpregnant females of *S. serrifer* were similar to those of nonpregnant females of *S. m. aureolus*. Unlike *S. m. aureolus* and *S. serrifer*, *S. macdougalli* prefers higher temperatures in the field and lower temperatures in the laboratory. *S. serrifer* regulates its body temperature precisely and effectively. Females of *S. m. aureolus* exhibit thermoregulatory behavior only during nonpregnant stage, while *S. macdougalli* is a thermoconformist. Thermal quality of the environment offers different conditions to each species. Species of the *S. torquatus* group inhabit warm climates through different strategies: *S. m. aureolus* and *S. serrifer* exhibit thermoregulatory behavior to compensate the environment thermal deficiency, while *S. macdougalli* is a thermoconformist lizard because exposed environmental temperatures do not seem to have a negative effect on intrauterine embryonic development.

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**\*LOPEZ-FERNANDEZ, HERNAN; WINEMILLER, KIRK O.;  
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### Phenotype-environment correlations in the putative adaptive radiation of South American geophagine cichlids (Perciformes, Labroidei)

South American geophagine cichlids include 18 genera with a striking variety of morphologies, feeding habits and habitat preferences. Based on phylogenetic evidence we hypothesized Geophaginae is an adaptive radiation sensu Schluter (2000). Here we further investigate that hypothesis by exploring the correlation of morphological traits with diet and habitat use in genera of Geophaginae. In an adaptive radiation, correlations between phenotype and environment are the result of ecological specialization of each lineage to its particular niche. Significant correlations between morphology, diet, and habitat use would thus strengthen the adaptive radiation hypothesis. We use our previously proposed genus-level phylogeny to test for these correlations while accounting for phylogeny-based similarity among genera. Thirty-two morphometric characters were associated with stomach contents data and habitat preference variables obtained from the field and museum records. Principal Components Analysis was used to determine if morphological groups occupy different portions of multivariate space corresponding with differences in diet or habitat. Two-block partial least squares were used to establish covariation between morphological and ecological data, and Phylogenetic Generalized Least Squares to determine if covariation persisted after accounting for phylogenetic relatedness. Two morphologically distinct groups have different habitat preferences but feed primarily on benthic invertebrates. Large-bodied benthic feeders in three separate lineages (*Geophagus* group, *Satanoperca* group, tribe Acarichthyini) feed mostly by substrate sifting and are associated to relatively deep waters with moderate to no habitat structure. 'Dwarf' benthic feeders in four separate lineages (*Mikrogeophagus*, crenicarine clade, *Apistogramma*, *Biotoecus*) may feed mostly by picking the substrate surface or by much shallower sifting and are associated to shallow waters with highly structured habitats. *Crenicichla* is a predatory geophagine with a unique body shape and preference for structured habitats.

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**LÓPEZ-VERA, CAROLINA; MAZ, ALEJANDRA; \*GALVÁN-MAGAÑA, FELIPE; ROSILES-MARTINEZ, RENE**

(LVC, MA) Universidad Jorge Tadeo Lozano. Facultad Biología Marina. Carrera 4 # 22-61 Bogota, Colombia; (GMF) Centro Interdisciplinario de Ciencias Marinas. A.P. 592 La Paz, Baja California Sur, Mexico. COFAA-IPN; (RMR) Universidad Nacional Autónoma de México. Facultad de Medicina Veterinaria y Zootecnia. C.P. 04510. México. D.F.

Mercury bioaccumulation in sharks from Baja California Sur, Mexico

The bioaccumulation of mercury in muscle tissue was determined for four shark species: *Carcharhinus falciformis* ( $2.64 \pm 0.28$  ppm Hg), *Isurus oxyrinchus* ( $1.50 \pm 0.20$  ppm Hg), *Sphyrna zygaena* ( $1.33 \pm 0.22$  ppm Hg) and *Prionace glauca* ( $0.82 \pm 0.34$  ppm Hg), caught off the western coast of Baja California Sur and in the Gulf of California. We obtained significant differences in mercury concentration by shark size, except for *P. glauca*, which did not present a significant correlation ( $r=0.09837$   $p=0.7610$ ). We found no significant difference in mercury concentration between sexes ( $p=0.4438$ ) among the shark species analyzed. Mercury was also measured in the main prey consumed by the sharks, including jumbo squid (*Dosidicus gigas*  $0.1158 \pm 0.0527$  ppm Hg), mackerel (*Scomber japonicus*  $0.570 \pm 0.0202$  ppm Hg), red crab (*Pleuroncodes planipes*  $0.1303 \pm 0.0090$  ppm Hg), and myctophid fish (*Symbolophorus evermanni*  $0.3396 \pm 0.1324$  ppm Hg). The prey species that biomagnificate the most mercury to sharks was the squid, with more than 1 ppm Hg. We concluded that all sharks, with the exception of *P. glauca*, have levels of mercury that are above the established limit for human consumption ( $> 1$  ppm Hg).

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**LORENZ, O. THOMAS**

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Effects of salinity on an invasive cichlid in Louisiana

The negative impact of invasive species on native fauna is considered second only to habitat destruction. The Rio Grande cichlid (*Herichthys cyanoguttatus*) has become established in natural and degraded habitats of New Orleans, Louisiana. In natural habitats, *H. cyanoguttatus* has only been documented irregularly and without clearly-defined size distributions. This suggests that freshwater habitats in city canals may act as a source for sink habitats in the more natural La Branche wetlands outside of the city. These wetlands are connected to Lake Pontchartrain, an oligohaline estuary that may experience elevated salinities higher than 10 ppt. These conditions may limit the success *H. cyanoguttatus* in these more natural habitats and prevent further dispersal. For example, I measured growth in juvenile *H. cyanoguttatus* held at 3 salinity levels (0, 8, and 16 ppt) and observed that those in 16 ppt grew less in 10d than those in the lower salinity treatments. Should more natural habitats prove to be barriers for these invasive fish, it could guide management efforts to control their further dispersal. Survey evidence, however, indicates the persistence of this species

in high salinities and the cichlids have also survived Hurricane Katrina and the surge of high salinity water associated with the flooding.

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**LOTTERS, STEFAN**

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Harlequin frogs in Amazonia and the Guianas – are they threatened with extinction?

Harlequin frogs (*Atelopus*) belong to the most threatened amphibians worldwide, since at least three fourth of the more than 100 species known are threatened with extinction or are even extinct. Among the relatively few species which are suggested to be in a less dramatic situation are the *Atelopus* from the Amazon basin and the adjacent Guiana Shield. I claim that this view needs revision, however, since geographic ranges, systematics and population status of the known harlequin frogs, and the possible occurrence of chytridiomycosis are poorly understood. I provide examples from (i) GIS mapping of presence/absence data, (ii) tree-based DNA taxonomy, (iii) population census, and (iv) tests for chytridiomycosis which may help to answering the question about the status of harlequin frogs in the mentioned regions.

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**\*LOWERRE-BARBIERI, SUSAN K.; BICKFORD, JOEL W.; WALTERS, SARAH L.**

*Florida Fish and Wildlife Research Institute 100 8th Ave. S.E. St. Petersburg, FL, 33701-5095, USA*

Using telemetry to determine the reproductive dynamics of spotted seatrout, *Cynoscion nebulosus*, at a known spawning site

A spotted seatrout spawning site has been identified at a pass at the mouth of Tampa Bay, FL. Spotted seatrout have spawned at this site for the past four years and the site appears to be used almost exclusively for spawning (97% of sampled females were active spawners, n=173). To better understand the reproductive dynamics involved, we set up a telemetry study to determine site fidelity and site specific spawning frequencies. From 2000 to 2004, we worked on protocol development: evaluating if fish implanted with ultrasonic tags would spawn, mapping the boundaries of the spawning site, and determining the minimum tag range to calculate how many receivers it would take to cover this site. In 2005 an array of 15 receivers (Vemco VR2s) were deployed at the spawning site. Three additional receivers were added to evaluate movement into the Gulf of Mexico or into the estuary (1 receiver in the pass channel approximately 300 m west of the site and 2 receivers acting as an estuarine gate, approximately 700 m east of the site). Early in the 2005 spawning season, 32 fish (13 males and 19 females) were surgically implanted with Vemco V8sc-2L tags.

Thirty-one of the fish were relocated either within the spawning site or at the estuarine gate from mid-May through July 12th. Multiple implanted fish were detected every day during this time period (from 2 to 17 fish/day) indicating site fidelity. A movement pattern through the array in the afternoon/evening hours was consistently observed both within the group (males and females) and multiple times for individuals. This behavior appears linked with spawning and was more frequently observed in males. Although spawning at this site usually continues through mid-September, no fish were relocated after mid-July, coinciding with a strong red tide bloom (*Karenia brevis*) in the area.

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**\*LOZANO-VILANO, M<sup>a</sup> DE LOURDES; CONTRERAS-BALDERAS, ARMANDO J.; GARCÍA-RAMÍREZ, M<sup>a</sup> ELENA**

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Distribution and prespective of jewelfish *Hemichromis guttatus* in Cuatro Cienegas Basin, Coahuila, Mexico

The jewelfish *Hemichromis guttatus* in Cuatro Cienegas Basin, increase the area of geographical distribution and population in each one of them. Was found for first time in Poza Churince, and the second area, was San Jose del Anteojo, where was virtually extirpate. But, now, we report the presence of this species in eight different areas more, as follow: 1-Churince, 2-San Jose del Anteojo (Extirpate), 3-Dos Gueros, 4-Balneario Mezquitez, 5-Rio Mezquites, 6-Poza 600m NW Churince, 7-Poza 700m NW Churince, 8-Poza NW km 100 HW Torreon and 9-Poza Azul (only one time). Our study was realized during 5 years: 45 months: 143 days. We think that expansion of this species impact in the native fishes, these observations we have from Poza Churince. The costs of control from 1999-2005, was \$641,000.00 M.N. (\$60,000.00 DLLS). The grants were obtained of: PEMEX, PRONATURA, PAICYT-UANL, INST-COAH-ECOL and we self.

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**\*LUER, CARL A.; WALSH, CATHY J.; WYFFELS, JENNIFER, T.; BODINE, A.B.**

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Reproductive biology of the clearnose skate, *Raja eglanteria*, in captivity

Clearnose skates (*Raja eglanteria*) are a common species of skate found seasonally along the Atlantic coast of North America from Cape Cod to mid-Florida and in the Gulf of Mexico from mid-Florida to eastern Texas. Clearnose skates inhabit the west central coast of Florida during winter months, when Gulf temperatures are

conducive to mating and egg-laying (approximately 16-22 °C). Specimens collected during this time will breed in captivity and, if maintained at 20 °C, mated females will store sperm and continue to lay fertile eggs for up to six months. Following copulation, sperm move up the female's paired uterine horns and are stored in the shell glands (also known as oviducal or nidamental glands) located between the uteri and oviducts. Ova are released from the ovaries in pairs, enter a common ostium and travel through the oviducts to the shell glands, where fertilization and encapsulation of eggs take place. Experiments resulting in the first artificial insemination for any elasmobranch fish have provided evidence for functional roles of the alkaline gland, whose secretions stimulate sperm motility and may enhance migration of sperm to the shell glands, and the clasper gland, whose secretions may provide nutrition during storage of viable sperm in the shell gland. Females will lay 30-35 pairs of eggs per season with a 3-5 day interval between laying of successive egg pairs. Developmental landmarks include formation of primitive streak (day 4), closure of neural tube (day 6), early stages of sensory organs, CNS, and gill arches (days 10-14), rostral migration of pectoral fins (weeks 3-5), proliferation and resorption of external gill filaments (weeks 3-8), and appearance of dermal pigmentation (weeks 8-9). If eggs are maintained at 20 °C, embryos will develop and offspring will hatch after a period of approximately 12 weeks (84±6 days).

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**LUJAN, NATHAN K.**

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New catfishes from the Western Guyana Shield

As a follow-up to productive collections made in the río Ventuari in 2004, a second All Catfish Species Inventory-funded expedition was launched to further investigate tributaries draining the Western Guyana Shield. From February to April 2005, 55 sites were sampled, from Raudales Autures, upstream to La Esmeralda in the upper Orinoco, down the Casiquiare to the río Negro, and up the Siapa to Salto de Oso. This region is very ichthyologically diverse, with a total combined species list for the 2004 and 2005 expeditions exceeding 550 species. Many of these, including over 30 new Siluriformes for 2005 alone, are undescribed. Images of many of these species will be presented along with new insights concerning biogeography of the Guyana Shield gained from sampling in headwater streams around its western rim.

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**\*LUJAN, NATHAN K.; ARMBRUSTER, JONATHAN W.**

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Phylogenetically informative new loricariid genera from the Western Guyana Shield

Recent fieldwork in the upper Orinoco has yielded a host of new suckermouth armored catfishes (Siluriformes: Loricariidae). Included in these are at least two new

species each comprising new monotypic genera in the tribe Ancistrini, and two new and atypical species in the genus *Pseudancistrus*. The two new genera are both among the smallest hypostomines ever discovered. One is sister to the *Acanthicus* group and is supported by the presence of an enlarged swim bladder and a loss of the posterior condyle of the mesethmoid, and the other has a naked snout like *Ancistrus* and *Chaetostoma*, but the pattern of deplation is quite different, and it lacks the synapomorphies of the *Ancistrus* and *Chaetostoma* groups. The two new *Pseudancistrus* represent the extremes of the genus. One species is very small, and likely to be sister to *P. orinoco* and the second is very large with 10 or 11 dorsal-fin rays. Photos of the new species and osteological evidence supporting both the erection of new genera, and the inclusion of species in *Pseudancistrus* will be presented.

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**LUNDBERG, JOHN G.; \*LUCKENBILL, KYLE**

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Catfish Bones: The on-line atlas of catfish morphology

Catfish Bones is a website that freely offers high quality digital images of catfish skeletal morphology made from museum voucher specimens. A central goal of Catfish Bones is to illustrate the details of skeletal anatomy of at least one species for each family of catfishes. To date multiple images are on Catfish Bones for 57 species representing 14 families. Imaging methods and materials used by Catfish Bones range from 2D static images of dry skeletal preparations, cleared and stained specimens, radiographs, and static images and 3D animations from catscans (HRXRT, high resolution Xray computed tomography). Catfish Bones exemplifies the power and speed of the Internet and modern imaging technology for facilitating and improving organismal and comparative biology. The specimen images on Catfish Bones do more than illustrate data and research results; these are shared specimen resources put into the hands of the research community for continuing data discovery, reinterpretation and discussion. The images and links on Catfish Bones are also available to educators and the public. This presentation will emphasize large-format visual examples of the range of imaging and image processing methods in Catfish Bones using existing and several new images and animations.

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**\*LUNDBERG, JOHN G.; SULLIVAN, JOHN S.; RODILES HERNANDES, ROCIO; HENDRICKSON, D. A.**

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Phylogenetic relationships of the Chiapas catfish, *Lacantunia enigmatica* (Siluriformes: Lacantuniidae) inferred from *rag* gene sequences

In 2005 Rodiles Hernandez et al. described *Lacantunia enigmatica*, a large and unusually distinctive catfish from the Río Usumacinta watershed, Chiapas, Mexico. Morphological comparisons revealed that *Lacantunia* lacks the diagnostic synapomorphies of all siluriform families. A phylogenetic analysis using 290 morphological characters identified the Chiapas catfish as a member of the large suborder Siluroidei, but therein unresolved in a basal polytomy of 22 siluroid subgroups. Recently Sullivan, Lundberg and Hardman (in press) conducted a molecular phylogenetic study of the major groups of catfishes using the two *rag* nuclear genes from 110 species that represent all siluriform families but two, Lacantuniidae and Austroglanididae. We have now sequenced the *rag1* and *rag2* genes of *Lacantunia* and have added the species to our molecular dataset. Here we will present the results of maximum parsimony, maximum likelihood and Bayesian phylogenetic analyses of *Lacantunia* based on 3660 aligned base pairs of the *rag* genes over all families except Austroglanididae. The best-supported tree(s) will be used to reassess as potential synapomorphies the salient morphological characters shared by *Lacantunia* and other catfishes. In the same phylogenetic context(s), we will explore the biogeographic implications of the relationships of *Lacantunia*.

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Predicting historical, current, and future fish species distributions across Wisconsin streams and rivers

Geographic areas on the scale of a state or province typically have a vast quantity and diversity of aquatic resources, far more than could ever be directly sampled for fishes. However, recently developed spatial databases (GIS) and analytical techniques (CART, GARP, Neural Nets) allow for comprehensive estimation of fish species distribution and abundance in un-surveyed waters. We used classification and regression tree (CART) modeling of watershed and riparian land cover and geology and stream network position and connectivity to predict the presence/absence of 60 fish species over the entire 50,000+ km of streams and rivers in the state of Wisconsin. For a test dataset, model species distributions were 70-90%

accurate. Key predictor variables differed among species, but most models included summer water temperatures (predicted from watershed and riparian land cover and geology plus regional air temperature data), stream flows (predicted from watershed land cover and geology plus regional precipitation data), and watershed and riparian human land uses (agriculture and urbanization from satellite imagery). Based on the species models, we used data layers of pre-European-settlement land cover (from pre-statehood land surveys) and projected land-use trends (from land transformation models) to estimate historical (1830) and future (2030) occurrence patterns and compared these with predicted current distributions. Many fish species, especially coldwater forms (e.g., brook trout *Salvelinus fontinalis*, mottled sculpin *Cottus bairdii*) and sensitive warmwater forms (e.g., northern hog sucker *Hypentelium nigricans*, rainbow darter *Etheostoma caeruleum*) have declined precipitously over the last 175 years and are expected to decline further during the next 25 years. Other more tolerant generalist species (e.g., creek chub *Semotilus atromaculatus*, white sucker *Catostomus commersonii*) have shown relatively little loss of habitat and may actually increase in distribution in the future.

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**MABRAGAÑA, EZEQUIEL; \*FIGUEROA, DANIEL E.; SCENNA, LORENA B.; DIAZ DE ASTARLOA, JUAN M.; COLONELLO, JORGE H.; MASSA, ANA M.**

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### Chondrichthyan egg cases from the southwestern Atlantic

Egg cases of 16 species of oviparous chondrichthyans from the southwestern Atlantic were described and compared. Samples (n= 130) were obtained from females containing egg cases in their uteri and egg cases found in benthic samples, collected during research cruises carried out by the Instituto Nacional de Investigación y Desarrollo Pesquero on the Argentinean continental shelf (34 °-55 ° S) and from captivity specimens in Museo del Mar. Eight morphometric characteristics were measured following traditional methodology and two more were added, keel thickness (KT) and straight distance from anterior apron margin to curvature of anterior horn. The speciose genus *Psammobatis*, whose ECL (egg case length without horns) ranged 25-53 mm, presented a great variety of egg cases features and showed the smallest ECL. Those of the endemic genus *Sympterygia* (ECL range: 51-68 mm) presented the highest KT and the longest posterior horns. Egg cases of *Rioraja agassizi* (EC range: 61-68 mm) had relative straight sides. Egg cases of the genus *Bathyraja* (ECL range: 75-98 mm) were characterized by a conservative morphology, rough surface case and curved horns. *Atlantoraja castelnaui* presented a large egg case with a wide lateral keel (ECL range: 97-104 mm). The genus *Dipturus* (ECL range: 115-230 mm) showed the largest ECL and very developed posterior apron. The unique

oviparous shark that occurs in Argentinean waters, *Schroederichthys bivius*, had a cigar-shaped egg case with curled tendrils on posterior tip. Egg cases of the elephant fish, *Callorhynchus callorhynchus*, were spindle-shaped with anterior and posterior tubular extensions. Chondrichthyans egg cases can be a useful tool for identifying individual species and egg laying areas, therefore a provisional key to the southwestern Atlantic chondrichthyans egg cases was constructed. Some results presented in this abstract are part of an ongoing study about ecology, biology and biodiversity of species of *Bathyraja* on the Argentinean continental shelf.

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**\*MACESIC, LAURA J.; KAJIURA, STEPHEN M.**

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Behavioral function of the electric organs of Bancroft's numbfish, *Narcine bancroftii*

All elasmobranchs have the ability to detect electricity, however only skates (Rajiformes) and electric rays (Torpediniformes) are capable of bioelectrogenesis. Within these orders, skates emit weak electric organ discharges (EODs) involved in communication, whereas electric rays emit strong EODs during prey-capture. Of the Narcinids, Bancroft's numbfish, *N. bancroftii*, produces both strong and weak EODs from large main electric organs and small accessory organs respectively; however, the function of these discharges remains unknown. Prior to investigating the behavioral function of the EODs, morphometrics were studied to examine possible sexual dimorphisms and ontogenetic changes in the electric organs. The number of electroplaques and the surface area of the main electric organ correlate positively with size morphometrics. The mean electro-somatic indices (ESIs) for the main and accessory electric organs were  $13.69 \pm 0.63\%$  SE (n=15) and  $0.10 \pm 0.01\%$  SE (n=15), respectively. Moreover, the ESI for the accessory electric organ demonstrates positive allometry, whereas, for the main electric organ, it is negatively allometric. None of the morphometric characters were sexually dimorphic. Electrophysiological experiments reveal a logarithmic relationship between the main EOD amplitude and disc width; disc widths ranged from 6cm (9V) to 23cm (56V). Main EODs were often in trains fewer than 10, however, trains of more than 100 were also observed. Fundamental frequencies for the main EODs ranged from 78-215Hz. Results of behavioral experiments indicate that the main EOD functions primarily in defense, and not in predation. Preliminary results from behavioral experiments of accessory EODs suggest their use in intraspecific communication.

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**\*MACKESSY, STEPHEN P.; BAXTER, LOUISE M.**

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### Synthesis, storage and deployment of biological weapons by venomous snakes

A paradoxical task of the venom gland of snakes is the synthesis and storage of an instantly available suite of toxins to immobilize prey and the protection of the snake against its own venom components. Autolysis of venom constituents due to the action of venom metalloproteases is an additional problem, particularly among viperid venoms, which are typically rich in lytic enzymatic proteins. To address questions concerning these problems, glandular structure was investigated using light microscopy, SEM and TEM. The composition of venom originating from the intact apparatus or from the main gland alone was analyzed by electrophoresis. Results from several species of rattlesnakes demonstrated that the venom gland is structurally complex, particularly in a small rostral portion called the accessory gland, which may be a site of activation of venom components. Secreted venom is stable in extremes of temperature and dilution, and several proximate mechanisms, including pH and endogenous inhibitors, exist which inhibit enzymatic activity of the venom during storage within the gland but allow for spontaneous activation upon injection into prey. We propose that the mitochondria-rich cells of the main venom gland, which are morphologically very similar to the parietal cells of the mammalian gastric pit, play a central role in the stabilization of the venom by secreting acidic compounds into the venom and maintaining the stored venom at pH 5.4. Hence, our results indicate yet another trophic link between the processes of venom production and digestion, and demonstrate that the venom glands of snakes may represent an excellent model for the study of protein stability and maintenance of toxic proteins.

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**MACNEIL, M. AARON**

*University of Newcastle, School of Marine Science and Technology, Newcastle upon Tyne, NE1 7RU, United Kingdom*

### Robust estimates of reef fish community dynamics: MCMC simulation in Python

Underwater visual censuses (UVCs) are the most widely used techniques for sampling coral-reef fishes. Normally conducted as either strip transects or point counts, these methods can incur substantial biases when estimating community parameters if - as is frequently the case - cryptic species or behavioural responses to sampling occur. Capture-recapture models for closed populations can readily be adapted to UVC data to provide robust estimates of community parameters in the presence of substantial detection heterogeneity. Here I show how Markov Chain Monte Carlo (MCMC) simulation can be used to estimate species richness and community change in the reef-fish community of coastal Kenya. These methods are

implemented in PyMC, a powerful toolkit for the open-source, object-oriented Python programming language. MCMC results from Kenyan surveys demonstrated considerable heterogeneity in species detectabilities and estimates of species richness differed substantially from the naive estimates routinely used with UVC data. Because such methods deal explicitly with sampling where not all species are detected, their use is encouraged for studies addressing reef-fish community dynamics.

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**\*MAERZ, JOHN C.; BLOSSEY, BERND**

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Can plant growth and nutritional quality predict invasive plant impacts on larval amphibians

Though examples of invasive species impacts on native biota are increasing, there are few general principles that can be used to predict how invaders will affect particular organisms. In wetlands, emergent macrophytes are the major source of energy and nutrients, and changes in detrital quality can have large effects on the performance of heterotrophs in the wetland. In order to determine whether invasive plant nutritional chemistry could predict the effects of plant invasions on wetland fauna, we collected senescent leaves from 3 native and 3 nonnative wetland plant species, measured detrital nutritional chemistry, and then used the detritus to raise mixed-species larval anuran assemblages in aquatic mesocosms. Nonnative plant detritus tended to have lower %N and, consequently, greater C:N. This was particularly apparent when comparing closely related native and nonnative *Phragmites australis* and native *Typha latifolia* and nonnative *T. angustifolia*. C:N ratio was a strong predictor of anuran metamorph richness, total productivity, and individual species performance. Two anuran species were only able to metamorphose in mesocosms with native plant detritus, and the two species that successfully metamorphosed in all treatments showed reduced survival, longer larval periods, and reduced mass at metamorphosis in nonnative plant treatments. We suggest that the rapid growth exhibited by many nonnative plants will be associated with a reduction in plant nutritional quality, with predictable effects on invaded food webs and the native fauna they support.

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**\*MAGLIA, ANNE M.; MUELLER, JESSICA M.; PUGENER, L. ANALIA**  
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Osteology and development of *Acris crepitans blanchardi*: Unique morphology right under (and behind) our noses

Of the North American hylids (Anura: Hylidae), the osteology of frogs in the genus *Acris* has been the least studied. Based on cleared-and-stained and dry whole-mount specimens, serial sections, and 3D reconstructions of anatomy (from the MorphologyNet digital library: [www.morphologynet.org](http://www.morphologynet.org)), we describe the adult osteology of *Acris crepitans blanchardi*. Novelty in the cranium of this species relates to distinctive calcification of cartilages and to unique nasal cartilage morphology. In addition, there are several features in the postcranial skeleton that are uncommon. We compare the adult osteology, timing of onset of ossification, and chondocranial modification of this species to that of other North American hylid taxa (*Pseudacris* and *Hyla*), and discuss skeletal and developmental-pattern evolution among the group.

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**\*MAIA, ANABELA; MARQUES, JOANA F.; CABRAL, HENRIQUE N.**  
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Parasitic fauna of the digestive tract of Shortfin Mako, *Isurus oxyrinchus*, off Portugal, NE Atlantic

The shortfin mako, *Isurus oxyrinchus*, is caught in the eastern North Atlantic as a steady bycatch of the surface drift longline fishery, mainly directed to the swordfish (*Xiphias gladius*). Endoparasites were recovered from the stomach of 87 of the 112 shortfin mako individuals sampled. Nematoda and Cestoda were the most common endoparasites, being present in all shark life stages including young-of-the-year sharks. All Nematoda (mainly Anisakidae) were found as L3 larvae indicating that they use this species as an intermediary host, while some Cestoda were found as adults with completely developed and mature proglottids, as is the case of *Nybelinia* and *Echeneibothrium* species. *Nybelinia lingualis* and *Echeneibothrium cf. dubium abyssarum* had the highest prevalence, mean abundance and mean intensity values. Digenea and Acanthocephala were also present although with low prevalence. Results indicate that Cestoda and Nematoda are important parasites throughout the host's life-cycle since they appear in a very early stage, when elasmobranchs start feeding. Parasitosis' dynamics are thus discussed regarding the host's life-cycle and feeding ecology off the Portuguese coast.

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**MAKOKHA, SAKWA J. ; \*BAUER, AARON M.; MATTHEE, CONRAD A.**  
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### Molecular phylogenetics of sand lizards, *Pedioplanis* (Sauria: Lacertidae)

Sand Lizards, genus *Pedioplanis* comprises eleven recognized species. They are restricted to the Southern African subcontinent with a few species extending into Angola. In this study we aimed to determine the phylogenetic relationships among the 11 recognized taxa by using mitochondrial (ND2 and 16S) and nuclear (RAG-1) gene regions. In many instances the molecular analyses supported the evolutionary relationships based on morphology and protein electrophoresis data. The monophyly of the genus *Pedioplanis* is supported with *P. laticeps* and *P. burchelli* being sister to all the other species. Unlike the morphological data, the molecular data supports the monophyly of the *P. undata* complex group (*P. undata*, *P. inornata*, *P. gaerdesi* and *P. rubens*) although not all *P. inornata* was included both mtDNA and nuclear data suggest a paraphyletic origin for this species. Intraspecific relationships with *P. namaquensis* shows two distinct lineages, and these might represent distinct taxa. The variation in *P. lineocellata*, currently expressed as three subspecies, is even more complex than assumed and at least four separately evolving lineages were identified. The tree is congruent with two major biogeographical clades: South-North clade (*P. burchelli*, *P. laticeps*, *P. lineocellata*, *P. namaquensis* and *P. breviceps*) found Southern range of the genus with a few other that extend to Namibia and Botswana in fairly mesic habitat; Namibian clade (*P. husabensis*, *P. undata*, *P. rubens*, *P. inornata* and *P. gaerdesi*) which is more arid adapted and had to undergone radiation in the more extreme Namib desert with a few extending their range into southern Angola. Potential candidate vicariant events that could have driven cladogenesis in this group are climate change and particularly those associated with the development of the Benguela current as well as the isolation and eastward movement of the Kalahari Sands.

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**\*MAKOWSKY, R.; CHESSER, J.; RISSLER, L.**

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### Understanding the biodiversity of reptiles and amphibians in the southeastern United States

The southeastern United States is unusually species rich for reptiles and amphibians compared to most of North America. Several geographic mechanisms have been proposed to explain this diversity, which range from physiography to drainage systems. In order to better understand the mechanisms generating this pattern, we examined 2 novel species phylogeographically to determine what effect geography has had on these taxa. The taxa examined were *Nerodia erythrogaster*, the plain-bellied watersnake, and *Gastrophryne carolinensis*, the eastern narrow-mouthed toad. These

taxa make interesting subjects because of their broad, similar ranges, their disparate ecologies, and their reliance upon water. Six subspecies of *N. erythrogaster* are currently recognized and were originally described using morphological characters (such as color and scale count), which have been found to not necessarily represent evolutionary lineages. Moreover, most of the taxonomic boundaries are not supported by any ecological or geographic explanations. *Gastrophryne carolinensis*, on the other hand, is recognized as a monotypic species and therefore a single evolutionary lineage. Here, we seek to determine if taxonomy or geographic boundaries (physiographic regions and drainages) are concordant with evolutionary lineages discerned from molecular characters. We used Cyt b and NADH II (c. 1,500 bp) for *N. erythrogaster* and Cyt b and 12S (c. 1,400 bp) for *G. carolinensis*. In addition, AFLPs will be added as a nuclear component to verify the mitochondrial hypotheses. Preliminary data suggest that lineages are not concordant with the existing taxonomy for *N. erythrogaster*, and that certain regions appear concordant with monophyletic clades. Collectively, this information will provide a better understanding of the evolutionary forces that have driven biodiversity patterns in the southeastern United States.

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**MANDICA, MARK L.**

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**Comparison of photoperiod related activity patterns and *zeitgeber* of two South Florida bufonids**

Early natural history notes (Hamilton, 1955; Wright & Wright, 1949; and Duellman & Schwartz, 1958) described the oak toad, *Bufo quercicus*, as diurnal. These descriptions are postulated upon field observations but have never been confirmed empirically. I collected adults and larvae of both *B. quercicus* and *B. terrestris* (the putatively nocturnal Southern toad) near Everglades National Park, Florida. The goals of this study were to: 1) verify these earlier accounts experimentally, 2) compare activity patterns between the two bufonids, and 3) determine if an ontogenic shift occurs in activity patterns throughout and after metamorphosis. We used time-lapse videography to sequence toad and larvae movements every 30 seconds for 24 hours (Using a 12:12 light cycle). Our preliminary data indicate that *B. quercicus* is more active during the day than *B. terrestris*. However, *B. quercicus* also displays significant nocturnal activity, suggesting a cathemeral rather than diurnal pattern, as previously suggested. Furthermore, visual and non-visual photoreception information is coordinated in the suprachiasmatic nucleus (SCN) of the mid brain in amphibians. We compared the morphology of the SCN of *B. quercicus* and *B. terrestris* using a Nissl (Cresyl Violet) stain to ascertain any anatomical differences in the mid brain between the two bufonids.

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**MANNING, GLENN J.**

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Water mains, a death trap for small vertebrates

Vertebrate mortality caused by man-made structures has been frequently observed. On the 20th of June 2003 a slightly ajar cover on an upraised water main was discovered in Fort Sumner, New Mexico. Upon investigation, one living *Uta stansburiana* (side-blotched lizard), four *U. stansburiana* skulls, one *Eumeces obsoletus* (great plains skink) skull, and four *Reithrodontomys* sp. (harvest mice species) skulls were discovered. This was a large-scale death event for both *U. stansburiana* and *Reithrodontomys* sp. No subsequent mortality was found after visits in 2003 through 2005, when proper closure was preformed to prevent, or at least minimize, this kind of mortality. Similar to standard pitfall traps, water pipe lids should always be snugly closed when not in use if no mechanism exists to allow the escape of trapped animals. Individuals may be using this structure as overnight cover or an escape from daytime heat. The latter would be an example of an "Ecological Trap".

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Species at Risk or Cockroach of the Sea? Abundance of Spiny Dogfish (*Squalus acanthias*) in the New Zealand Exclusive Economic Zone

Spiny dogfish (*Squalus acanthias*) is a small- to moderate-sized benthopelagic squaloid shark distributed globally in temperate marine waters. It has been commercially exploited on an industrial scale over much of its range for more than a century, but recently concerns have been raised about the status of the stocks in certain areas, notably in the North Atlantic. At this time, the Northwest and Northeast Atlantic stocks are thought to be severely depleted, with the reproductive biomass of each stock thought to be about 25% and 5% (respectively) of average unfished biomass. Indeed, the stocks were assessed as 'vulnerable' and 'endangered' (respectively) by the IUCN in 2003. However, below the equator, the status of stocks in the New Zealand Exclusive Economic Zone (EEZ) appears much less perilous. At this time, stocks in the New Zealand EEZ support four major commercial fisheries with a total catch that has averaged over 8000 t per year over the past ten years (1995–2004). In this paper, we summarise the results of recent studies on the abundance of the New Zealand stocks. We briefly describe their known biology, major fisheries, available abundance indices, and ongoing management measures, comparing and contrasting the New Zealand experience to date with that in the North Atlantic – of the four major New Zealand fisheries, in only one does stock abundance appear to be declining; in the remaining three, abundance appears to be static or increasing.

Finally, we speculate on what effect current fisheries and management practises in New Zealand might have on the future abundance of the New Zealand stocks.

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**\*MÁRQUEZ-FARIAS, J. FERNANDO**

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Size of maturity of (*Raja velezi*) taken in the Gulf of California, Mexico

The rasptail skate, *Raja velezi*, is a relatively deep-water member of the family Rajidae that occurs from the Gulf of California (GOC), Mexico to Peru where little is know of its life history. It is incidentally caught in artisanal ray fisheries of the GOC in low numbers. However, it may be taken in significant amounts by trawling vessels targeting fishes and deepwater shrimp in the GOC where bycatch of skates is known to be common. Previous studies of skates worldwide have demonstrated low resilience to sustained, often indirect fishing mortality. It is therefore imperative to investigate biological characteristics of exploited skate species to provide details necessary for sustainable management. For the present study, specimens examined from trawlers and landings of the artisanal ray fishery in Sonora were used to determine the size at maturity of *R. velezi*. Maturity of males was judged based upon the condition (calcification, rotation) and development of the claspers. Macroscopic observation indicated that males reach maturity from 61 cm disc width (DW) onwards. Histological analysis of the testes of specimens ranging from 55.5–63.4 cm DW (mean= 60.8; sd= 2.8; n= 8) indicated the presence of spermatozoa in different levels of development. Females 64 cm DW and greater were determined to be mature. Histological analysis of females ranging from 60.5–65.0 cm DW (mean= 63.8; sd= 2.25; n= 4).

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Investigation of the movement and depth-temperature preferences of the white shark (*Carcharodon carcharias*) from the Gulf of California, Mexico

Commercial fishermen have reported the occurrence of the white shark (*Carcharodon carcharias*) throughout the Gulf of California (GOC) for many years. It has been hypothesized that the location of pinniped colonies, among other factors, may play an important role in determining its presence in the region, but little is actually known of the distribution, seasonality, movement patterns, or residence time of *C. carcharias* in this region. Given the extent and importance of commercial fisheries in

the GOC, identification of movement patterns may provide essential details for reducing fishery interactions and improve the management and conservation of this species. Satellite tagging efforts were therefore conducted to better understand the behavior and ecological preferences of *C. carcharias*. A satellite PAT-Tag was attached to a 280 m total length (estimated, sex no available) white shark in the vicinity of San Pedro Nolasco Island (eastern central GOC) in November 7, 2004 and the tag successfully released April 30, 2005 166 km to the south. Maximum recorded depths by month were Nov 232 m, Dec 92 m, Jan 104 m, Feb 180 m and March 244 m. The monthly temperature ranges logged by the tag were Nov 13.2 -26.4°C, Dec 18.2-22.7 °C, Jan 16.2-21.3 °C, Feb 13.9 -20.2°C and 13.2-22.3°C during March. Preliminary tracking results indicate movements of the white shark into the upper GOC.

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**\*MARSHALL, ANDREA D.; BENNETT, MICHAEL B.**

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#### Impacts of shark predation on *Manta birostris*

The impact of predation upon elasmobranch populations has rarely been considered. *Manta birostris* has traditionally been considered to have few natural predators. However, data gathered since 2003 in an ongoing study on manta rays in Mozambique suggests otherwise. Of 317 different individuals, 73% exhibit injuries (all of which include missing flesh or tails) inflicted by sharks. Many minor injuries were also recorded, including crescent-shaped tooth mark punctures, rake marks from upper or lower teeth, and discoloration to the dorsal and ventral surfaces. While some individuals have as many as 7 discrete bite wounds, the mean number of bites marks is 1.41. Ninety percent of bite marks and injuries occur along the trailing edge of the pectoral fins, while six percent of bites occur on the head or cephalic fins. Two percent of bites are fresh, while a further seven percent are recent. Shark attack is likely to be a major source of natural mortality, while the fitness of individuals is also detrimentally affected by non-fatal attacks. Many rays cannot be visually sexed because of extensive damage to the posterior half of their body. Several males are missing one or both claspers. Damage to cephalic fins will also affect feeding efficiency. The prevalence of injuries also has a major influence on cleaning behavior, impacting upon short-term movement patterns and habitat usage. Therefore, the number and severity of shark bites sustained within this population may have a significant effect on manta ecology.

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**\*MARSHALL, ANDREA D.; BENNETT, MICHAEL B.**

*The University of Queensland, School of Biomedical Sciences, St Lucia, QLD 4072, Australia*

#### Reproductive ecology of *Manta birostris*

Manta rays, *Manta birostris*, are common in southern Mozambican waters. Research since 2003 has identified 350 individual rays, using their unique dorsal and ventral

markings, on a single reef. The study site supports three major cleaning stations, where mantas spend a significant amount of time allowing several species of fish to remove parasites and necrotic tissue. The reef is utilized year-round, with multiple individuals generally present. This population is sexually segregated, with 22% male and 78% female. The high re-sighting rate (32%) infers a semi-resident local population, which has allowed the reproductive condition of known individuals to be regularly assessed. The smallest mature male observed was approximately 3.5 m disk width, while the smallest pregnant female recorded was 3.8 m DW. Pregnancy has been observed in over 60 individuals. Courtship and mating behavior occurs in November/December, while pregnancy becomes externally evident around August. Parturition occurs in the summer months, from late November to early February. One, or rarely two, pups are born per litter. The smallest free-swimming individuals measured 1.2-1.4 m DW, while a 1.3 m DW pup was extracted in early October from a pregnant female killed by local spear fisherman. Preliminary data suggests that the gestation period in this population is 12 months with an overall two-year reproductive cycle.

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### A three-year study of ichthyoplankton in the lower Savannah River and its tributaries

This presentation is based on a three-year study done from 1983 through 1985; the data from this study have not been previously published. For all three study years, samples were taken monthly from February through July. In 1983 28 stations in the main channel of the river between river miles 29.6 and 187.1 were sampled as were the lower reaches of 27 creeks entering the river between river mile 30.0 and 187.2. For 1984 the same river channel stations were sampled but two creeks were dropped from the sampling regime and two others were added. For 1985, only those river channel station between river miles 89.3 and 187.1 were sampled as were only the 14 previously sampled creeks entering the river between river mile 92.6 and 183.3. We will compare larval community composition and total larval transport between creek and adjacent river stations and upper coastal plain versus lower coastal plain river stations and creeks; we will also examine the effects of annual flow rate patterns on larval transport.

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**MARTIN, R. AIDAN**

*Fish Museum, Zoology Department, University of British Columbia, 6270 University Boulevard, Vancouver, BC, V6T 1Z4, Canada*

Behavioral ecology of white sharks in False Bay, South Africa, with recommendations for local management and conservation

The white shark (*Carcharodon carcharias*) is a nomadic apex macropredator exploiting a broad range of habitat types and prey. False Bay, South Africa, is a rich coastal temperate ecosystem inhabited year-round by a small resident population of white sharks and visited seasonally by large numbers of individuals during late autumn and winter. Since 1997, the author and his co-workers have studied selected aspects of the synecology of white sharks in False Bay. The physical environment of False Bay is briefly reviewed and seasonal patterns in white shark distribution within the bay are described. Seal Island, at the foot of False Bay, is a seasonal aggregation site for white sharks; site fidelity and residence times of individuals are described. Seasonal differences in the diet of False Bay white sharks are described and trophic relationships are modeled. Predatory behaviour of white sharks at Seal Island, along with social and environmental factors affecting predatory success, are reviewed and compared with published data on this species at the Farallon Islands, California. Size and sex distribution and growth rate of known individual white sharks is summarised and compared with published estimates. Intraspecific associations and social interactions among white sharks observed at Seal Island are described, including agonistic displays that facilitate establishment and stability of social rank. The uneasy relationship between humans and white sharks within False Bay is reviewed, including attacks on people and boats, sport angling for white sharks, and white shark ecotourism. Recommendations for local management and conservation of white sharks are offered.

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**MARTIN, R. AIDAN; ROSSMO, D. KIM; \*HAMMERSCHLAG, NEIL**

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**Geographic profiling of white shark (*Carcharodon carcharias*) predation**

Stalking predators must balance minimum strike distance against the need to maintain crypsis. White sharks (*Carcharodon carcharias*) aggregate seasonally off Seal Island, South Africa, where they stalk and attack Cape fur seals (CFS, *Arctocephalus pusillus pusillus*). White sharks typically attack CFS at the surface via a sudden vertical strike, a strategy which maximises their ability to spot prey silhouetted in Snell's window and minimises strike distance and duration while limiting preys' ability to detect, assess, and escape attack. White shark attacks on CFS at Seal Island are concentrated at the seals' primary entry-exit point, but it is not known whether

sharks search randomly or limit their search to areas adjacent to prey entry-exit points. Direct observation of white sharks near Seal Island is difficult, due to water turbidity and low crepuscular light levels, when predatory activity is greatest. Geographic profiling, originally developed as a law enforcement tool that prioritises suspect searches to the probable area of a serial criminal's residence or base, was used to show that white sharks hunting CFS at Seal Island do not search randomly around the island or at the primary entry-exit point, where prey concentration is highest. Instead, white sharks appear to concentrate hunting effort to an area seaward of the entry-exit point along the travel path seals follow to and from the island. Our results suggest that hunting strategy of stalking predators and serial criminals are optimal behaviours, shaped by common tactical constraints. We propose six constraints shared by both human and non-human predators.

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**MARTIN, SHANNON B.**

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The influence of microhabitat on the association behavior of the mangrove killifish, *Kryptolebias marmoratus*

*Kryptolebias marmoratus* is a small, cryptic cyprinodontid fish which inhabits the burrows of land crabs in the intertidal zone of coastal mangroves. These burrows in the mangroves are important microhabitats which act as refuge from desiccation during low water and refuge from predators during high water. The predominant form of reproduction in *K. marmoratus* is reported to be self-fertilization and the production of isogenic offspring. However, a large proportion of males were found in a Belize population. Consequently, heterozygotes were detected in this population of presumed obligate, self-fertilizers. Studies have proposed that male x hermaphrodite mating is the source of the heterozygosity in this population. I compiled a catalog of behaviors some from direct empirical observations in the field and the laboratory and some from published and unpublished literature. Preliminary observations identified conspicuous body postures and movements that could be quantified according to the frequency and duration and were used to examine the interactive social behavior for various experimental pairings of *K. marmoratus* of different sexual states (i.e. hermaphrodite and male) in an aquarium with simulated crab burrows to allow observation of behaviors that would normally take place below the substrate and could not be observed in the field. *Kryptolebias marmoratus* regardless of sexual state spent 40% of their time in the burrow. Hermaphrodites exhibited a preference for associating with males rather than other hermaphrodites. The observed complexity and frequency of displayed behaviors between paired conspecifics indicated that *K. marmoratus* has a rich repertoire of social behavior not predicted for a strictly selfing species, that the microhabitats of the land crab burrows play an important role in their social interactions, and finally that *K. marmoratus* exhibits a preference of association with individuals of a different sexual state which has implications for examining the potential for a complex mating system.

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### Molecular phylogeny of the *Sceloporus torquatus* (Squamata: Phrynosomatidae) group

A phylogeny hypothesis of the *Sceloporus torquatus* group was obtained on the basis of 457 pb of the 16S ribosomal gene, 892 pb of the 16S ribosomal gene and 893 of the ND4 gene, for an overall of 50 specimens of 24 taxa that have currently been acknowledged for this group. These data were analyzed separately and combined using parsimony and Bayesian inference. Analysis of the separately and combined data supports that *S. serrifer* subspecies are not a monophyletic group, this results refute morphological evidence according to which *S. s. pliopus* and *S. cyanogenys* are closely related to *S. s. serrifer* and *S. s. prezygus* in the Southeast of Mexico, even though these last two are recuperated as sister taxa. Furthermore, our phylogenetics results showed that *S. ornatus ornatus*, *S. mucronatus* and *S. dugesii* subspecies do not form monophyletic groups.

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### Extreme population subdivision throughout a continuous range: Phylogeography of *Batrachoseps attenuatus* (Caudata, Plethodontidae) in Western North America

The genus *Batrachoseps* includes 19 species exhibiting a remarkable degree of morphological similarity, especially in the most speciose subgenus, *Batrachoseps sensu stricto* (16 species), where several supraspecific complexes have been previously described. We present a detailed study of the phylogeography and historical demography of *B. attenuatus*, the most widespread species, using molecular markers (partial sequences of the mitochondrial gene cytochrome b). The results show deep divergences, with 4 genetically well-differentiated and geographically structured lineages. We estimated the timing of the main splitting events between the main intraspecific lineages applying relaxed molecular clock methods combining different possible mutation rates. The results suggest most vicariant events are old (Pliocene), whereas differentiation within lineages is often associated with more recent times, perhaps with post-glacial recolonization of northern areas from southern refuges in the Pleistocene. The observed patterns will be discussed in the context of the reconstruction of common biogeographic patterns in California, as well as with regard to their taxonomic and conservation implications.

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The diet of jewelfish [*Hemichromis guttatus*] an exotic African species in select areas from Cuatro Ciénegas Valley, Coahuila, Mexico

This study was conducted in Cuatro Ciénegas Valley, to know the diet of Jewelfish *Hemichromis guttatus*, an exotic African species We compare seasonal changes and length of the fishes in two localities: Poza Churince and Poza San Jose del Anteojo, into de Protected Area of Flora and Fauna from Cuatro Ciénegas, Coahuila, Mexico. We realized 8 samples in both localities, were obtained 120 specimens of each locality: San Jose el Anteojo and Poza Churince. *Hemichromis guttatus* the weight average in Poza San Jose el Anteojo was 6.16 gr. and length 52.65 mm; while Poza Churince was 4.44 gr. and 49.37 mm. We found 26 taxa in the items: 1 family of plants: algae and 18 families of animals: crustaceans (6), mollusks (3), insects (7) and (2) fishes. The preference in the diet is: algae, crustaceans and insects, mainly Zygnemataceae, Cypridae (ostracoda) and Chironomidae (Diptera), respectively. This fish have changes during the different seasons. Our results implicate, that occur competence with the native species.

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Learning by embryos: Experience with predatory cues in the egg stage influences post-hatching behavior of salamanders and trout

Aquatic vertebrates often are very efficient at altering their behavior based on their perception of local levels of predator threat. We extended this view by hypothesizing that embryos that detect predators during development would alter post-hatching behavior in ways that are consistent with levels of threat experienced as embryos. We tested this hypothesis by raising clutches of ringed salamanders (*Ambystoma annulatum*) and rainbow trout (*Oncorhynchus mykiss*) in the laboratory under high and low threat conditions and then comparing post-hatching behavior of free-swimming individuals reared in the different treatments. Larvae of ringed salamanders that had been reared as embryos under high threat conditions (chemical cues from predatory larvae) were less active (a documented antipredator behavior) and showed a stronger

attraction to plant cover than larvae reared under low-threat conditions (chemical cues from tadpoles or to a chemical blank). Similarly, rainbow trout that were exposed to high-threat levels (chemical cues from sunfish that were fed trout eggs) as embryos, showed lower levels of post-hatching activity than trout exposed to lower levels of threat (chemical cues from sunfish that were fed brine shrimp or a blank) during embryonic development. For these two species, experience with chemical stimuli from predators during embryonic development can influence post-hatching behavior.

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Age and growth of the Alaska skate, *Bathyraja parmifera*

The Alaska skate (*Bathyraja parmifera*) is the most abundant species of skate on the Bering Sea shelf, accounting for over 90% of total skate biomass. However, little is known regarding the life history of this species despite its common occurrence in the bycatch of Bering Sea cod longline and flatfish trawl fisheries. Studies focusing on age, growth, and reproductive biology are essential to stock assessment and management of this species. Since 2003, over 600 specimens have been collected in the summer during groundfish surveys conducted by the National Marine Fisheries Service (NMFS) and seasonally by the NMFS Observer Program. Banding patterns in thin sections of vertebrae and in whole caudal thorns, a non-lethal aging method, were compared for age determination. Periodicity of annulus formation was verified by marginal increment analysis. Results presented will include maximum age, age at maturity, and von Bertalanffy growth parameters. Life history parameters obtained from this study will be considered in the development of a stock assessment for *B. parmifera* and will serve as a model for other skate species in the Bering Sea for which life history parameters have not yet been described.

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Taxonomic significance of morphological variation in the West African eleotrid teleost genus *Kribia*

The African pygmy sleepers, genus *Kribia*, are eleotrid fishes endemic to the Nile River basin, and rivers of Central and West Africa. Eight taxa, including four

subspecies, have been described since 1907 and, to date, our understanding of their diversity is incomplete. Currently, the described species are primarily distinguished by small differences in meristic characteristics. The taxonomic significance of the slight variation reported is explored in light of genetic analysis of many specimens recently collected in Guinea, West Africa. Genetic distinction as estimated as a percentage of sequence divergence in the mtDNA gene ND2 among populations, paired with historical geographic events in Guinea, was examined to elucidate phylogeographic patterns among populations of the region and to determine the diagnostic significance of meristic variation.

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### Seasonal habitat use and site fidelity of *Rana muscosa*, the mountain yellow-legged frog, in a high elevation basin in the Sierra Nevada

We used PIT (passive integrated transponders) tags to determine the seasonal habitat use and site fidelity of 1244 mountain yellow-legged frogs (*Rana muscosa*) in Dusy Basin (3470 m), Kings Canyon National Park from 1997-2005. Seasonal habitat use in this high elevation basin containing twelve lakes and 8 adjacent stream sections was assessed during the three main activity periods of overwintering, breeding, and feeding. Of the 1244 tagged frogs, 1000 have been recaptured at least once (80%). Through 2005, we recaptured 1000 individual frogs for a total of 6238 recaptures. Frogs were tracked up to 9 years although many (n = 416) were only seen in one subsequent year after tagging. Typically, frogs were found in one water body throughout the 9-year study: 49% of recaptures were found in one water body, 31% in two, 13% in three, and less than 1% of the recaptured frogs were found in six water bodies over the study period. During overwintering and breeding, frogs primarily were found in five main water bodies, but during feeding periods, frogs were distributed throughout the basin and were recaptured in most of the 20 water bodies. To quantify site fidelity, the tendency to return and reuse previously occupied habitats, we used the % of frogs recaptured two years or more and exclusive to one water body during a specific activity period. Frogs had over 80% site fidelity and were exclusive to one water body during breeding, feeding, and overwintering. In 2005 we caught 43 frogs of the 356 frogs originally tagged in 1997; these frogs were at least 9 years old. Mountain yellow-legged frogs have strong site fidelity for specific water bodies for breeding, feeding, and overwintering and this information will be crucial to recovery plans for this declining amphibian.

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**Character chauvinism in systematics, working towards the common good, and living in glass laboratories**

All current-day biologists working within the scientific paradigm rely to some degree on aspects of the theory of descent with modification (DWM). This is especially true of comparative biologists, ecologists, biogeographers, etc. and taxonomists and systematists. Interestingly, DWM, Hennig's theory and methods of phylogenetics, and the multiple algorithms existing for generating phylogenies do not identify any special types of attributes of organisms that are uniquely modified during descent and are to be targeted by systematists and evolutionary biologists for phylogeny reconstruction. In fact, DWM and systematic theory underlying the reconstruction of descent relate to the notion of features of organisms/species that are modified or derived during descent that serve the community as 'clues' to prior ancestors. Our discovery of these derived features permit humans to group taxa into natural entities hypothesized to have shared unique common ancestors. In recent years the advancement of systematic and biodiversity programs have been accompanied with the community's ability to generate different types of data relevant to these fields (morphological, biochemical, molecular, behavioral, etc.). Interestingly, some researchers and programs sharing the general goals of these fields have found difficulty in accepting the intrinsic value of the different types of data or characters for studies of descent and biodiversity. All too often, the advancement of the underlying missions of the varied fields related to systematics, biodiversity, and conservation is hindered because of disputes over the relevance or quality of data used. In reality, however, all types of data and analyses have their own sets of limitations and problems that can often be ignored or overlooked by researchers that all work in 'glass laboratories.' These general objectives and the unique and common problems with different data and analyses, as well as the benefits of collaborative and constructive interactions necessary to advance systematics and biodiversity are reviewed.

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Phylogenetic inference of relationships of Cypriniformes (Actinopterygii; Teleostei) diversity using cytochrome b sequences: Evaluating standard methods versus insight from substitution stationarity

A tremendous diversity of data exist on the variation and phylogenetic utility of the mitochondrial Cytochrome b gene. Cytochrome b is a membrane-bound protein and as such is subject to physicochemical properties of amino acids for the survival of individuals. In standard phylogenetic analyses users assume that the sequences coding for proteins and their function exhibit a pattern of stationary substitution over evolutionary time, and that the sequences will represent both gene trees and, indirectly, phylogenetic trees of taxa. Recent comparative studies using Cytochrome b sequences, however, have demonstrated nonstationary substitution patterns in clades that are phylogenetically misleading unless they are modeled appropriately and regions of sequences that are misleading in phylogenetic inference are dealt with accordingly. The software package DRUIDS (Detecting Regions of Unexpected Internal Deviation from Stationarity) by Fedrigo, Adams and Naylor is a multi-alignment-based method used to identify gene regions that are likely to contain misleading signal due to changes in constraints during the evolutionary history of the group. Using a sliding window approach the program evaluates sequences for regions with statistically significant deviation across the taxa. This method has been successfully implemented in recent comparative studies to illustrate improved accuracy of mitochondrial gene trees to known trees. In this analysis we have accumulated all available Cytochrome b sequences plus many new sequences of species through the Cypriniformes Tree of Life Initiative (CToL) to compare phylogenetic resolutions using standard phylogenetic methods with those derived following the submission of these same data to DRUIDS to identify regions that may contain misleading phylogenetic signal. Given that regions of nonstationarity in gene sequences across taxa through evolutionary time can be responsible for phylogenetically misleading signal in molecular data sets, the identification and proper handling of this information should improve phylogenetic estimation of this widely used gene sequence.

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Phylogenetic relationships of *Danio* within the order Cypriniformes: A framework for comparative and evolutionary studies of a model species

The evolutionary relationships of species of *Danio* and the monophyly and phylogenetic placement of the genus within the family Cyprinidae and subfamily Rasborinae forms fundamentally important phylogenetics necessary for direct evaluations of an array of pertinent questions in modern comparative biology. While the genus is not one of the most diverse within the family, historical decisions have made this group, and *Danio rerio* in particular, one of the most important biological models in some areas of biology. Many investigations across the breadth of biological sciences have used this species or presumed close relatives to address specific questions that can have lasting impact on the hypothesis and theory of vertebrate development. Largely lacking from this picture has been a holistic view of the exact phylogenetic or evolutionary relationships of this species, the genus, and presumed close relatives. If there is one thing that was learned in the previous century in comparative biology, it was that many organismal attributes, pathways, ecologies, behaviors, speciation, etc. of species are historically constrained and their origins and functions are best explained via a historical or phylogenetic context. Herein, we provide a comprehensive evaluation of the phylogenetic placement of the model species *Danio rerio* within *Danio* and its relationships to many of the hypothesized closely related species and genera in Cyprinidae. Our analysis is derived from two nuclear genes (RAG1, Rhodopsin) and four mitochondrial genes (ND4, ND5, COI, Cyt *b*) evaluated using maximum parsimony, maximum likelihood, and Bayesian analyses. This effort is part of a much larger targeted Cypriniformes Tree of Life Initiative ([www.cypriniformes.org](http://www.cypriniformes.org)).

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**MCALILEY, L. REX**

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Captive breeding of the endangered San esteban chuckwalla, *sauromalus varius*. Effects of a decade of captive breeding on genetic diversity

Despite the increasing numbers of vertebrate species maintained in captive breeding programs, there is a paucity of data directly examining the temporal effects of captive breeding on genetic variation within these colonies. To elucidate the effects of captive breeding on a colony as well as the progeny in the colony of the endangered vertebrate species *Sauromalus varius* (the San Esteban Chuckwalla), we have utilized

seven polymorphic microsatellite loci. F statistics and analysis of molecular variance strongly suggest that the colony is exhibiting genetic signs of inbreeding. Genetic variation within the colony has decreased by an average of 12.2% between the two colonies sampled, with an average loss of 30.5% of the genetic variation within offspring. This study provides an important test of the effectiveness of captive breeding colonies at maintaining genetic variation within a vertebrate group. We discuss the results as they pertain to the conservation and management of this endangered reptile.

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#### Are crocodiles really monophyletic? Evidence for subdivisions from sequence and morphological data

Recently, the phylogenetic placement of the African slender snouted crocodile, *Crocodylus cataphractus*, has come under scrutiny and herein we address this issue using molecular and morphological techniques. Although it is often recognized as being a "basal" form, morphological studies have traditionally placed *C. cataphractus* within the genus *Crocodylus*, while molecular studies have suggested that *C. cataphractus* is very distinct from other *Crocodylus*. To address the relationship of this species to its congeners, we have sequenced portions of two nuclear genes (*C-mos* 302bp and *ODC* 294bp), and two mitochondrial genes (*ND6-tRNA<sup>glu</sup>-cytB* 347 bp and control region 457 bp). Analyses of these molecular data sets, both as individual gene sequences and as concatenated sequences, support the hypothesis that *C. cataphractus* is not a member of *Crocodylus* or *Osteolaemus*. Examination of 165 morphological characters supports and strengthens our resurrection of an historic genus, *Mecistops* (Gray 1844) for *cataphractus*.

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Herpetological conservation and biology, a journal dedicated to the conservation, ecology, and natural history

Herpetological Conservation and Biology is a peer-reviewed journal publishing original research, reviews, perspectives and correspondence on the life history ecology, management and conservation of amphibians and reptiles. Its focus demonstrates the importance of natural history to conservation efforts. Submissions of experimental, descriptive or inferential research are welcomed. Subject matter and topics for inclusion in the journal generally includes: Life history reproduction, physiology, etc.), Sampling (design, techniques), Inventory and long-term monitoring, All aspects of ecology, especially field studies, Management Case Studies. Types of material (all peer reviewed) include: Research articles and notes (original data and studies), Critical reviews, Invited Papers, Herp-Spectives, Reply to, Comments, Opinions), Short communications and notes typically published in Herpetological Review are not accepted. This publication is fill a niche in support of the leading herpetology journals and is supported by an advisory/ editorial board of 40 scientists.

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A morphological and molecular analysis of *Brycinus macrolepidotus*, a West African characoid fish

The True Bigscale Tetra, *Brycinus macrolepidotus*, is a characoid fish endemic to West African coastal streams, including the Niger River Basin. It is among the larger species present and an important part of African freshwater fisheries. Guinean ecologists noted two color morphs of *B. macrolepidotus* with different breeding

seasons. The two morphs are best separated by the tail color, red versus yellow pigment. A recent review of *B. macrolepidotus* recognized two differing body forms of across the species range. Specimens were collected in Guinea, West Africa during May 2002 and 2003. Tissue samples were taken during the May 2003 expedition. A morphometric analysis was performed using a truss analysis of 13 landmarks. Twenty-six measurements were taken for individuals previously identified by color. Principal components analysis and canonical variates analysis were used to examine the data for concordance between morphometric variation and color differences. Our analyses suggest that the two color forms may not be distinguishable by morphometric features. Intron 5 of the nuclear gene  $\alpha$ -tropomyosin was sequenced (200bp) using *Brycinus nurse* and species of *Alestes* as outgroups. Preliminary results do not reveal significant divergence between the two color phenotypes of *B. macrolepidotus*. Future work will include a molecular study using the more variable nuclear gene S7.

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Evolutionary biology of skates (Chondrichthyes: Rajidae)

Skates (Rajidae) are a highly corroborated monophyletic group and interrelationships within the taxon are fairly well resolved. However, a number of polytomies remain within the subfamily Rajinae, and two generic level taxa are unnamed and poorly defined. A new analysis of the interrelationships of rajids largely corroborates an earlier study but further resolves some of the polytomies and provides additional support for recognition of the unnamed generic level taxa. The family consists of two subfamilial-level taxa: Rajinae and Arhynchobatinae. The two subfamilies have similar numbers of genera and species but are largely complementary in their distributional patterns. Rajinae dominate, in both generic level taxa and species richness, in the North Atlantic, eastern Central and South Atlantic, western South Indian Ocean, western Central Pacific, and eastern Central Pacific. Arhynchobatinae dominate, in both generic level taxa and species richness, in the North Pacific, eastern South Pacific, Antarctic waters, and western South Atlantic. In ocean basins where the subfamilies overlap, Rajinae are more diverse at lower latitudes and lesser depths and Arhynchobatinae are more diverse at higher latitudes and greater depths. The distributional patterns suggest that most of the evolution of Rajinae occurred in the Atlantic while most of the evolution of Arhynchobatinae occurred in the Pacific. Despite the fact that Rajidae is the most species rich family within Chondrichthyes, most of the evolution appears to be the result of vicariance events rather than adaptive radiations. Skates remain ecological generalists that occur on terrigenous substrates over a wide depth range.

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### Diet and ontogenetic change of juvenile sandbar sharks, *Carcharhinus plumbeus*, in the Delaware Bay nursery

The sandbar shark (*Carcharhinus plumbeus*) is a common coastal shark species along the U.S. Atlantic coast, and it is one of the most heavily exploited species by both commercial and recreational fisheries. This species uses coastal estuaries as nursery areas, and Delaware Bay is one of the largest nursery areas along the U.S. east coast. This portion of a larger feeding ecology study characterizes the diet of the sandbar shark in Delaware Bay. Sharks were caught using bottom longlines and gillnets at locations throughout the bay. Stomachs were everted and contents were collected using non-lethal techniques. Stomach contents were identified to the lowest taxon possible, and the diet characterized using several indices. A total of 654 of 1,173 sandbar sharks sampled contained food in their stomach. The diet was predominantly composed of teleosts (82% by IRI), with crustaceans (16%) and elasmobranchs (1%) as the other major prey categories. Important teleost prey species included *B. tyrannus*, *A. mitchilli*, *T. maculatus*, *O. marginatum*, and several species of sciaenid. *L. emarginata*, *C. sapidus*, *O. ocellatus*, and some Pagurid crabs composed the majority of the crustacean prey. Neonates and smaller juveniles fed to a greater extent on crustaceans, benthic, and smaller fish species. Larger juveniles preyed upon a greater diversity of species, and elasmobranchs, larger bodied, and faster swimming species were increasingly found in the diet.

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### Migration patterns of Big Skate (*Raja binoculata*) in British Columbia waters

Since 1996, catches of Big Skate have increased dramatically in British Columbia waters as a response to increased market demand. Two major fisheries occur: in Queen Charlotte Sound and; Dixon Entrance in Northern Hecate Strait. Concern regarding exploitation of this elasmobranch species led to questions regarding the stock structure of big skate populations in Northern waters. Since 2003, approximately 12,000 big skate have been tagged and released in these two areas combined. This program is the most extensive tagging study conducted on a skate species and offers a rare opportunity to examine migration patterns big skate. As of May 2005, 549 tagged skate have been recaptured with reliable recovery location information. Generally, big skate were recaptured close to their release site, within 20

km. Approximately 18% of the recapture big skate had moved between 20-100 km from their release location. Some big skate (5 % of those recaptured) moved between the two main fishing areas (i.e. >100 km). Most surprising are the five extensive migrations (>1000 km) that have been observed. One big skate released in March 2003 in Dixon Entrance, was recaptured in the Bering Sea, just north of the Aleutian Chain, in November 2004. Two big skate released in August 2003 in Queen Charlotte Sound, were recaptured in April 2004 in Prince William Sound. An additional 2 big skate released in August 2003 in Queen Charlotte Sound, were recaptured in April and May 2005 in Prince William Sound and near Kodiak Island , respectively. Although 76% of recaptured big skate were recovered very close to their release location, the movement of the remaining 24% illustrates that big skate migration may be more complex than previously thought.

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**MCGRATH, PATRICK E.**

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Preliminary stomach content analysis of Longnose Gar within the tidal waters of Virginian rivers

Longnose Gar (*Lepisosteus osseus*) is one of six gar species residing in North America. It is a common predator residing within all of the major Virginian rivers extending from fresh to mesohaline waters. Forty-four longnose gar were opportunistically collected in the tidal stretches of seven different rivers in Virginia in order to examine their stomach contents. Longnose Gar were found to be dominantly piscivorous and most of the fishes consumed were juveniles. Menhaden was the most important prey item and accounted for 46% by weight and 35% by number of all identifiable prey. White perch was the next most important prey item, accounting for 44% by weight and 15% by number of identifiable prey items. Both species also occurred in at least one third of all stomachs containing prey items. Other important game-fish consumed were spot, croaker, catfish, American shad, and weakfish.

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**\*MCMEANS, BAILEY; HIGGINBOTHAM, DAVID; BECHTOL, WILLIAM; FISK, AARON**

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Essential and non-essential element concentrations in polar sharks

Certain elements/metals, which are often toxic and known to biomagnify (e.g., mercury, cadmium), have raised increasing concern in the Arctic, and for large predatory fish. Past studies on element concentrations in the Arctic have focused on marine mammals and seabirds, but element concentrations for the only two shark species known to regularly inhabit Arctic waters have never been reported. Twenty-

five essential and non-essential elements were analyzed in liver tissue of Greenland sharks (*Somniosus microcephalus*), collected about Cumberland Sound in the Canadian Arctic, and Pacific sleeper sharks (*Somniosus pacificus*), collected about Prince William Sound in Alaska, to assess the influence of Arctic region on element concentration. Univariate and multivariate statistics were used to assess both absolute concentrations and patterns of elements. The two shark species were assumed to have similar physiologies, and were combined in the analysis to help elucidate geographical exposure differences. Zn had the highest absolute concentrations of all samples, followed by As, Cd, Cu, Se, and Rb. Mean concentrations of hepatic Hg and Cd were higher in the polar sharks than for other previously reported Arctic fishes, but were lower than concentrations in other shark species that inhabit more southern latitudes. Of the non-essential elements, As, Ag, Cd, Hg, and Rb were significantly different between locations, and all but Rb were higher in Cumberland Sound than Prince William Sound, which could suggest geographical exposure differences, but could also be related to species differences (e.g., diet). Concerning the essential elements, Mo and Se did not significantly differ between locations, but Co, Cu, Mn, Zn did vary between locations, which may indicate different physiological requirements between the Greenland and Pacific sleeper sharks. Essential elements are likely regulated to maintain necessary concentrations, and could therefore be useful in drawing conclusions about an organism's physiology.

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**\*MCNEIL, SHAUN M.; MOSS, TYLER J; STEPHEN, CATHERINE L.**  
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### Milking a data set: Phylogeography of *Lampropeltis* and population history of the Utah Milksnake

Milksnakes and kingsnakes (genus *Lampropeltis*) are found throughout the United States, Mexico, Central America, and parts of South America. The range of *L. triangulum* is the broadest, overlapping the ranges of most of its congeners. The central range of one subspecies, *L. triangulum taylori* is northern Utah, which has had dramatic geologic changes in the recent past. The Stansbury mountain range in northwestern Utah was an island at the time of Lake Bonneville, 23,000 years ago. Thus, this milksnake population has potentially been isolated from other populations of *L. t. taylori* for many thousands of generations. In fact, some individuals of *L. t. taylori* within the Stansbury population vary substantially from the holotype description. On a broader scale, the interspecific evolutionary relationships and biogeographic history of *Lampropeltis* remain unclear. The traditional use of morphological characteristics and more recent molecular work has failed to yield one strongly supported phylogeny of *Lampropeltis* relationships. This study focuses on two aspects of milksnake history 1) the relationships between populations of *L. t. taylori* in Utah and 2) the particular placement of *L. triangulum* within the genus. Morphological data was collected from 40 individuals of *L. t. taylori* (from 9 hydrological units) and DNA was extracted from samples of *L. t. taylori*, *L. t. celaenops*, *L. t. multistrata*, and *L. alterna*. Individuals were sequenced at the nuclear

DNA locus Ornithine Dehydrogenase (OD, 565 bp) and the mtDNA locus NADH Dehydrogenase subunit 4 to Leucine tRNA (ND4, 806 bp). Sequences of the ND4 locus were combined with data available on Genbank for analyses. DNA sequence and morphological data were used to explore how geologic events in Utah have shaped the current distribution of *L. t. taylori*, as well as the broader phylogeographic history of *Lampropeltis*.

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The utility of instream vs. landscape-level data in predictive ecological niche modeling analyses

Predictive ecological niche modeling [ENM] analyses, in which niche models are developed and used to predict species distributions, have a variety of applications from understanding species distributions, to predicting the potential distribution of invasive species, to establishing areas of conservation priority for threatened and endangered species. Conducting ENM analyses in aquatic systems can be challenging because of the lack of broadly-applicable, instream environmental data sets. One way to address this challenge is to use landscape-level variables, instead of instream data, though this limits the biological interpretability of the resulting models. Though accurate predictive models based on landscape-level data have been developed, the question remains whether models could be improved with the inclusion of instream variables. I will present the results of ENM analyses for stream fishes in Kansas using an instream data set based on water quality monitoring data from the Kansas Department of Health and Environment. Predictive models were developed using DesktopGARP and MaxEnt, both machine-learning approaches. These results will be compared to models developed using landscape-level variables alone. The relative utility of these datasets will be discussed.

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Age and growth estimates of four species of northwest Atlantic skate (Family Rajidae) on the eastern Scotian Shelf

Little is known about the life histories of the most common species of skate (Family Rajidae) inhabiting waters off the coast of Atlantic Canada. Recent declines in numbers of all species, and a subsequent consideration of the winter skate (*Leucoraja ocellata*) on the eastern Scotian Shelf (ESS) for listing under Canada's Species at Risk Act, have heightened the need for validated age and growth estimates in this region. Winter skate, little skate (*Leucoraja erinacea*), thorny skate (*Amblyraja radiata*), and smooth skate (*Malacoraja senta*) were collected seasonally from the eastern Scotian Shelf on research vessel surveys and aboard commercial vessels from July of 2004 to

March of 2006. Vertebral band counts taken from digitally photographed vertebral sections of 100 skate of each species, ranging in size from embryonic to mature, were used to estimate length-at-age, growth, and longevity. Mark-recapture of chemically-tagged wild skates, captive rearing of skates within the laboratory, and a marginal increment analysis were undertaken to validate the age interpretations. Age-bias plots and the coefficient of variation indicated that band counts represent a reproducible method for estimating age in all four species, particularly in winter and thorny skate. Relative growth rate was found to be inversely related to species' longevity. Growth increment deposition in other structures with calcium phosphate deposits, such as caudal and dorsal thorns, was also examined using both recaptured and laboratory-reared fish. Results indicate that skates on the ESS exhibit age and growth characteristics known to increase species' susceptibility to extirpation, with certain species (such as the smooth and little skate) exhibiting greater resiliencies to exploitation based on life history theory.

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**\*MCRAE, MARK G.; FITZSIMONS, J. MICHAEL**

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#### Seaward migration in larval *Lentipes concolor*, Hawaii's waterfall-climbing goby: spatial patterns and conservation implications

Indigenous stream fishes in Hawai'i are limited to four species of gobies and an eleotrid. All have an amphidromous life cycle in which adults spawn in fresh or brackish water and larvae undergo two migrations. One migration occurs when newly hatched larvae are swept downstream into the sea. The second occurs months later when the fishes, still in the larval stage, return to estuaries and streams. When returning to fresh water, fish of one species, *Lentipes concolor*, typically migrate farther inland and above higher waterfalls than the other stream species. However, larvae of these fish have a correspondingly longer distance to travel during seaward migration. My research explored the hypothesis that the larvae of *L. concolor* living in the headwaters of large streams have a greater mortality during downstream migration than conspecifics living in smaller streams with spawning sites nearer the ocean. The implication is that large numbers of *L. concolor* located well inland in large streams may include fish residing in sink habitats in which most offspring die en route to joining the offshore pool of larvae that could potentially recruit back into streams. In contrast, small streams with fewer numbers of adults located near stream mouths may serve as source habitats from which more larvae successfully reach the ocean and eventually return to one or more streams. In the context of successfully completing the life cycle, results indicate that the quality of a stream habitat for *L. concolor* may not be correlated to adult population densities but rather on how far from the ocean that population is located.

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**MEIER, PAUL T.**

Muhlenberg College, Biology Department, Allentown, PA, 18104, USA

## Effects of female choice of mate and breeding pond on progeny performance in wood frogs

Female wood frogs exhibit high fidelity to their natal pond for breeding, and also prefer large males as mates. I used a controlled mating experiment to determine the effect of male mating status and pond origin on larval traits in wood frogs *Rana sylvatica*. Females were crossed with four categories of sires: their natural mate, the natural mate of a female from the same pond, the natural mate of a female from another pond, and an unmated male captured from the same pond as the female. Resulting progeny were raised under three conditions: individually in the laboratory under either high or low food conditions, and as sire-category groups in enclosures within the natural pond of the female. In the laboratory, tadpoles grew at significantly different rates among sire categories at both high and low food levels, but there were no differences in tadpole survival rates. In the pond enclosures, tadpoles survived and grew at significantly different rates among sire categories. Thus choice of mate and pond for breeding by a female could affect her reproductive success

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## MELO, MARCELO R. S.

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## A revision of the genus *Kali* (Acanthomorpha: Chiasmodontidae), with emphasis on dentition characteristics

The genus *Kali* is composed of five valid and one undescribed species of pelagic deep-water fishes, widespread in all of the world's oceans up to 3,500 meters. The monophyly of *Kali* has never been demonstrated and usually two characteristics are referred to diagnose it, the Gargaropteron larval stage, and presence of enlarged fang-like teeth. However, the Gargaropteron stage is also found in *Dysalotus*, and *K. parri* lacks enlarged fangs. Dentition pattern was found to be useful on diagnosing *Kali*, at genus and species level. The dentition in *Kali* is composed of a biserial row of teeth on the dentary and premaxillary bones, and a single row on the palatine bone. All teeth have a type 4 tooth attachment, i.e. the anterior border is free, and the posterior border has a collagen attachment to the bone that works as a hinge. Teeth of palatine and external series of both premaxillary and dentary are straight or curved canines with an elongate base, which lies on a crest of bone surrounded by an anterior and a posterior fossa. A collagen attachment is positioned on the posterior fossa, allowing them to bend dorsally; this kind of attachment is also found in all other chiasmodontid genera. Teeth of the internal series of dentary and premaxillary have a unique configuration, they are S-shaped and have an enlarged and rounded base. The collagen attachment is also located on the posterior fossa, but instead of the anterior fossa, there is an enlarged area of contact between the bone and the rounded teeth base anteriorly, which allows each tooth not only to bend backwards, but also

to rotate about 200° around its own axis. The species of *Kali* can be distinguished from each other by the combination of teeth characteristics, such as number, shape and size of teeth.

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**\*MELVILLE, JANE; SADLIER, ROSS; DOUGHTY, PAUL; ROSE, REBECCA J.; SHOO, LUKE; AUSTIN, JEREMY J.**

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Species diversification in desert environments: Phylogeography of the earless dragons, Genus *Tympanocryptis* (Agamidae), from the Australian arid-zone

Eighty percent of Australia is desert or semi-arid, of which stony 'gibber' or cracking-soil plains constitute the largest areas. These plains, with biogeographic histories dating back to the Miocene, form vast landscapes across Australia's interior. Despite the harsh environment of these plains, there is a diverse reptilian fauna that includes the agamid genus *Tympanocryptis*. The eight small, squat species of *Tympanocryptis* inhabit these open arid and semi-arid regions, providing an interesting study of the patterns of species diversification across seemingly continuous desert environments. In such continuous landscapes it may be expected that there would be relatively low levels of genetic structuring within species with extensive geographic distributions. To add weight to this hypothesis, there are ongoing problems with identifying species boundaries within *Tympanocryptis*, where numerous species are very similar morphologically. Thus, we have undertaken a phylogeographic study of *Tympanocryptis* to examine species diversification across these desert landscapes. We focused on two species in particular, *T. tetraporaphora* and *T. cephalus*, which have caused much confusion. *Tympanocryptis tetraporaphora* occurs on the cracking soil plains of arid and semi-arid regions of eastern Australia and shows great morphological affinity to *T. lineata*, which occurs in similar habitats. *Tympanocryptis cephalus*, on the other hand, is a pebble mimic that occurs in the 'gibber' deserts and appears to have a number of morphologically distinct forms in Western Australia, which may be evolutionarily separate lineages. In addition, it is unclear whether *T. cephalus* populations identified from other regions are the same species as those from Western Australia. We sequenced an 1800bp region of mtDNA for >80 individuals of both *T. tetraporaphora* and *T. cephalus*, plus population-level sequencing across the entire genus. We will be presenting results from this phylogeographic study of *Tympanocryptis* and discussing the patterns of species diversification across these desert landscapes.

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**MENDELSON, JOSEPH R., III**

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The scope and scale of emergency conservation efforts for global amphibians.

Since 1989, the herpetology community has been grappling with the reality and extent of a perceived amphibian crisis. Since that time, significant research efforts have verified that the declines and extinctions are real and widespread, and further efforts have identified a series of causal mechanisms. Recent realization is that we are facing a biodiversity crisis that is evidently beyond human experience. Continued research is crucial to stemming any further extinctions, but it must be acknowledged that continued reliance on traditional conservation measures limited to habitat protection and control of trade will be insufficient to save significant numbers of species of amphibians.

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Latitudinal variation in stress responsiveness in anurans

Tropical vertebrates generally exhibit a different suite of life history traits from their temperate counterparts. Additionally, there are physiological traits that also exhibit a latitudinal cline. For example, tropical birds and mammals have long been documented as having lower basal metabolic rates than temperate counterparts. Basal testosterone (T) and corticosterone (CORT) levels have also been shown to be lower in tropical vs. temperate birds. It is hypothesized that, due to the high parasite load in the tropics, tropical species would maintain low levels of hormones that might act in an immunosuppressive manner (e.g. CORT and T). In a survey of existing metabolic literature on anurans, we found that tropical frogs and toads (38 species, 8 families) also exhibit significantly lower standard metabolic rates than temperate species (47 species, 7 families). In a previous field study, we also found that the tropical (i.e. from La Selva, Costa Rica: 10°N) anurans sampled (n=5 species, 4 families) displayed significantly lower baseline CORT levels than their temperate (i.e. Alabama, US 32°N) counterparts (5 species, 3 families). None of the tropical species sampled exhibited a significant increase in B in response to the ACTH challenge (n=4 species, 3 families), while the same challenge significantly increased CORT in all the temperate species. In the present study, we collected anurans (6 species, 3 families) from Botucatu, Brazil, a site just north of the Tropic of Capricorn (22°S) and compared the same baseline and maximum CORT measures from this intermediate latitude locale. Results will be compared from those of previous surveys.

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Spatial ecology of male cottonmouth snakes (*Agkistrodon piscivorus*) at the northern edge of their range

Radiotelemetry was used to examine the spatial ecology of male cottonmouth snakes (*Agkistrodon piscivorus*) in southwestern Missouri. Habitat use, thermoregulation, and movement patterns of eleven males were analyzed. Movement patterns and home range size of males were significantly larger than both gravid and non-gravid females from the same site. Use of old field non-riparian grassland during a large portion of the activity season, extended movement away from water sources and home ranges larger than those previously reported for the species could be the result of prey availability and gender specific prey use.

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Olfactory responses of the clearnose skate, *Raja eglanteria*

Elasmobranchs are reputed to possess extremely sensitive olfactory capabilities despite a relative paucity of empirical evidence. Olfaction has been demonstrated to play an important role for elasmobranchs in the localization of prey, and amino acids in particular are known to be effective odorants. Whereas the responses to amino acids have been examined for stingrays, carcharhinid and sphyrenid sharks, the olfactory capabilities of the most speciose elasmobranch order, Rajiformes, remain unexplored. We employed an electro-olfactogram (EOG) technique to assay a suite of twenty proteinogenic amino acids to determine which elicited the greatest magnitude responses from the clearnose skate, *Raja eglanteria*. The largest responses were elicited by, in decreasing order, cysteine, glutamic acid, lysine, and aspartic acid. These four amino acids were subsequently assayed at decreasing concentrations to determine the threshold sensitivity of the skate, which is between  $10^{-4}$  and  $10^{-6}$  M. A greater stimulant concentration is required to elicit a response from the skates compared to other elasmobranchs that demonstrate thresholds of approximately  $10^{-7}$  to  $10^{-8}$  M. The relatively poor performance of *R. eglanteria* may indicate that olfaction is not of premiere importance as a sensory modality for this species. An unusual phenomenon was observed in which sixteen of the twenty amino acids elicited a positive deflection in the EOG trace. This may be due to an influx of negatively charged ions across the olfactory epithelium resulting in a net accumulation of positively charged ions within the olfactory capsule. The only amino acids that generated the typical negative deflection in the EOG trace were cysteine, arginine, and lysine. This study provides the first electrophysiological examination of the olfactory capabilities of skates making *R. eglanteria* only the fourth elasmobranch species to be empirically tested.

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Population status and behavior of a threatened wild population of *Atelopus* sp. from southeastern Ecuador

On August 2003, a new remnant population of an undescribed species of *Atelopus* was found close to Limón city, Morona Santiago Province, Southeastern Andes slopes from Ecuador, at 1100 masl. *Atelopus* is one of the most affected genera by the global amphibian population extinction process. A systematic monitoring program was carried out between November 2004 and December 2005. Population structure and dynamic, ethological, and environmental data were collected. 12 transects (100x2.5m) along the stream, and 18 transects (50x5m) in the creek slopes, were set up and were surveyed during 15 days per month. Behaviors were recorded by direct observation (approximately 100 hours per month). 219 individuals were captured and photo-identified by their dorsal patterns. 175 males, 32 females, and 12 juveniles were recorded (including 14 amplexant pairs). The presence of females, close to the stream, was seasonal. 49 tadpoles were recorded under rocks into the stream in the period from June to November. Every behavior (moving, feeding, calling, amplexus) was recorded during 1366 hours (males 1084, females 92, amplexus 190). The calls of males were described and associated to their ethological context. Several abnormal movements were recorded, and were linked to chytridiomycosis, a fungal lethal sickness caused by *Batrachochytrium dendrobatidis*. The fungus was identified by skin scraping microscopy. Using standard methodologies it was isolated, and a culture stock was stored. Presence of 25 individuals (22 males and 3 females) affected by the chytrid fungus, scarcity of tadpole and juvenile stages is a red flag that indicates the critically endangered status of one of the few remaining species of extant Ecuadorian *Atelopus*. Urgent and innovative conservation strategies must be applied. The Pontificia Universidad Católica del Ecuador has started the *ex situ* management and conservation of endangered amphibian species.

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Systematics of *Sceloporus aeneus*, *S. subniger* and *S. bicanthalis*

*Sceloporus scalaris* group is conformed by *S. chaneyi*, *S. goldmani* and *S. scalaris*, and three formerly subspecies of *S. aeneus*: *S. aeneus*, *S. subniger* (oviparous) and *S. bicanthalis* (viviparous). Nowadays, these subspecies are considered species, although there is no evidence to support *S. subniger* as a species. We included in a phylogenetic analysis (maximum parsimony and bayesian methods) haplotypes (fragment of ND4 and RNA<sup>Leu Hist Ser</sup>) of several populations of those three species to evaluate *S. subniger* taxonomic status and phylogentic relationships among these three taxa. *S.*

*scalaris*, *S. jalapae* and *S. occidentalis* were chosen as outgroups. According to this analysis *S. aeneus*, *S. subniger* and *S. bicanthalis* constitute a monophyletic clade. *S. bicanthalis* is monophyletic while *S. aeneus* from the type locality (Tres Picos) form a clade with haplotypes from Ajusco, previously considered *S. subniger*. Finally, *S. subniger* is paraphyletic with respect to *S. bicanthalis* and to *S. aeneus*. *S. aeneus*, *S. subniger* and *S. bicanthalis* could be considered a single species, however, *S. bicanthalis* should maintain the specific status, due to its viviparity. Therefore, we suggest that all oviparous populations represent a single paraphyletic species. According to the principle of priority *Sceloporus aeneus* Wiegmann 1928 should be the correct name for all populations, except those from *S. bicanthalis*.

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### **MICANCIN, JONATHAN**

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#### Background noise as a potential constraint on interspecific mate discrimination and reproductive isolation in cricket frogs

It can be challenging to determine whether communication differences between closely related species arose in allopatry or sympatry. In some instances, selection on a morphological trait like size also alters mate recognition systems (the signals used in reproduction and the sensory mechanisms to receive them). The history of differences in mate recognition systems is further obscured by the conflict between species recognition and mate quality recognition when high-quality conspecifics resemble heterospecifics and because background noise limits the ability of females in intraspecific mate choice discriminations. Background noise may similarly limit interspecific mate choice decisions. Further investigation is necessary to determine if background noise causes females to alter acoustic preferences to avoid heterospecific males that resemble high-quality conspecific males. For my dissertation, I am examining the cricket frogs *Acris crepitans* and *A. gryllus* where their ranges overlap in North Carolina to test the hypothesis that species differences in mating signals are masked by background noise and females alter preferences in sympatry to minimize heterospecific contact. I have recorded and collected 461 calling males at 31 sites, identified a broad area of overlap across North Carolina, and found the species in syntopy at two parks in the middle of the Coastal Plain. Preliminary analysis of recordings from one syntopic site indicates that there are significant differences in the dominant frequencies of the two species but no difference in snout-vent length. Because the frequency of a cricket frog's call is correlated with body size, this result suggests that syntopic cricket frogs have evolved differences in their vocalizations specifically to avoid interbreeding. I am currently completing acoustic analysis of the remainder of my recordings and constructing synthetic calls of cricket frogs with and without background noise for use in experiments on female choice to be conducted in summer, 2006.

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**MICKLE, PAUL F**

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Life history and habitat use of the Alabama shad, *Alosa alabamae* in the Pascagoula river basin

Information about the life history of the Alabama shad, *Alosa alabamae* and its presence along the Gulf of Mexico coast is limited. Although the species is not currently listed, it is a candidate species and projects are currently underway to conduct stock assessments within the rivers where they reproduce. This anadromous fish enters central gulf drainages in the spring to spawn. The Pascagoula drainage is unique in that it is the only undammed major waterway in the lower forty-eight states. First year Alabama shad have been caught in summer holding areas of both of the two major tributaries of the basin. These two rivers greatly differ regarding flow rates and flood plain area, and the juveniles there demonstrate significant difference in growth rate. The abundance of productive habitat may be a contributing factor to the weight and overall success of young of the year Alabama shad. A logistic regression model successfully classified 76.3% of the samples as presence/ absence. After habitat parameters have been adequately characterized, conservation recommendations toward critical habitat may be suggested. Understanding the life stages of the Alabama shad and its habitat use in the river will provide crucial information toward its conservation.

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Herpetofaunal use of golf courses as refugia in an urban landscape

The Rouge River Watershed, located in Southeast Michigan, is a major tributary of the Detroit River and has a drainage area of over 1,110 square kilometers. This area has suffered over 100 years of environmental abuse. Only an estimated 4% of the original wetlands and 7% of the woodlands remain intact within the watershed, and these areas are highly fragmented. An intense, year-long herpetofaunal survey was conducted along nearly ten kilometers of the river's floodplain to determine amphibian and reptile species presence and distribution. Wetland and woodland communities were monitored from early spring to late fall and mapped using Geographic Information Systems (GIS) and Global Positioning System (GPS) technology. Surveying methods included use of artificial cover objects, funnel traps, dip netting, visual encounters and calling surveys. In total, 11 reptile and 7 amphibian species were recorded. Results of this study revealed significant clustering of the area's remaining reptile and amphibian inhabitants on and near local golf courses. These areas contained the most diverse wetland habitats and also provided critical upland habitats required by many amphibians and reptiles. The wetlands

with the greatest duration of seasonal inundation were positively correlated with increased herpetofaunal species diversity. However, wetlands with permanent water that supported predatory fish had lower amphibian diversity. The United States has over 15,800 golf courses, more than 850 of which are located in Michigan. The average golf course ranges from 50 to 60 hectares in size, 25-40% of which is comprised of non-playing areas (or rough). This study has revealed that, if managed correctly, golf courses can provide critical sanctuaries for urban herpetofaunal populations and may serve as sources for dispersal to adjacent habitats.

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**\*MILLER, DEBRA L.; GRAY, MATTHEW J.; RAJEEV, SREEKUMARI;  
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### Influences of cattle on pathogen prevalence in larval amphibians

Anthropogenic stressors are hypothesized to be the driving force behind worldwide amphibian declines. One possible stressor of amphibians that has received minimal attention is cattle grazing in temperate wetlands. In particular, cattle may change the aquatic environment such that resident larval amphibians become stressed, resulting in compromised immunity and increased susceptibility to infection by endemic pathogens. A natural experimental design exists at the University of Tennessee Plateau Research and Education Center, where wetlands in close proximity to one another (<2 km maximum separation) have been exposed to cattle grazing for >10 years, while others have never had direct cattle access. Therefore, we tested for a difference in prevalence of two pathogens known to be associated with amphibian die-offs (frog virus 3 [FV3] and *Aeromonas hydrophila*) between tadpoles in cattle-access and non-access wetlands. Tadpoles were collected for two species (American bullfrog, *Rana catesbeiana*; green frog, *Rana clamitans*) during three seasons (winter, summer and fall) in 2005, humanely euthanized, and tested for these pathogens using standard viral and microbial isolation techniques. Green frog tadpoles were 3.9X more likely ( $P=0.02$ ) to be infected with FV3 in cattle-access wetlands than in non-access wetlands. There also was a strong seasonal effect ( $P<0.02$ ) in FV3 prevalence for both tadpole species. Prevalence of FV3 was greater in winter than in summer and fall for bullfrog tadpoles, and greater in fall than in summer for green frog tadpoles. Bullfrog tadpoles were 45X more likely ( $P=0.03$ ) to be infected with *A. hydrophila* in cattle-access wetlands than in non-access wetlands during fall. Also, prevalence of *A. hydrophila* was greater ( $P=0.04$ ) in fall than in summer for green frog tadpoles. Our results suggest that cattle use of wetlands may potentiate pathogen prevalence in tadpoles, especially during fall and winter, yet this effect may be species dependent.

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### Broad scale investigation of the effect of non-native species on North American fish assemblages

Species introductions have become a growing threat to freshwater ecosystems in the United States. Such threats include predation, increased competition, habitat modification, and hybridization, all of which have the potential to reduce native populations. Despite these potentially deleterious effects, little attention has been given to the impacts of non-native fish introductions on freshwater communities across a broad geographic range. The purpose of this research is to determine whether the presence of non-native species is correlated with variation in measures of diversity in North American freshwater fish assemblages. Fish abundance data from 814 streams in North America (available from the United States Geological Survey National Water Quality Assessment program) were used to calculate measures of evenness, species richness, and diversity at each locality. Differences in these measures were then compared between sites with native assemblages and sites that contained non-native species. Results show no significant difference between native richness of invaded and native communities. However, native communities had significantly higher evenness, but lower community diversity. The number of non-native species and individuals were both negatively correlated with native species richness, yet positively correlated with evenness. Life history traits of the non-native species were found to be significantly correlated with community diversity. Native species diversity and richness were significantly higher in communities without piscivorous non-native species, while evenness increased at these sites. Such results suggest non-native species are reducing native species richness and diversity in freshwater communities across a wide geographic range. These findings help to form more accurate, broad generalizations concerning the effects of non-native species in freshwater communities.

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### **MITCHELL, KERRI E.**

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### The effects of recreational golfing facilities on terrestrial biodiversity

The current trend toward environmental awareness in the general population of industrialized countries has affected the construction of recreational facilities. Golf courses were not previously at the forefront of the eco-friendly revolution based on their inherent vegetative properties; however, many new or renovated courses are marketed under the auspice of being wildlife friendly. In countries with a long history of golf, such as Great Britain, the total land area utilized for golf is equivalent to and may exceed that of total protected reserve area. The objective of this study is to examine the biodiversity of birds, mammals, Orthoptera, and herpetofauna within and around Apache Mesa Golf Course, Holloman, New Mexico, USA. A common lizard species, *Uta stansburiana*, will be PIT tagged to examine the effects of year

round water availability and subsequent higher insect densities on lizard foraging behavior. This preliminary plan of research is being presented for feedback from the collective intelligence of the attendees.

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Phylogeny of *Bothrops*, *Bothriopsis*, and *Bothrocophias* species from morphological data (Serpentes: Viperidae: Crotalinae)

Monophyly of the South American pitviper clade (consisting of the genera *Bothrops*, *Bothriopsis*, and *Bothrocophias*) has been supported by several morphological and molecular studies. Relationships among the species in these genera had been examined, but not in a taxonomically comprehensive manner. In addition, morphological data had been lacking for many species. I conducted parsimony and Bayesian analyses of all species in the South American pitviper clade for a total of 49 OTUs. The analyses were based on 89 characters from scales, color pattern, hemipenes, crania, and vertebrae. I tested the monophyly of *Bothriopsis* and *Bothrocophias* and investigated the paraphyly of *Bothrops*. Preliminary results from parsimony analysis of 60 scale and hemipene characters suggest the presence of a basal *Bothrocophias* group, a *neuwiedi* group, and an *atrox* group with a *Bothriopsis* group nested inside. The recovered relationships are generally consistent with the most recent molecular trees from Parkinson (2002), Wüster (2002) and Castoe and Parkinson (in press) as well as morphological trees from Gutberlet and Harvey (2002). By using morphological characters, the present analysis has allowed the inclusion of 14 additional taxa, complementing these previous studies.

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Leaping lizards! The biogeography of herpetofaunal communities on the Mississippi Gulf Islands

In spring 2004, we began field surveys to quantify the species composition of herpetofaunal communities in the Mississippi units of Gulf Islands National Seashore. Five barrier islands stretch across the Mississippi coastline and are located between 10 and 16 kilometers offshore. The amphibian and reptile populations on these islands are subject to a wide range of physical stressors (heat, wind, salt spray, limited fresh water) and large-scale disturbance events, including hurricanes. These dynamic coastal islands offer a unique opportunity to examine changes in the herpetofaunal communities within the context of classical island biogeography theory. The islands' close proximity to the mainland facilitates frequent colonization and re-colonization, unlike distant oceanic islands. Hurricane Katrina directly struck

our study sites in August 29, 2005. Afterward, we examined the effects of this major hurricane on island herpetofaunal populations specifically in regards to colonization, re-colonization, and local extinction.

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**\*MONTAÑA, CARMEN G. ; LAYMAN, C.A; TAPHORN, D.C.**

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Fish assemblages in morichal (*Mauritia flexuosa*) habitats of a neotropical stream

Morichales, habitat types dominated by the moriche palm (*Mauritia flexuosa*), are important habitat for aquatic organisms in Neotropical freshwaters. We described fish assemblage composition of morichales in Cano La Guardia during two months of the dry season (February and March 2005) to document the extent to which organisms utilize this habitat type. Small-bodied fishes, characterized by diverse trophic and life history strategies (< 100 mm), were abundant. Fish assemblages of morichales differed significantly from those sampled on sandy beaches or rocky habitats in the river. We discuss how particular characteristics of morichales, especially their high degree of habitat heterogeneity, contribute their value as habitat, and suggest that these habitats warrants further study in Neotropical freshwaters.

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Ethoxyresorufin-O-deethylase (EROD) activity in bonnethead sharks (*Sphyrna tiburo*) and their relationship with infertility

Exposure to some cytochrome P450A (CYP1A)-inducing pollutants, such as polycyclic aromatic hydrocarbons (PAHs) and compounds present in pulp mill effluent, has been associated with reductions in circulating estrogen concentrations and vitellogenin production in females of certain fish species during the period of follicular development. These effects may lead to reductions in yolk quality and fertility that, in turn, reduce population growth and stability. In this study, we explored whether exposure to CYP1A-inducing pollutants may be associated with high rates of infertility in certain Florida populations of the bonnethead shark (*Sphyrna tiburo*), which exhibit evidence of hormonal alterations in females during oocyte development. Exposure to CYP1A-inducing compounds was evaluated by measuring hepatic ethoxyresorufin-O-deethylase (EROD) activity in bonnethead sharks obtained from 2 Atlantic and 5 Gulf populations, including 1 population with low infertility rate (Florida Bay) and at least 3 sites that are known experience

comparatively high rates of reproductive failure (Apalachicola Bay, Tampa Bay, Charlotte Harbor). Prior to this, EROD activity was measured in sharks exposed to a known CYP1A inducer, -naphthoflavone (BNF), and compared with that in control animals to validate use of this procedure. Animals treated with BNF experienced nearly a 7-fold increase in hepatic EROD activity compared with control animals, supporting use of this technique. However, EROD activity was low in sharks from Florida estuaries, suggesting that exposure to CYP1A-inducing compounds may not be linked with infertility in this species. In general, hepatic EROD activity was substantially greater in Atlantic sharks in comparison with their Gulf counterparts. Therefore, these populations appear to experience greater risks from the physiological effects of CYP1A-inducing pollutants.

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Food availability affects energy allocation between growth and reproduction in timber rattlesnakes, *Crotalus horridus*

Organisms allocate energy to competing functions of growth, maintenance, reproduction, and storage based on genetically determined allocation rules and environmental conditions. The goal of our study was to better understand the effect of food availability on the allocation of energy to growth and reproduction in adult female timber rattlesnakes (*Crotalus horridus*). Based on bioenergetics modeling, we predicted that allocation of energy to growth in mature females should not exceed 3% of the individual's energy budget. We also expected variation in litter size to occur as a result of resource availability to females during the pre-ovulation (vitellogenic) stages of the reproductive cycle. An increase of available energy should induce an increase in offspring number, and/or offspring size. There are numerous ways that reproductive effort may respond to variation in resource input (e.g., in a high food intake treatment we would expect the number and size of offspring to increase). Mature female timber rattlesnakes were manipulated in the laboratory to test the role of mass-energy availability in determining reproductive effort. Females were divided randomly into three feeding regimes, which produced variation in available energy for growth and reproduction. Rations in the three treatments were based on multiples of standard metabolic rate for individual snakes, where low food was 6-times estimated SMR, medium food was 8-times SMR and high food was 12-times SMR. For each snake, we calculated the total energy available for biomass production (kJ), by subtracting total energy lost to maintenance, cost of digestion, feces, and uric acid, from total energy consumed. We found that food availability did not affect the relative allocation of mass and energy to growth; snakes feeding at different levels allocated a relatively fixed proportion of available production energy to growth. Understanding interactions between resource availability and patterns of reproductive effort is required for accurate life-history modeling.

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### Effects of amphibian decline on a mid elevation tropical snake community

Anuran eggs, tadpoles, and adults are well-documented sources of food for snakes, especially in the tropics. The loss of all stages of the amphibian life cycle can influence the diversity and abundance of the local predator community. In the tropics, where amphibian eggs, larvae, and adults represent a large proportion of available prey, massive losses of amphibian biomass would be expected to affect populations of frog-eating specialists and generalists, such as many snakes in the region. During the fall of 2004 the amphibian community of Omar Torrijos National Park (OTNP), Coclé Province, Panama crashed due to a *Batrachochytrium dendrobatidis* epizootic. Approximately 80% of the total amphibian biomass was lost over the course of four months. From May, 2003 to November, 2005 we conducted visual encounter surveys along forest and stream transects to determine the abundance and diversity of snakes in OTNP. The snake community showed a significant shift in relative abundance among the five most common species across the year following decline ( $X^2 = 18.54$ ;  $df = 4$ ,  $p < 0.001$ ), with predominantly frog and frog egg consumers declining and predominantly lizard consumers increasing. *Sibon annulatus*, *S. longifrenis*, and *Leptodeira septentrionalis* decreased in relative abundance (17% to 5%, 14% to 8%, and 6% to 1%, respectively), while *Imantodes cenchoa* and *Oxybelis brevirostris* increased in relative abundance (6% to 24% and 56% to 62%, respectively). There was also a decrease in overall snake diversity, including the loss of a previously common genus, *Rhadinea*.

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### Testing the monophyly of the Gobiinae and Gobionellinae

The subfamily Gobiinae (family Gobiidae) has been defined by a modified oculoscapular canal system with only a single median anterior interorbital pore and a single terminal pair of nasal pores. This proposed monophyletic grouping encompasses well over 80 genera and the majority of gobiid species. Remaining gobiids are grouped together by default, with assemblages of convenience such as the Gobionellinae often being treated implicitly as monophyletic. We present evidence from gill arches, anterior axial skeleton, and posterior cranium that suggests that the gobiines *Exyrias*, *Istigobius*, and *Macrodontogobius* are more closely related to gobionellines such as *Awaous*, *Gnatholepis*, *Oligolepis*, *Oxyurichthys*, and *Stenogobius* than they are to other gobiines. This indicates a broader array of character systems needs to be surveyed outside the constraints of currently recognized gobiid taxa to provide robust hypotheses of their relationships.

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The evolution of high-performance tail muscles in snakes

Rattling by rattlesnakes is one of the fastest vertebrate movements and involves some of the highest contraction frequencies sustained by vertebrate muscle. Specifically, the shaker muscles in the tails of rattlesnakes can sustain contraction frequencies up to 100 Hz for minutes to hours. To study the evolution of these high-performance muscles, we compared the activities of the enzymes citrate synthase (an indicator of aerobic capacity) and lactate dehydrogenase (an indicator of anaerobic capacity) in the tail muscles of rattlesnakes and their relatives. Rattlesnake tail muscles contracted at the highest frequencies and had the highest aerobic capacity, but only moderate anaerobic capacity. In other species that vibrate their tails, contraction frequencies and enzyme activities varied. Copperhead tail muscles had very high aerobic capacity but only moderate contraction frequencies and anaerobic capacity. In contrast, cottonmouth tail muscles had low contraction frequencies and enzyme activities. The tail muscles in colubrid snakes varied widely in contraction frequency and enzyme activity. These results indicate that defensive tail vibration and physiologically specialized tail muscles evolved in diverse lineages of snakes before the rattle evolved. However, it remains unclear whether highly aerobic tail muscles were ancestral or derived in rattlesnakes. We are currently testing whether aerobic capacity is associated with the duration of tail vibration bouts or with the different levels of mechanical energy output that occur with different tail morphologies.

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Is bigger better? The social mating system of tuatara (*Sphenodon punctatus*)

Sexual selection theory predicts that territoriality leads to increased sexual size dimorphism and body size in males and predominantly polygynous mating systems. Tuatara, medium sized, sexually dimorphic reptiles and the sole extant representatives of the Order Sphenodontia, are highly territorial, particularly during the breeding season. On Stephens Island, New Zealand, where the largest population of tuatara remains, we investigated the spatial structure and mating system of these reptiles. From 2005 - 2006 observations were made on individually marked tuatara in three study plots, and behaviors were recorded. Locations were recorded before and during the mating season (November and March) and were plotted in a GIS. Spatial

structure of individuals remained stable over seasons, with the exception of gravid females migrating to and from nesting rookeries. Male territories did not overlap, and sizes did not correlate with morphometric measurements. Female-male territories did overlap, and mating observations confirmed that the mating system is socially promiscuous. Adult males observed mating were significantly larger and heavier than the average adult male. Larger males are therefore more effective at securing territories and winning aggressive interactions, thereby gaining greater access to females. Further research is needed to confirm what is actually driving this system, and whether the genetic mating system reflects the social mating system.

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The capture depth, time and hooked survival rate for bottom longline caught sharks

Over the past year, the Florida Program for Shark Research (FPSR) has been working cooperatively with commercial shark fishers in conducting fishery independent monitoring in the Gulf of Mexico and Atlantic Ocean off the southeastern United States. Bottom longline gear, hook timers and time depth recorders were used to collect data pertaining to the relationship between soak time and capture depth on fishing mortality and catch per unit effort (CPUE) of individual shark species and shark species aggregates. Primary species represented in the catch included the Atlantic sharpnose (*Rhizoprionodon terraenovae*), 36.8% of total catch), nurse (*Ginglymostoma cirratum*, 19.2%), blacknose (*Carcharhinus acronotus*, 16.1%), tiger (*Galeocerdo cuvier*, 10.4%) and blacktip (*Carcharhinus limbatus*, 10.4%) sharks. We report preliminary results related to the length of time the fishing gear was in the water prior to a shark biting and being hooked, and the length of time individual shark species remained alive after being hooked. Initial analyses demonstrate that the majority of sharks bit the hook within the first four hours the hooks were in the water. Sixty percent of the sharks were caught during the first two hours in sets with soak times lasting 0-4 hours or > 8 hours, and 68% of sharks were caught during the first four hours in sets with soak times ranging between 4-8 hours. Tiger and nurse sharks were retrieved alive 100% of the time, while blacknose and blacktip sharks suffered 100% mortality on sets over four hours in length. The latter two species suffered 20% and 0% mortality, respectively, on sets of less than four hours. The Atlantic sharpnose shark also suffered a 100% mortality rate during sets longer than eight hours and 88.9% during sets lasting 4-8 hours, while only a 20% mortality rate occurred on sets of less than four hours.

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Are hatchling snakes of an insular gigantic population large like as in adults?

Insular gigantism in snakes is a well-known phenomenon, and its causation is considered to be associated with the abundance or size of available prey. When snake size is compared among populations, mean or maximum size of adult snakes has been used as an index of the degree of gigantism. Thus, when proximate and ultimate factors are considered, size differences of adult individuals have been the focus. In contrast, body size of hatchling snakes in gigantic populations has not received much attention compared to adult body size. We compared hatchling body size of *Elaphe quadrivirgata* on four insular populations of the Izu Islands, Japan, including a gigantic population on Tadanae Island. Snout-vent length of female hatchlings from Tadanae Island was larger than that from two non-gigantic insular populations, and male hatchlings of Tadanae population were larger than those of only one non-gigantic population. Mean hatchling snout-vent length was not correlated with maternal body mass in any population. Prey handling behavior of ingestively naive hatchlings was compared between Tadanae population and Kozu Island, one of non-gigantic population, using a scincid lizard, *Eumeces latiscutatus*, which is a major prey item of *E. quadrivirgata* on the Izu Islands. Hatchling snakes of Tadanae Island showed more efficient prey handling and were more successful in predation than those of Kozu Island, especially when yearling skinks were provided as prey. This result suggests that large hatchling size of Tadanae population has an advantage in exploiting wide size range of prey, that is, both hatchlings and yearlings of skinks. We presume that large hatchling size of Tadanae population is an adaptation to low availability of small prey, and this "gigantism" of hatchlings may be a phenomenon independent from adaptive significance of gigantism of adult snakes.

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Evolution of advertisement calls in chorus frogs (*Pseudacris*: Hylidae)

Frogs use acoustic signaling to communicate information about species identity and individual fitness. Different components of the call communicate different types of information to potential mates. Previous authors hypothesized that call components that are under physiological or behavioral control should evolve more rapidly than call parameters under morphological control. We employ comparative methods to test this hypothesis using the diversity of advertisement calls found in the genus *Pseudacris*. We examine correlations among call parameters and morphology and discuss evolutionary implications. We include call data for 15 chorus frog species (25 populations) and analyze our data within a phylogenetic framework based on

mitochondrial and nuclear DNA sequence data.

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Age-structure of garter snake populations having two alternate life-histories

Long-term studies of garter snake (*Thamnophis elegans*) populations inhabiting Lassen County, California have revealed two alternate life-history phenotypes in this mountain lake/meadow environment. Lower elevation lakeshore populations are characterized by individuals that grow fast, reproduce early and die young. In contrast, higher elevation meadow populations have the opposite life-history pattern: slow growth, late maturation, and short life. The differences in growth rates are due to genetic differentiation among high and low elevation populations. Here, we present data that test the hypotheses resulting from classic demography predictions that: (1) the age structure of meadow sites is skewed toward older individuals relative to lakeshore sites, and (2) the proportion of individuals within the adult stage (vs. juvenile) is greater in meadow sites. Results are based on skeletochronology techniques applied to individuals sampled from current populations.

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Morphological variation in the electric organ of *Leucoraja erinacea* and its possible role in courtship

Skates are among a small grouping of fish families that have electric organs. Of that limited number of families, skates are one of only ten families that have electric organ discharges (EODs) too weak to be used for defense or predation, and skates may be alone in that grouping in that they do not discharge the organ continuously for electrolocation. Much research, physiological, morphological, and behavioral, has been done on the weakly electric teleosts (e.g., mormyrids and gymnotiforms) that has led to the conclusion that their electric organs serve a communicative purpose during courtship. It follows that skates may have evolved a similar device for a similar function. This research aims to support the notion that the electric organ in skates may play a role in interspecific communications, particularly during courtship. To do so, it is important for us to determine if any sexual or ontogenetic variations exist in their electric organs. Therefore, male (n=30; 20.2 – 50 cm TL) and female (n=45; 25 – 50 cm TL) electric organs of the little skate, *Leucoraja erinacea*, were removed and examined using light-level microscopy and common histological procedures. Mean organ weight, organ length, organ height, electrocyte width, number of electrocytes, number of electrocyte rows, height of electroplate layer, and electrocyte height were correlated with skate mean total length, mass, width, clasper

length (in males), and oviducal gland width (in females). This research will determine whether or not the electric organ varies sexually or ontogenetically in the little skate. Such variation, if detected, will support our hypothesis that the electric organ of skates may play a role in communication during courtship.

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Fine scale variation in defensive behavior in *Taricha*: Is it related to toxicity?

Newts of the genus *Taricha* display an antipredator defensive posture known as the unken reflex. This behavior is characterized by the newt elevating its head and tail, revealing the brightly colored ventral surface. The animal also lifts both the fore- and hindlimbs above the substrate, and in some populations newts will coil the tail in addition to the other aspects of the behavior. This antipredator reflex is variable from locality to locality, even those within close proximity. In order to analyze this variation, operational definitions can be used to give quantitative values to qualitative observations. These definitions help to measure the degree or intensity of each characteristic of the behavior. By scoring the behavior in this fashion there is a standard rubric that can be utilized to help evaluate the differences from one population to another, and even across species within the genus. Another antipredator mechanism that these newts employ is a very toxic skin secretion containing the sodium channel blocker tetrodotoxin. The toxicity of newts also varies between localities and we expect to see a relationship between the differences in behavior and toxicity. We examine *T. torosa* from two ponds from Santa Lucia Preserve, Monterey County, CA and *T. granulosa* from two ponds on Prince of Wales Island, AK for fine scale variation of behavior and correlation with skin toxicity.

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Species-specific patterns of aggressive behavior among larvae of three syntopic species of *Ambystoma* salamanders

Relative size among larval *Ambystoma* is an important determinate of the nature and frequency of aggressive interactions, and recent studies suggest that aggression may depend on larval species as well as larval size. To test this hypothesis directly, we quantified intra- and interspecific nonlethal aggression, predation, and cannibalism occurring among pairs of larval *A. opacum*, *A. jeffersonianum*, and *A. maculatum* in a

laboratory setting. Both larval size and species were shown to be important indicators of agonistic behavior, and distinct patterns of aggression, predation, and cannibalism were evident for the three focal species. Nonlethal aggression was most prevalent among *A. opacum*, and it was directed primarily towards conspecifics; however, this species rarely preyed on con- or heterospecific larvae. Predation was most commonly performed by *A. jeffersonianum*. This species consumed both conspecifics and *A. maculatum*, but cannibalism was observed more frequently than predation on *A. maculatum*. Nonlethal aggression and cannibalism were uncommon among *A. maculatum*, and aggression directed at heterospecific larvae was almost nonexistent. We believe that temporal staggering in the breeding seasons of adult *Ambystoma*, differences in larval morphology, and the risk of pond drying may contribute to the observed differences in larval aggression displayed by these species. The results of our study support previous conclusions regarding the effects of population size structure on aggressive interactions. However, our results also suggest that species composition of a larval assemblage may be as important as size structure when examining the frequency of nonlethal aggression, predation, and cannibalism among larval salamanders.

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#### Hanging on for the ride: Suction disk performance of echeneid fishes

The evolution of functional novelties can result in the occupation of novel niches. One such novelty in the echeneid fishes involves the formation of a laminated adhesive suction disk from the first dorsal fin. This disk is used to attach to marine hosts including elasmobranchs, bony fishes, cetaceans, and sea turtles. This study investigated the anatomy of the suction disk of two species of echeneid fishes, *Echeneis naucrates* (Linnaeus 1758) and *Echeneis neucratoides* (Zuiew 1786) as well as their suction performance on a smooth surface and denticulated shark skin. Disk muscles erect or depress the numerous paired laminae, or toothed plates, which bear two to four rows of posteriorly directed spinules. The erect laminae create a sub-ambient chamber, allowing these fishes to adhere to fish and inanimate objects. Resting sub-ambient suction pressure differentials were recorded followed by greatest sub-ambient pressure differentials as the fish were pulled posteriorly to simulate drag induced by a swimming host. Resting pressure differential averaged -0.5 kPa, with no significant difference between Plexiglas and shark skin surfaces. With a force applied to their caudal peduncle the echeneids generated suction pressure differentials averaging -92.7 kPa within the disk cavity while attached to Plexiglas. On shark skin, the use of spinules increases friction and reduced the maximum sub-ambient suction pressure differential to -46.6 kPa, while requiring considerably more force (17.4 N) to dislodge them as compared to the smooth Plexiglas (11.2 N). The presence of spinules on the laminae apparently increases shear friction and the force necessary for detachment, while reducing the necessity for large sub-ambient pressure differentials.

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Evolution of the anuran nasal capsule: Cutting off the nose to spite the face

The cartilages that form the nasal capsule of frogs typically are complicated and minute, and thus, usually are not included in osteological descriptions. Traditional methods of anatomical examination (i.e., gross dissection) result in an incomplete understanding of nasal structure; thus, the morphologies of only a handful of species have been described. However, comparisons of structures that have been identified to date suggest variability that may reflect functional or phylogenetic importance. Herein, we compare the nasal capsules of several anuran species representing a diversity of anuran taxa (e.g., bombinatorids, pelobatids, pipoids, ranoids, hylids, bufonids) based on cleared-and stained specimens and 3D digital reconstructions of anatomy (from the MorphologyNet digital library: [www.morphologynet.org](http://www.morphologynet.org)). We comment on morphologies that are conserved among groups and those that are highly variable, and discuss the possible functional and phylogenetic implications of our findings.

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**MUELLER, ROBERT F., JR.**

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Relating fish assemblage and abundance variation to substrate composition in the middle Wabash River

We collected fishes at 28 sites of the middle Wabash River using a boat electrofisher and 10 additional sites using a 10 m beach seine, our interest was to test for associations between fish assemblage and substrate composition. Previous experience with Qualitative Habitat Evaluation Index (QHEI) resulted in poor explanation of fish assemblage variation when compared to Index of Biological Integrity (IBI) scores for our boat electrofishing collections. An alternative habitat quantification approach used systematic substrate and depth measurements at multiple locations within each site. We used Canonical Correspondence Analysis to test for fish assemblage variation that was related to substrate variation. Analysis resulted in a strong upstream-downstream gradient in fish assemblages that was related to substrate variation. However results show substrate-fish assemblage patterns differed among June and July collection periods.

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**MULCAHY, DANIEL G.**

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## Phylogeography of nightsnakes (*Hypsiglena*) using a hierarchical approach of mtDNA sequence data: Revisiting the subspecies concept

The subspecies concept has received much criticism, yet this is often the most informative level of investigation for studying speciation. Most subspecies were described based on morphological variation associated geographic areas of wide-ranging species. The variation may be clinal, represent ecological associations, or reflect homologous differentiation. The point of secondary contact is essential for ultimately determining whether speciation has occurred. Either renewed gene flow prevents speciation from happening or divergent lineages remain reproductively isolated. Contemporary systematists aim to identify the type of morphological variation observed, and recognize discrete evolutionary lineages at the specific level, and remove subspecific epithets, thus eliminating trinomials. There are 17 subspecies described for the nightsnake (*Hypsiglena torquata*); 11 are concordant with major biogeographic regions of western North America, the rest are endemic to islands off the coast of Baja California. I collected 850 bp of mtDNA sequence data (nad4 + tRNAs) from 163 individual nightsnakes, encompassing most mainland and two island subspecies, including 4 *Eridiphas*, and additional outgroup taxa. Parsimony, likelihood, and Bayesian analyses identified six major clades within *Hypsiglena*; however the relationships among them were not resolved. Three of the clades are consistent with subspecies (*H. t. jani*, *H. t. torquata*, and *H. t. affinis*) and a fourth represents a previously unrecognized lineage found in the Chihuahuan–Sonoran transition zone (Cochise clade). The two remaining clades are widespread (Coast and Desert clades), several sub-clades within each are consistent with subspecies. To resolve the relationships among the major clades, I collected complete mt-genome sequences from 14 individuals. All phylogenetic analyses based on the mt-genome data converged on one well-supported tree. I use these data to infer biogeographic events, identify areas of secondary contact, between sister- and non-sister lineages, showing varying degrees of hybridization. I recommend a revised taxonomy retaining some subspecific names until further investigation.

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**\*MULL, CHRISTOPHER G.; LOWE, CHRISTOPHER G.; YOUNG, KELLY A.**

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## Plasma testosterone concentrations and GSI as predictors of mating periodicity in male round stingrays (*Urobatis halleri*)

Round stingrays breed annually during the late spring- early summer, with parturition occurring in autumn. While breeding behavior, gonadosomatic index (GSI), and hormone levels correlate in some species, this is not true of all elasmobranchs. We hypothesized that the annual cycle of testosterone in a wild population of male round stingrays was correlated with seasonal gonad development and spermatogenesis. Round rays were collected monthly for 12 months in Seal Beach, CA. Gonadal tissue and blood samples were collected for each ray, and

processed for histological examination and analyses by radioimmunoassay, respectively. Seasonal changes in testes structure were categorized into three phases: inactive (May-July), recrudescence (August-October), and degenerative (November-April). During the inactive phase testes were composed primarily of stage I spermatocysts and both GSI and testosterone were reduced as compared to other stages ( $p < 0.05$ ). The recrudescence phase was characterized by increases in both GSI and testosterone compared with all other groups ( $p < 0.001$ ). While testosterone levels were not significantly different between the inactive and recrudescence stages, plasma levels did increase 4.75 fold when the testes returned to their active state. Maturation of spermatocysts and sperm from early stage I and II spermatocysts to later stages (III-V) was noted during the recrudescence stage. Finally, the degeneration phase was characterized by a decrease in GSI, following the peak in October, ( $p < 0.001$ ) and a final maturation of sperm and degeneration of spermatocysts (stage VI and VII). Testosterone levels continued to rise throughout the degeneration phase and remained elevated until mating occurs ( $p < 0.01$ ). Interestingly, GSI peaked in October, 5 months before the established mating season, and peak sperm production occurred in December, two months after peak GSI and 3 months prior to mating. These results suggest that plasma testosterone is a more reliable indicator of seasonal maturation of testes in round stingrays than GSI.

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**\*MUNDY, BRUCE C.; PARRISH, FRANK A.**

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### Upper island slope fishes at the central Pacific U. S. Line Islands

Exploratory surveys of the upper slope fauna of the U. S. Line Islands of Jarvis Island, Palmyra Atoll, and Kingman Reef were conducted during July 2005 with six dives made by the Hawaii Undersea Research Laboratory's Pisces IV and V submersibles. These were the first surveys of central Pacific deepwater island slopes outside of Hawaii. The 6-9-hour dives included exploratory transects upslope from initial depths of 1027-740 m to 500 m, and 30-minute quantitative horizontal transects at 500, 450, 400, and 350 m. Below 500 m the topography was sediment-covered 35-60° slopes. Above 500 m, the terrain was largely composed of vertical cliffs, ridges, and canyons, particularly at Jarvis. Palmyra and Kingman had more intermixed areas of cliffs, sedimented ridge-top domes, and canyon floors. The most abundant fish were juvenile scorpionfish (*Setarches* sp.), seen on sedimented areas of Palmyra and Kingman but not at the steeper topography of Jarvis. Deepwater cardinalfish (*Epigonus* sp.) were abundant at vertical topography. Other numerically dominant fish families included the Ophichthidae, Myctophidae, Macrouridae, Moridae, Trachichthyidae, Grammicolepididae, Acropomatidae, and Percophidae. Large predatory fishes included prickly sharks (*Echinorhinus cookei*), Randall's snapper (*Randallichthys filamentosus*), and oilfish (*Ruvettus pretiosus*). Fishes at the Line Islands were more abundant than at the Hawaiian Islands previously surveyed with the same protocols. Several taxa commonly seen in Hawaii were either not observed (Symphysanodontidae, Chlorophthalmidae) or were rarely observed (Serranidae,

Etelinae) in the Line Islands. New central Pacific records of fish families from our surveys included the Torpedinidae and Oreosomatidae. The need for more exploration of deepwater island slope fishes in the central Pacific is exemplified by observations of *Hoplostethus*, which ranked eighth in abundance in our surveys but are otherwise unrecorded from the region.

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**\*MUSHINSKY, HENRY R. ; MCCOY, EARL D. ; LINDZEY, JONATHAN K.**  
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### Habitat quality, disease, and the Gopher Tortoise

We resurveyed 10 populations of the Gopher Tortoise originally surveyed about a decade ago to compare changes in the demography at four sites that were known to have seropositive (for the *Mycoplasma agassizii*, an agent for upper respiratory tract disease) individuals with those of populations at six sites that were unknown to have seropositive individuals. We also documented changes in the spatial arrangement and potential connectivity of individuals within populations to determine if changes are related to habitat structure and/or management practices. Blood samples from as many as twenty individuals at each site were examined for the presence of *M. agassizii* and levels of stress hormones. Demographic profiles of each population were made indirectly using burrow frequency, status and size. Demographic well being declined at most sites. Spatial arrangement changed only slightly between surveys. Changes in habitat structure were related to management history. We detected a connection between population declines and habitat quality. A mixture of loss of herbaceous cover and an increase of canopy was responsible, in part, for some of the declines. Reduction in habitat quality was most apparent at relatively small sites. The mycoplasma was more widespread than suspected and no connection between the observed declines and the presence of the mycoplasma was indicated. Plasma corticosterone levels did not differ among sites of seropositive or seronegative individuals. The most readily detectable hematological response both to the presence of the mycoplasma and to chronic stress was elevated heterophil/lymphocyte ratios.

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### Monitoring reintroductions: Providing defensible data

Relocation of animals is a recognized tool in the conservation of species. In spite of successes it has a somewhat equivocal position in the tool box for endangered species, primarily because programs are often initiated, but not properly monitored. Translocation, repatriation, reintroduction, relocation and otherwise moving animals appear in numerous conservation plans from local to state to national level programs. However, what is often missing is the next critical step of monitoring that particular action. We use repatriation of juvenile Wyoming toads as an example of how capture recapture methods can be used to initiate, refine, and effectively monitor such a program. If the culmination of a repatriation effort is a self-sustaining population, the system is expected to change over the course of the effort, and an adaptive management approach is necessary. Using proper methods, even with sparse data, statistically defensible information can be collected. Monitoring and data analyses need to be amenable to change in response to the environment and the released animals. We illustrate this with the robust design and an iterative approach to our analysis.

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**\*NAGLE, BRETT C.**

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### Molecular phylogenetics and biogeography of the cyprinid genus *Nocomis* (Ostariophysi: Cyprinidae)

Species of the cyprinid genus *Nocomis* are widespread in the Mississippi, Mobile Basin and Atlantic Slope drainages of the eastern United States. At present, the genus contains nine described taxa with six species and three subspecies within the polytypic *Nocomis leptocephalus*. Previous studies noted morphometric, meristic and biochemical variation across populations of wide ranging species in this group; however, no phylogenetic hypotheses regarding relationships at the species-level have been produced. Herein, I use nucleotide sequences of the mitochondrially encoded cytochrome *b* gene to infer species relationships within *Nocomis*. Multiple individuals from each major river drainage within the ranges of widespread taxa were included to test effectively the monophyly of named species. Species of the *N. biguttatus* species group are sister to a clade containing all other *Nocomis*. Within this larger clade, the three subspecies of *Nocomis leptocephalus* are paraphyletic. Populations of *N. leptocephalus* from major drainages of the Atlantic slope form monophyletic groups. *Nocomis leptocephalus* populations from the Mobile Basin are sister to a clade containing the *N. micropogon* species group plus the remainder of *N.*

*leptocephalus* populations. Populations from direct Mississippi river tributaries west of the Mobile Basin are sister to Atlantic Slope populations east of the Mobile Basin. This counterintuitive pattern of relationships across the mobile basin has been observed in other clades of fishes. Biogeographic implications and estimates of divergence times will be discussed.

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Population genetics of the scalloped hammerhead shark, *Sphyrna lewini*, in the Gulf of California

The scalloped hammerhead shark, *Sphyrna lewini*, is a circumtropical species that uses shallow bays and estuaries for reproductive purposes. While Mexico's Gulf of California (GOC) is the only large inland sea along the eastern Pacific and therefore may be vital to the reproductive success of the eastern Pacific stock, populations of *S. lewini* have declined there in recent years and require protection from over-exploitation. Genetic markers are widely used to study such threatened species, and can be useful in the design of marine reserves. To effectively protect a species, genetic connectivity must be maintained among populations throughout the species' range. Connectivity is a measure of gene flow among populations and can be determined by studying the genetic variation, or genetic structure, within those populations. Knowledge of population structure is necessary for managers to determine the effect that fishing in one part of a species' range will have on other populations elsewhere. I have used microsatellites to determine the genetic structure of *S. lewini* populations in the GOC spatially and temporally. Two microsatellites were used in previous studies on blacktip sharks, and a third was designed for the bonnethead shark. While I am in the process of designing more loci for *S. lewini*, a difference among frequencies of these genetic sequences resistant to selection indicates that populations within La Paz Bay were significantly different in January 2001 and January 2004. This temporal structure suggests that *S. lewini* populations do not practice natal homing by returning to the same pupping grounds in La Paz Bay for reproductive purposes. However, these results are tentative. More microsatellite loci, as well as analyses of tissue samples from La Paz Bay, Mazatlan, and Chiapas in 2006 are requisite before definitive conclusions can be made regarding the population structure of *S. lewini*.

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**NASEKA, ALEXANDER M.**

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Major patterns of phenotypic diversity, phylogeny and systematics of the gudgeons (Teleostei: Cypriniformes: Gobioninae)

The Gobioninae are a diverse group of small to medium-sized cyprinids native to Northern Eurasia and East Asia down to central Vietnam. They are mostly benthic and display a number of anatomical peculiarities connected with dwelling at the bottom which make them similar to typical representatives of European and Near-

East Barbinae sensu stricto. To approach the problem, a wide set of species from both groups was examined with special regard to anatomy, mainly osteology and sensory canals. It is shown that this similarity is rather a result of close phyletic affinities than of pure convergence. Phylogenetic relationships among the Gobioninae were analyzed using 136 morphological characters based on examinations of over 1000 specimens from 52 species of nearly all 29 valid (and questionably valid) genera. Character polarity was investigated using numerous outgroup comparisons (with representatives of Barbinae, Schozothoracinae, Leuciscinae, Cultrinae, Acheilognathinae). It was possible to give plesiomorphic states for the subfamily. The results support the monophyly of the Gobioninae and suggest at least five subgroups within the subfamily which may be identified by unique combinations of apomorphic character states. However, within each apparent lineage some members are apomorphic with respect to certain characters and plesiomorphic with respect to others, while other members have the reverse situation. The phylogeny was then used to investigate agreement with the most recent molecular study, taxonomic classification on generic level and the evolution of feeding and moving strategies. The results support multiple independent origins of "bottom-dweller appearance" and it is suggested that the evolutionary plasticity of the axial skeleton and ethmoid cranial region have been fundamental to the adaptive radiation of this subfamily. The study is a part of the project "Cypriniformes Tree of Life".

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Catalogue of fish collections in Zoological Institute, Russian Academy of Sciences: Gobies (Teleostei: Gobiidae) of the Black Sea-Caspian Sea basins

Gobies of the genera *Benthophilus*, *Benthophiloides*, *Knipowitschia*, *Hyrceanogobius*, *Caspiosoma*, *Pomatoschistus*, *Proterorhinus*, *Neogobius* and *Mesogobius* represent one of the most distinguishing elements of the fish fauna of Black Sea, Sea of Azov, Caspian Sea and river drainages of their basins. Major part of the species is endemic to the area. In general, the origin of the Neogobiinae and Benthophilinae auctorum are intimately connected with the paleohistory of Para- and Peri-Tethys. Most of these gobies inhabit brackish waters of 1-13‰ salinity, some occur in fresh waters, and some are tolerant to higher salinity. Being an example of rapid adaptive radiation and high morphological and ecological diversity, the Ponto-Caspian gobies attract much attention of taxonomists and biogeographers. The Zoological Institute Fish Collection in St. Petersburg (ZIN) which includes one of the largest collections of Ponto-Caspian fishes, has been undergoing computerization since 2004 with support from FishBase and Russian Foundation for Basic Research (05-04-49218). The goals of this phase were to inventory the Ponto-Caspian gobiid holdings that contain over 1000 jar lots of some 60 species and subspecies. Special attention has been paid to type specimens, all original descriptions checked and holotypes or lectotypes

photographed. All other specimens have been re-identified and comments given whenever required. The product includes data sets digitized with the use of the Artedian Ichthyological Collection Management System (Artedian 2.0). The collection records are completely georeferenced. There were prepared hierarchical gazetteers for automatic filling up of some fields in respective tables (country, ISO codes, FAO codes, coordinates, basin, an aquatic zoogeographic unit, drainage unit, aquatic ecological system, name of locality) in Russian and English languages. This top-down approach (hierarchical classification framework analogous to the one traditionally used in taxonomy) is used for visualization of the data and mapping results of analytic search and synthesis on different level.

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Age and growth of the smooth skate, *Malacoraja senta*, from the western Gulf of Maine

The smooth skate, *Malacoraja senta*, is a small rajid species endemic to the offshore waters of the Northwest Atlantic. While not directly targeted, precipitous declines, as a consequence of bycatch in the groundfish fishery, have consistently placed the stock status of this species at or below threshold levels in the Gulf of Maine, USA. Although the smooth skate has a relatively broad geographic distribution, ranging from Newfoundland, Canada to New Jersey in the United States, no direct biological data exists for this species. The present study intends to use counts from vertebral centra to age this species. To date, vertebrae from 495 skates ranging in size from 230 mm to 680 mm have been processed. Contingency tables and coefficient of variation will be used to test for bias and precision in our age assessment. Marginal increment and edge analyses will be used to verify annual band formation. Growth will be assessed using the original von Bertalanffy (VBGM) with size at birth ( $L_0$ ) as a parameter. Additional methods including a set  $L_0$  and the  $t_0$  form of the VBGM equation will also be evaluated in order to produce the best representation of the data. The resulting information will represent an important life history parameter needed for the proper management of this overfished species.

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**NAUWELAERTS, SANDRA; \*WILGA, CHERYL D.; LAUDER, GEORGE V.; SANFORD, CHRISTOPHER P.**

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### Fluid dynamics of suction feeding in bamboo sharks

In suction feeding, a volume of water is drawn into the mouth of a predator. Previous models and experiments of suction feeding in fishes have shown that significant fluid velocities are confined to a region within one mouth width (MW) from the mouth. Therefore the predator must be relatively close to the prey to ensure capture success. Most of those studies were conducted on bony fishes that feed in the water column with relatively little attention given to benthic feeding fishes. White-spotted bamboo sharks, *Chiloscyllium plagiosum*, live in benthic environments around coral reefs and are strong suction feeders. We predict that the shape of the fluid velocity field will change when feeding on the substrate compared to that in the water column due to conservation of momentum. Height should decrease while width and length should increase when feeding on the substrate compared to that in the water column. Therefore, the boundary of the fluid field will lie further away from the mouth, thereby exceeding the theoretical prediction of a maximal one MW distant flow field. To test these predictions, high resolution DPIV was used to visualize the fluid field and analyze the fluid dynamics around the mouth of bamboo sharks while suction feeding on the substrate and in the water column. Prey captures, transports and missed strikes were recorded as bamboo sharks were fed squid at various heights from the substrate. DPIV analysis results show that the boundary length of the flow field can be increased up to 2.5 MW distances from the center of the mouth due to passive substrate effects during prey capture. This indicates that feeding near a substrate extends the distance that suction flow is effective and thus requires less accuracy than feeding in the water column using the same effort.

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**\*NAZDROWICZ, NATHAN H.; BOWMAN, JACOB L.; BROWN, WILLIAM P.**

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### Larval growth and metamorphosis in the salamander *Eurycea longicauda longicauda*

Variation in larval growth and metamorphosis has been documented for several species of stream breeding salamanders. We investigated variation in larvae of the long-tailed salamander (*Eurycea longicauda longicauda*) among 5 populations associated with springhouses in southeastern Pennsylvania and northern Delaware in 2005. We captured a minimum of 20 larvae at each site every 14–21 days from the

time of hatching until metamorphosis and recorded snout-vent length, tail length, and mass. At our study sites, *E. l. longicauda* larvae appeared inside springhouses around mid-January, although eggs were not always present. Hatchling total length varied from 1.90–2.02 cm among sites ( $P=0.049$ ). Around mid-March, most larvae had migrated to outside surface streams. Metamorphosis varied among sites with the earliest occurring at the end of May and the latest at the end of July. Mean total length at metamorphosis varied from 3.73–4.53 cm among sites ( $P<0.001$ ). We used regression analysis to determine if growth could be predicted by water variables (temperature, pH, conductivity, and % nitrates).

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### Nesting ecology of the Eastern Box Turtle in a fragmented landscape

A paucity of information is available on the nesting ecology of the eastern box turtle (*Terrapene carolina carolina*). Specifically, minimal research has been conducted on nest site selection and how it relates to nest success. In 2001–2002, we investigated nest site selection, clutch size and frequency, nest success, and nest site fidelity of eastern box turtles and compared them among 4 study sites in northern New Castle County, Delaware. Using radio-telemetry, we monitored 57 gravid females. The earliest documented nesting date was 27 May and the latest was 11 July. Gravid females moved long distances to nest (up to 450 m), and females in the interior forest moved more than 3 times farther than those at other study areas. Clutch size ranged from 1 – 9 eggs, and was positively related to female body size. We marked and monitored 39 nests to determine nest fate. Females most often nested in areas with an open canopy and in close proximity to a forest edge. Nest sites had less canopy cover and a lower percentage of grass and forbs than random sites, whereas exposure to sunlight and percentages of vines, woody vegetation, woody debris, organic litter, and other life forms, did not affect nest site selection. Percentage of successful nests was greatest at the most fragmented areas. However, our data suggest that although females in fragmented areas move less to nest, females in urban fragments are more likely to choose unsuitable nesting sites such as roadside edges, which may reduce hatchling survival.

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### Swimming with dinosaurs: Gondwana origin of cichlid fishes

The rapid tempo of speciation in East African cichlid fishes is a benchmark against which virtually all lineage diversification rates across the Tree of Life are compared.

Over 2,400 species of cichlid fishes are found in tropical freshwater ecosystems of Africa, the Neotropics, Madagascar, and India. Despite the importance of cichlids to evolutionary studies, there remains significant disagreement regarding the timing of cichlid diversification. The present day distribution of cichlids and the generally accepted phylogenetic relationships of the major cichlid lineages are indicative of a Gondwana origin, suggesting Cichlidae began diversifying in the Jurassic. However, this age is much earlier than the oldest cichlid fossils that imply a more recent Cenozoic origin for Cichlidae. Using a molecular phylogeny calibrated with non-cichlid fossils, we consistently converged on molecular age estimates that match the estimated geologic dates of Gondwana fragmentation events. We then constrained the cichlid molecular phylogeny using two Gondwana fragmentation events and show that Cichlidae date to approximately 163 million years ago. Given this age estimate, Cichlidae has an exceedingly low per-lineage diversification rate of 0.043 to 0.033 species per million years. Despite putatively unparalleled bursts of recent and rapid diversification in the East African Rift Lakes, cichlids are an evolutionary ancient lineage that has been heavily shaped by non-adaptive processes influenced by Earth history events, and as a whole exhibits an unexceptional diversification rate.

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A genomic fossil reveals key steps in hemoglobin loss by the Antarctic icefishes (Notothenioidei: Channichthyidae)

Antarctic icefishes are the only vertebrates that do not have hemoglobin and erythrocytes in their blood. These startling phenotypes are associated in several icefish species with deletions of juvenile and adult globin loci, which in red-blooded teleosts are typically composed of tightly linked pairs of alpha- and beta-globin genes. Was loss of hemoglobin expression in icefishes the direct result of such deletions, or did other mutational events compromise globin chain synthesis prior to globin gene loss? Here we show that 15 of the 16 icefish species have lost the adult beta-globin gene but retain a truncated alpha-globin pseudogene. Surprisingly, a phylogenetically derived icefish species, *Neopagetopsis ionah*, possesses a complete, but non-functional, adult alpha-beta-globin complex. This cluster contains two distinct beta-globin pseudogenes whose phylogenetic origins span the entire Antarctic notothenioid radiation, consistent with an origin via introgression. We conclude that the globin pseudogene complex of *N. ionah* is a genomic fossil that reveals key intermediate steps on the pathway to loss of hemoglobin expression in all icefish species.

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Molecular systematics and phylogeography of the Mexican stoneroller, *Campostoma ornatum*

We examined patterns of genetic variation across the range of the enigmatic and polymorphic Mexican stoneroller. This minnow is widely distributed in highland areas across the Sierra Madre Occidental, with a disjunct population in the Big Bend region of Texas. Previous workers identified substantial differentiation in meristic, morphometric, and pigmentation characters, but interpreted the variation as not having geographic components and did not recommend taxonomic changes. We examined genetic variation at the cytochrome *b* gene from specimens representing all extant populations. Mexican stonerollers were recovered as a monophyletic group in all analyses, however, substantial differentiation exists between major drainages, supporting previous hypotheses of polytypy. Three major clades, representing populations from the Rio Conchos, Rios Yaqui/Mayo/Fuerte, and Rios Nazas/Mesquital exhibit marked differentiation, and are recovered as deeply divergent and monophyletic in all analyses. This is congruent with patterns of diversification in other fishes inhabiting the Sierra Madre Occidental. The deep divergence between these clades, as well as anecdotal observations of morphological differentiation, suggest that reinterpretation of patterns of morphological variation is necessary.

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Ichthyofauna of the Gaoligongshan region, Yunnan, China

The Gaoligongshan is a large mountain range that is the southernmost extension of the Hengduan Mountains, and forms part of the border between China and Myanmar. The region is drained by tributaries of the Nujiang (Salween) and Irrawaddy drainages, which head in glacial snowfields on the Himalayan Plateau and flow southward to the Andaman Sea and Bay of Bengal, respectively. The Chinese portion of the Nujiang flows through a remarkably narrow valley and a series of spectacular gorges, and the combination of glacial melt and summer monsoons result in extreme seasonal fluctuations in flow and a generally high

sediment load. A collaborative effort to survey biodiversity of the region, conducted by the California Academy of Sciences and the Kunming Institute of Zoology and funded by NSF and the MacArthur Foundation, has substantially increased our knowledge of the ichthyofauna. The fish fauna is composed of both Indochinese and Himalayan elements, as well as several endemics. Diversity in the region is relatively low, and increases in a downstream fashion, with the highest species richness in each system observed at the border with Myanmar. Approximately 70 species are known from the area, including several undescribed species, but the fauna of the mainstem is poorly known and represents the most promising area for future study. The mainstem is under consideration for a series of major dams, which will have profound effects on the riverine fauna as well as the thousands of people who will be displaced from the region. In addition to providing information on regional patterns of diversity, specimens from the project are also supporting systematic research by the Cypriniformes Tree of Life (CToL) and the All Catfish Inventory (ACI) projects.

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Simulating the effects of temperature on individual and population growth of the cownose ray, *Rhinoptera bonasus*: A coupled bioenergetics-matrix modeling approach

The cownose ray, *Rhinoptera bonasus*, is a commonly observed elasmobranch throughout the Gulf of Mexico and appears to be sensitive to water temperature. We performed laboratory experiments and collected field data to obtain basic life history and metabolic information, and used the information to configure an individual-based bioenergetics model. The bioenergetics model was coupled to a matrix projection model, and the coupled models were used to predict how warmer and cooler water temperatures would affect the growth and population dynamics of the cownose rays. The bioenergetics model predicted that rays would have a slower growth rate and reach smaller average weights at age (9.6-16.8% smaller) if they inhabited 2°C warmer water than baseline (current) conditions, while individuals would grow faster and attain heavier weights at age (13.4-17.2% heavier) under a 2°C cooler scenario. Changes in growth rates under the warmer and cooler conditions also lead to changes in age-specific survivorship, maturity, and pup production, which we used as inputs to a matrix projection model. Faster growth of individuals under the cooler scenarios translated into an increased population growth rate (4.4-4.7%/year versus 2.7%/year under baseline), shorter generation time, and higher net reproductive rates, while slower growth under the warmer scenarios translated into slower population growth rate (0.05-1.2%/year), longer generation times, and lower net reproductive rates. Elasticity analysis indicated that population growth rate was most sensitive to adult survival. Reproductive values by age were highest for intermediate ages. The combination of coordinated laboratory experiments, field data

collection, and coupled individual-based bioenergetics and matrix projection models provides a powerful approach for relating physiology to demographic responses.

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### Phylogenetic and biogeographic relationships of the Ponto-Caspian neogobiins (Teleostei: Gobiidae) based on nuclear and mtDNA sequences

Phylogenetic and biogeographic relationships are evaluated for the neogobiin gobies, comprising a small species flock endemic to the Ponto-Caspian region (Black/Caspian Seas and associated drainages) that are invasive in the North American Great Lakes (since 1990) and central/eastern Europe. The neogobiins include *ca.* 20 species within four genera (*Apollonia*, *Mesogobius*, *Proterorhinus*, and *Neogobius*) whose taxonomic position and systematic relationships are weakly understood. Understanding the systematics of groups with multiple invasive species may shed light on the evolution of invasion success. We analyzed DNA sequence data from the mitochondrial COI and Cytb genes and the nuclear RAG1 gene to infer relationships among this subfamily, as well as from several outgroup species to begin to illuminate the position of the neogobiins within the higher gobioid phylogeny. Results reveal marked divergence between *Apollonia* (round goby *A. melanostomus* and monkey goby *A. fluviatilis*) versus all other neogobiin taxa. *Proterorhinus* is the sister genus to *Neogobius*, with *Mesogobius* as the sister genus to the *Proterorhinus* + *Neogobius* clade. Significant divergence is also seen between marine and freshwater species of tubenose goby *Proterorhinus*. The freshwater species of *Proterorhinus* was originally described as *P. semilunaris*, but was later synonymized with *P. marmoratus*; these molecular data support the resurrection of *P. semilunaris* for the freshwater tubenose goby. We also explore the relationship of the neogobiins to other Ponto-Caspian gobiid species, as well as discuss the comparative biogeography of the Black and Caspian Seas.

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### Advances in fish systematics and Fishes of the world, fourth edition

The recently published 4<sup>th</sup> edition of *Fishes of the world* presents 62 orders and 515 families for an estimated 27,980 valid (to end 2005) living species of fishes. Extant fishes are placed in 5 classes, one of which includes the approximately 26,730 species of tetrapods. Given the same species concept, the number of species of fishes alive today may be about 32,500. Numerous additional fossil taxa of fishes are integrated into the cladistic classification. Many changes and updated information appears in the

new edition of Fishes of the world. Each family and other unit of classification has been reworked. Much progress has been made in ichthyology following the 1976 edition when 18,818 valid fish species were recognized. Over the last 30 years the number of monotypic families has remained similar, but the number with over 100 species has increased. Some problems in 1) presenting a comprehensive classification for both fossil and extant fishes (including molecular and morphological data) and dealing with conflicting hypotheses, 2) names and composition of higher taxa, and 3) species concepts, will be mentioned. There are many problems facing future researchers in fish systematics, and there is need for all researchers to study the original literature and the fishes.

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#### Ontogenetic variation in diet and prey preference of juvenile lemon sharks, *Negaprion brevirostris*

Stomach contents were collected from 396 lemon sharks (*Negaprion brevirostris*) at Bimini, Bahamas, between March 2000 and March 2003, and analysed to examine ontogenetic variation in diet and feeding habits. Lemon sharks were predominantly piscivorous and diet was homogenous with shark size ( $r^2 = 64.36$ , 12 df,  $P = 0.057$ ), with mojarra (Gerreidae) the major prey of all shark sizes. High levels of dietary overlap (simplified Morisita and Horn's index  $> 0.88$ , Spearman rank  $P < 0.001$ ) between all shark sizes suggested no resource partitioning. However, a significant ontogenetic decrease in the number of dietary items (Kruskal-Wallis test,  $P = 0.006$ ) and a significant increase in stomach content weight (Kruskal-Wallis test,  $P = 0.017$ ) suggested larger sharks consumed fewer but larger prey. Prey sizes were measured where possible or calculated using bone-length regression equations, and sharks over 60.0 cm precaudal length were found to consume significantly larger prey than smaller sharks (ANOVA,  $P < 0.001$ ). Diet breadth decreased with increasing shark precaudal length, suggesting more opportunistic feeding by neonates that are typically associated with rapid growth and a large appetite. However, proportions of prey families in the environment were significantly different to those found in the diet of all sizes of lemon shark ( $\chi^2$ ,  $P < 0.0001$ ). Barracuda (Sphyraenidae), mojarra, toadfish (Batrachoididae) and parrotfish were highly selected, and silversides (Atherinidae) negatively selected by lemon sharks of all sizes. Larger sharks exhibited a switch in prey preference from slow benthic fish and invertebrates to faster moving snappers and grunts. These data suggest that lack of hunting experience, reduced swimming ability and a restricted home range may force smaller sharks to forage more opportunistically on small, easier to catch prey, while larger and faster swimming sharks may be more efficient foragers in nurseries with patchy prey distributions.

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### Red-eared sliders in Singapore

The Red-eared slider (*Trachemys scripta elegans*), originally native to Florida, U.S.A., is the only species of reptile legally imported to be kept as pets in Singapore. Populations of the sliders have been living in the water bodies of Singapore for more than 20 years and recent population studies found at least 400 sliders thriving in a small pond. The sliders currently occur in many South Asian countries, outside of their natural range, mostly due to the intentional release by the public. Despite the threats that these sliders pose to the native flora and fauna (such as the Malayan Box Terrapin (*Cuora amboinensis*) and the Black Marsh Terrapin (*Siebenrockiella crassicollis*)), it is not yet confirmed if they are reproducing in equatorial climates. This study aims to investigate this. Male and female terrapins were collected at monthly intervals and the development of gonads was scored. Developing follicles and sometimes, shelled eggs were found within the females, but it was not synchronous among the females. Hatchlings were also observed at a few sites. The results from this study indicate successful reproduction of the sliders in Singapore.

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### Strange bedfellows? The composition of the Sisoroidea re-examined

The composition of the siluriform clade Sisoroidea is re-examined utilizing both morphological and molecular characters in this study. Previous phylogenetic hypotheses have placed the Neotropical Aspredinidae as deeply nested within the Sisoroidea (an otherwise exclusively Asian clade). By re-examining previously described and investigating novel morphological characters, it is proposed here that the aspredinids should be excluded from the Sisoroidea. A parallel study utilizing both mitochondrial and nuclear genes supports the exclusion of the Aspredinidae from the Sisoroidea.

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Phylogenetic Analysis of the Tennessee Cave Salamander complex (*Gyrinophilus palleucus*) inferred from 12S rDNA and Cytochrome *b* mitochondrial DNA genes

The Tennessee Cave Salamander complex (*Gyrinophilus palleucus*) comprises populations of stygobitic, paedomorphic plethodontid salamanders endemic to subterranean waters of middle and east Tennessee, north Alabama, and northwest Georgia. Two species are currently recognized based on morphology, *G. palleucus* and *G. gulolineatus*, with the former comprising two subspecies. However, many populations are difficult to assign to any of the described taxa and the complex has not been examined phylogenetically. Portions of two mitochondrial genes, 12S rDNA and cytochrome *b*, totally 1640 base pairs were sequenced for 89 individuals from 38 localities of members of the *G. palleucus* complex and other cave-dwelling *Gyrinophilus*, to examine the biogeography and relationships among populations. Neighbor-joining, maximum parsimony, and maximum likelihood analyses of both separate and combined datasets resulted in nearly identical topologies. Sequence divergence was low both within and among populations of *G. palleucus* across much of the species range in middle Tennessee and north Alabama. The *G. palleucus* complex with the exception of *G. p. necturoides* and a population in northwest Georgia form a monophyletic group sister to *G. porphyriticus* populations from the northern Eastern Highland Rim in Tennessee. *Gyrinophilus gulolineatus* is the sister taxon of *G. palleucus*. However, the type-locality of *G. gulolineatus* shows evidence of introgression of *G. palleucus* haplotypes. All individuals sampled from a population in Knox Co., Tennessee, that show morphological evidence of hybridization between *G. porphyriticus* and *G. gulolineatus* possess *G. porphyriticus* haplotypes. *Gyrinophilus p. necturoides* is nested within *G. porphyriticus* from the northern Eastern Highland Rim in Tennessee and does not show evidence of gene flow with *G. palleucus* populations located within 10 km of the type-locality. Additionally, populations of *G. porphyriticus* within Tennessee and Georgia show up to 5% uncorrected sequence divergence suggesting that undescribed, cryptic taxa may exist within *G. porphyriticus*.

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The effects of fire on a herpetofaunal community in coastal sage scrub

Disturbances are important in maintaining diversity in many communities because of the patchiness they create and the resources they release with the removal of the dominant species. Fire is the primary disturbance associated with coastal sage scrub and chaparral vegetation. After a fire, the habitat is altered as vegetative cover is

drastically reduced and species composition changed. This opening of habitat is particularly important for sunlight-loving reptiles, but can negatively affect reptiles that need cover from vegetation and leaf litter. Reptiles are remarkably pre-adapted for surviving even intense wildfires by seeking refuge under substrate, where they are insulated from the extreme heat. Reptile abundance data were taken for two years before and two years immediately after a fall season fire, during activity periods on the same eight sites. By examining changes in abundance on the same sites after fire, reptile response to fire (through changes in habitat) can be directly accessed. Reptile species richness across all sites during the study period (gamma-diversity) was 19, with species richness the year immediately after the fire being significantly less than the other three years. Snake abundance decreased immediately after fire but then approached pre-fire levels within one year. This was consistent across all sites. Western whiptail lizards were the only lizard species that showed any change immediately after the fire with an increase in abundance. This change in abundance did not correspond to any change in a body condition index. It appears that although fire drastically changes habitat structure the reptile community is remarkably well adapted to this disturbance.

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A meta-analytical comparison of nearshore and pelagic fish assemblages from multiple estuarine regions in southeastern Louisiana (USA) using a taxonomic-based method

Previously we used a taxonomic-based method of meta-analysis to compare the benthic fish assemblages of multiple estuarine regions in southeastern Louisiana. These results showed that trawl samples from Lake Pontchartrain exhibited significantly more environmental impacts than other local estuarine regions. Here we use the same method to assess nearshore (beach seine) and pelagic (gillnet) fish assemblages from the same regions to determine relative ecological health. We analyzed fishery-independent beach seine and gillnet data from Barataria Basin, Lake Maurepas, Lake Pontchartrain, and the Biloxi Marsh/Chandeleur Islands region. We calculated average taxonomic distinctness and variation in taxonomic distinctness for 1474 beach seine and 1361 gillnet collections and compared each sample value to 1000 random values generated from a master species list. When the regions were compared using beach seine data, no region had significantly more samples with reduced taxonomic distinctness than expected (observed Chi-square = 4.7,  $p = 0.375$ ). That is, all regions were equally healthy in terms of nearshore fish assemblages. For gillnet data, Barataria Basin had significantly more samples with reduced taxonomic distinctness than expected (observed Chi-square = 23.21,  $p = 0.001$ ), suggesting that

estuarine pelagic fish assemblages in Barataria Basin are more impacted than in the other regions studied. In comparing these results to prior investigations, it is interesting to note that the assessment of relative ecosystem health differs depending on which fish assemblage habitats were sampled.

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### Lake Pontchartrain fish assemblage response to Hurricanes Katrina and Rita

After hurricanes Katrina and Rita impacted southeastern Louisiana in autumn 2005, most of the floodwaters that had inundated the City of New Orleans were pumped into Lake Pontchartrain. Because of the possibility that this water could contain damaging amounts of chemicals and toxins, national media repeatedly referred to the water as being toxic sludge. To determine if these events actually had a significant acute impact on the fish assemblages of Lake Pontchartrain, we conducted monthly sampling of fishes (beach seines and trawls) at five localities within the estuary between October 2005 and January 2006. We compared these post-impact data to fishery data collected during the same months for the years 2000 through 2005 to determine if fish assemblages had changed significantly due to the hurricanes. Fish assemblages collected by beach seines before and after the hurricanes were not significantly different (ANOSIM,  $R = 0.099$ ,  $p = 0.091$ ). Analysis of trawl data, though, revealed a significant difference between pre- and post-hurricane fish assemblages collected from benthic habitats (ANOSIM,  $R = 0.207$ ,  $p = 0.041$ ). Post-hurricane trawl samples were markedly less diverse (average  $S = 1.14$ ) than pre-hurricane samples (average  $S = 2.84$ ). Although these short-term changes in benthic fish assemblages may have resulted from hurricane impacts, it should be recognized that Lake Pontchartrain fish assemblages still exist despite the input of floodwaters from New Orleans and all available evidence suggests that the estuary continues to function as an ecosystem.

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The effects of behavioral interactions on sex differentiation in the Midas Cichlid, *Amphilophus citrinellus*

A period of gonad bisexuality occurs early in development in many fish species that only function as one sex throughout their lifetime. Sequential hermaphroditism is thought to evolve when this critical period of lability extends into adulthood, when development can be influenced by social interactions. Sexual lability at an intermediate life stage has been reported in the Midas cichlid, *Amphilophus citrinellus*, and was considered to represent a mid-point on a developmental continuum, lying between fish that have sex controlled genetically and fish that change sex as adults. At the juvenile stage, relatively large individuals of a group were reported to develop as males and small individuals as females. I employed detailed behavioral analyses in laboratory experiments to determine the effects of behavioral interaction and relative body size on sex determination in the Midas cichlid. Groups of fish from different lineages, containing various numbers of individuals, were grown out over long periods. Social interactions were found not to influence whether an individual differentiated as a female or a male. I histologically examined gonads of wild Midas cichlids in order to describe their pattern of development. Of 25 individuals of various ages from Lake Masaya, Nicaragua (the source of fish in the original reports), none had bisexual gonads, although these are often present in sexually labile species. In Lake Apoyo, Nicaragua, underwater observations revealed Midas cichlids socially assorted by body size. Two shoals of juveniles were captured in deep water. Histological analysis revealed that they were at the onset of sexual differentiation, but sex was not associated with body size in either group. The field observations and laboratory experiments consistently indicate that social conditions do not affect sex in this species and that differences in relative body size in adults are due to greater post-maturational growth in males than in females.

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Niche overlap between spiny and smooth dogfish from inshore and offshore winter habitats

Trophic ecology of marine fishes is important information for ecosystem modeling used by fishery managers. Currently, there is intensive management of spiny dogfish (*Squalus acanthias*), which declined in the late 20th century possibly due to fewer prey resources (depleted from commercial fishing) or due to it being bycatch or harvested. Like many other shark species, it has a late age to maturity (15 - 20 years), low fecundity (< 10 offspring), and long gestation periods (approximately 2 years).

These life history traits make it highly vulnerable to overfishing and resulted in it being declared 'overfished' in 1998. We were especially interested in understanding resource use by this species and its competition with other benthic fishes for those resources. The objective of our study was to provide information on niche overlap between two dominant, benthic elasmobranchs: spiny dogfish and *Mustelus canis* (smooth dogfish). We sampled nearshore and offshore habitats for dogfish along the northwestern Atlantic Ocean (January 2006). We supplemented these data with existing data from the National Marine Fisheries Service collected in February 2005. In January 2006, we collected 137 spiny dogfish (279 kg; 71 to 110 cm) and 52 smooth dogfish (123 kg; 74 to 98 cm) at nearshore and offshore sites. The major prey item was loligo squid (46 kg); additional prey items included molluscans, shrimp, crab, and polychaetes. Using the two data sets, we will determine the level of niche overlap between these species (for 2005 and 2006) and determine if niche overlap differs by depth or latitude.

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Direct mate choice for acoustic signal production in a pomacentrid fish,  
*Dascyllus albisella*

It has long been known that damselfish use acoustic signals in their courtship, but the role (if any) of acoustics in mate choice has remained unclear. Previous studies of domino damselfish, *Dascyllus albisella* mate choice yielded contradictory results, suggesting both promiscuous mating in one case, and female mate choice based on male acoustic courtship rate in another. Because most damselfish species exhibit exclusive male parental care of adhesive eggs, these studies bear on a persistent paradox in sexual selection theory. The aims of this study were to resolve whether mating was due to female mate choice or was random. Additionally, male traits that could serve as cues for sexual selection were assessed to determine which traits, if any, were correlated with male mating success. Observation made over ten reproductive cycles showed that mating was not random and that mating success was correlated with acoustic courtship rate. Based on other studies of damselfish that showed correlations between courtship rates, energetic reserves, and offspring survival, this result suggests that females choose mates based on a condition-dependent trait that advertises quality of paternal care. These results support the good parent models of sexual selection and demonstrate the importance of an often overlooked component of sexual selection in fishes.

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A morphometric phylogeny of the flatfish genus *Pleuronichthys*

The genus *Pleuronichthys* consists of seven species of right-eyed flatfishes found in the Pacific Ocean. Although these fishes have been included in several family and order level phylogenetic studies, the relationships of the species within the genus are often incomplete and unresolved. I have attempted to gain better phylogenetic resolution by focusing specifically on the genus as the ingroup. I have collected seventy-four measurements and ten counts for all seven species in the genus as well as for seven pleuronectid outgroup taxa. I used gap coding to obtain discrete characters and a multiple outgroup approach to polarize the data. Using parsimony analysis, I generated trees using ordered and unordered characters. Ordering the characters yielded a tree with a monophyletic ingroup, a consistency index (CI) of 0.558 and a retention index (RI) of 0.6571. The unordered characters resulted in a similar tree (CI = 0.740, RI = 0.561) with two main differences: the placement of *Pleuronichthys cornutus* and the rooting of the tree. The resolved trees and implications of the differences between them will be discussed.

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Occipital innervation of the sonic muscle and sonic motor nucleus in tigerfish, *Terapon jarbua* (Teraponidae, Perciformes)

The tigerfish, *Terapon jarbua*, produces sounds by contractions of a pair of extrinsic sonic muscles innervated by the first spinal nerve (Schneider, 1964). In our previous paper (Onuki & Somiya, in press), we briefly reported that the sonic muscle is innervated by branches (sonic branches) of the occipital nerve but not by the spinal nerve. Also, we showed that the tigerfish is not one of the rare sonic fishes with its sonic muscle innervated by the spinal nerve only. In this poster presentation, we show detailed sonic muscle innervation pattern of tigerfish. The sonic branches are diverged from three axon bundles of the occipital nerve extending laterally. Few relatively fine sonic branches of the most anterior lateral bundle enter the anterior region of the sonic muscle. Few fine and thick sonic branches of the middle lateral bundle enter the middle region of the sonic muscle. A sonic branch of the most posterior lateral bundle was relatively thick and enters the sonic muscle towards the posterior region. Presently, we are investigating the position of the sonic motor nucleus of tigerfish by tracer methods using wheat germ agglutinin-conjugated horseradish peroxidase.

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New data on two deepwater skates *Bathyraja richardsoni* and *Rajella kukujevi* from the North East Atlantic

The deepwater skate fauna of the North Atlantic Ocean has been insufficiently studied. Many deepwater species have been discovered rather recently. Most of these are known from only a few records. Richardson's skate, *Bathyraja richardsoni* (Garrick), was described in 1961 from waters around New Zealand. Since the original description, only 66 Richardson's skates have reportedly been captured. Of these, morphometric data were recorded for 21 adults and 4 advanced embryos. The Mid-Atlantic skate, *Rajella kukujevi* (Dolganov) was described more recently, in 1985, near the Mid-Atlantic Ridge. Since then only a single additional record appears from the literature, though no morphological data were provided with this record. Several specimens of *B. richardsoni* and *R. kukujevi* were caught in the summer of 2004 while sampling aboard the Norwegian trawler R/V G.O. Sars and the Norwegian longliner M/S Loran. Bottom trawls reached depths up to 3500 meters and bottom longlines were set in depths up to 4200 meters along the Mid-Atlantic Ridge from the Azores to Charlie Gibbs Fracture Zone and also in the Hatton Bank area. Additional specimens of *R. kukujevi* and *B. richardsoni* were examined at the Museum National d'Histoire Naturelle in Paris, France. Additional data on capture locations of *R. kukujevi* and *B. richardsoni* were obtained from the FishBase website (<http://www.fishbase.org>) and also through personal communications with numerous European fisheries scientists. Prior to our 2004 sampling, Richardson's skate was unknown from the Mid-Atlantic Ridge. However, our study indicates that this species is common in this area. The 151 specimens captured by the R/V G.O. Sars and the M/S Loran allowed us to obtain new data on external morphology, spatial distribution, size composition, sex ratio, maturation and sexual dimorphism of this species. New data on range, depth, size and external morphological characters of *R. kukujevi* are presented as well.

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New data on the ecology and biology of mud skate *Rhinoraja taranetzi* Dolganov, 1985 in the northwestern Pacific with emphasis to food habits of the species

The mud skate *Rhinoraja taranetzi* was described rather recently. This species is distributed from Central Kuril Islands to Pribyloff Islands in the eastern Bering Sea and along the Commander and Aleutian Islands to the western Gulf of Alaska. It is one of most abundant skates inhabiting Russian waters though the data on its ecology and biology are scarce. Spatial and vertical distribution and their seasonal changes, bottom temperature preferences, species co-occurring in catches, size composition, length-weight relation, sex ratio, sexual dimorphism in size and food habits of mud skate in the Pacific off the northern Kuril Islands and southeastern Kamchatka and relation between total length and maturity of mud skate in the western Bering Sea are considered. The mud skate during the whole year is most abundant in central part of study area. Proportion of this species in bottom trawl catches in different seasons has changed slightly. Maximum catches occur in September-December. In April-May mud skates occupy shallower depths moving deeper in summer period. In December-March this skate occurs at lower bottom temperatures while in the rest of the year it inhabits warmer waters. During the whole year decreasing of body weight with depth is observed indicating that adult and juvenile mud skates inhabit different depths. Total length of mud skates in catches ranged 17 to 70 cm with mean 51.71 cm. Males were more abundant among small skates only, while females predominated among larger skates. Female mud skates were longer and heavier than males. Species considered is benthophage, consuming mostly amphipods, polychaets, and decapods. Fishery discards also play considerable role in the diet. Small skates fed mostly on amphipods; medium-sized ate amphipods, polychaets and decapods; largest individuals consumed fishery offal and less amphipods and polychaets. Preliminary data on maturation of species considered in the western Bering Sea are also presented.

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Recent progress in the taxonomy and systematics of the skates (Rajidae) of Alaska and the North Pacific

The skates of Alaska are represented by 15 species in three genera: *Bathyraja*, *Raja*, and *Amblyraja*. Among the species of *Bathyraja*, we recently described *B. mariposa* from the Aleutian Islands, where it appears to be endemic. The description of another species, also apparently endemic to the Aleutian Islands and related to *B. parmifera*, is underway as part of a review of the subgenus *Arctoraja* and its three nominal species. We are progressing on an examination of the *B. interrupta* complex of northern waters, a complex that may be composed of three species, including two that are presently undescribed. Morphological variation among other species of *Bathyraja* will be examined in future research to clarify, in particular, the status of Aleutian populations as compared with Bering Sea populations. In conjunction with this morphological work, molecular analyses are also being conducted. Preliminary results from the analysis of cytochrome oxidase subunit 1 sequence data produced markers to separate all species known from Alaska, including the new species from the Aleutian Islands. The relationships and zoogeography of the skates of Alaska will be discussed in light of our results to date.

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The Integrated Taxonomic Information System (ITIS) contains names of fishes, reptiles, and amphibians

The Integrated Taxonomic Information System (ITIS) provides authoritative taxonomic information on more than 500,000 accepted scientific names, synonyms, and common names for terrestrial, marine, and freshwater species from all biological kingdoms. It presents the names in a standard classification that contains author, date, geographic (native vs. non-native), and bibliographic information related to the names. The system currently emphasizes North American species, but includes worldwide taxonomic treatment of many groups including fishes, reptiles, and amphibians. During the last five years, the ITIS program has reviewed over 26,000

fish species, 7,600 reptile and amphibian species, and included over 15,000 vernaculars for these groups. ITIS can be found at <http://www.itis.gov>.

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**\*ORTEGA, HERNAN; RENGIFO, BLANCA; CHOCANO, LUISA;  
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Fish diversity, habitats, local use and conservation of Urubamba River Basin (Cusco-Ucayali, PERU)

The Urubamba River watershed, located at the Peruvian southeastern, is important as source of water and food for local populations and as highway of the rainforest; much aquatic life depends upon them. As this area is developed and recently is related to the gas exploitation more people and human economic activity move into the basin, these watery lifelines could be compromised. But, they cannot be protected unless we understand how they work, what fishfauna live there, how people use them, etc. And so far, in the Peruvian Amazon, there has been very little basic research into these questions. This ichthyological study carried out by the biologists of the Museo de Historia Natural of San Marcos University through several expeditions (June 2003 to October 2005) with the support of ERM Peru. The fishes, related data were collected from Monte Carmelo (Cusco) to Sepahua (Ucayali). Were surveyed 21 different water bodies and have examined around 19,000 specimens which were deposited at the Museo de Historia Natural (MUSM) in Lima. The results show a list of 223 species, representing 34 families and 9 orders, following the classification of Reis et al. (2003). Are dominants Characiformes (57%) and Siluriformes (36%). At least 24 species are new records and may be nine could be new species, especially those small Characiformes as Glandulocaudines and Siluriformes as small Trichomycterids, Heptapterids, Auchenipterids and Loricarids. The local people are using as food 72 species; the bigger fishes have been showed less amounts of captures in the last two years and in conservation could be important some measures to help the sustainable use.

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Flotsam and the diamondback water snake (*Nerodia r. rhombifer*)

Small areas of protected land may act as islands of suitable habitat surrounded by human development. Although these areas may be protected, we have observed one possible way that the surrounding human population can still endanger the welfare of these animals. Through our observations of the diamondback water snake (*Nerodia r. rhombifer*) at the Edinburg Scenic Wetlands (a semi-protected nature park in the city of Edinburg, Hidalgo County, Texas), several individuals have been seen or captured

that were encircled with flotsam. Of the 83 juvenile through adult snakes that we captured, six were entangled in various types of objects (e.g., finger cots, dental elastics, and plastic bottle/jug neck rings). A seventh individual was observed to be trapped in some form of flotsam but was not captured. The injuries resulting from these bands range from body cavity constriction, broken ribs, skin ulcers, and scale loss to exposure of the body cavity and impaired feeding capabilities. All bands were found within the anterior third of the animal's body. Of the six animals captured that had bands, five had their objects removed and were released and one individual was euthanized due to its inability to eat. This individual had dental elastic that constricted the esophagus near the heart preventing the flow of ingesta through the gastrointestinal tract. The constriction formed a rotting and impassible mass of fish. To determine the context in which these animals are getting caught in this refuse, behavioral experiments are being conducted to determine if the entanglement was due to attraction or to incidental entrapment during activity. Our observations show that becoming trapped in refuse may be an important source of impairment and/or mortality in limbless reptiles, as has been previously documented in other reptilian species.

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### **ORTI, GUILLERMO**

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*Deepfin Update: How far are we from a phylogeny of all fishes?*

DeepFin is a research coordination network (RCN) project funded by the US National Science Foundation. The ultimate goal of the project is to establish the phylogenetic relationships of all fishes. This presentation will discuss progress in our most immediate goals: (i) building an open and diverse organization to provide leadership and foster collaborations for fish phylogenetic studies; (ii) developing cyberinfrastructure, a portal for fish phylogenetics ([www.deepfin.org](http://www.deepfin.org)); and (iii) fostering education on fish biodiversity, fish evolution, and disseminating knowledge on the phylogenetic relationships of fishes. New opportunities for students and established researchers alike made possible by the RCN and active research groups around the world will be presented. Plans for future activities will be discussed and feedback from the public will be solicited.

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Using best development practices for vernal pools to inform responsible development

We tested the application of Best Development Practices published by Calhoun and Klemens (2002) in four New England towns. Our goal was to see if citizen scientists could effectively inventory pools and provide data to towns to be used for proactive conservation planning. Potential vernal pools were remotely identified using aerial photography. Fifty-two citizen-scientists surveyed 382 potential vernal pools and the adjacent terrestrial habitat. Data were collected on breeding amphibians, egg mass numbers, presence of rare, threatened or endangered species, and the quality of the adjacent habitat within 750 feet of each pool. Two hundred and sixty-two (69%) of the 382 surveyed potential pools were confirmed as vernal pools. A rating system based on pool use by breeding amphibians and quality of adjacent terrestrial habitat was used to rank town pool resources from high to low conservation priority. Data from each pool were entered into a Geographic Information System (GIS) database and delivered to each town. Using this data and voluntarily applying the BDPs, town planners and developers can better manage highly rated pools adjacent to golf courses and plan for new courses which conserve valuable vernal pool habitat. All four towns have begun to propose and develop conservation plans and apply conservation mechanisms to protect high priority vernal pools. These four case studies illustrate that vernal pool conservation initiatives can be developed in local communities using citizen scientists and that these data can be used to inform development practices for a diverse array of interests (residential developments to golf courses and other recreational management needs).

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**\*OTT, BRIAN D. ; SECOR, STEPHEN M.**

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Scutes, fur, and feathers: Postfeeding metabolic response of the green anaconda (*Eunectes murinus*)

Green anacondas (*Eunectes murinus*) are large tropical snakes that employ a sit-and-wait foraging strategy to capture and consume a variety of prey species of different sizes, including capybara, caiman, and water fowl. Predicting that anacondas will experience variation in the energy expended during digestion as a function of meal size and type, we measured pre and postfeeding rates of oxygen consumption of anacondas digesting different meal types and sizes. We fed anacondas rodent meals equaling 5, 15, and 25% of their body mass, as well as chick and alligator meals equaling 25% of body mass. For the three rodent meal sizes, oxygen consumption increased rapidly after feeding and peaked at 1.5 to 2.5 days at rates that were 3.7-, 6.3-, and 7.8-fold of prefeeding levels, respectively, for the 5, 15, and 25% size meals.

Following the peak, rates decreased slowly before returning to fasting levels by day 5 to 8 of digestion. The total energy expended on digestion, the specific dynamic action (SDA), increased with meal size. For the 5%, 15%, and 25% size meals, SDA was equivalent to 57, 207, and 355 kJ/kg, respectively. Anacondas exhibited similar postfeeding metabolic responses to each of the three different meals. Peak  $\text{VO}_2$ , a 7.3-7.7-fold increase above prefeeding rates, was reached two days postfeeding for the rodent meal and 2.5 days postfeeding for both the chick and alligator meal. The duration of significant elevated rates of metabolism was 6, 8, and 9 days, respectively, for the alligator, rat, and chick meals. The SDA of the rat, chick, and alligator meal was 355, 416, and 350 kJ/kg, respectively. For the green anaconda, meal size had significant impact on the SDA response. In contrast, there was little difference in the SDA response among the three different meals.

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Determinants of specific dynamic action in the eastern garter snake,  
*Thamnophis sirtalis*

The eastern garter snake (*Thamnophis sirtalis sirtalis*), an actively foraging snake inhabiting eastern North America, consumes a variety of prey species of different sizes and experiences a wide range of environmental temperatures. Given the diversity of its prey type, meal size, and body temperature, we used eastern garter snakes to study the determinants of specific dynamic action (SDA), the postfeeding metabolic response to digestion. To assess the effects of meal type, we fed garter snakes minnow, frog, and mouse meals equaling 25% of the snake body mass at 30°C. To identify the impact of meal size, we fed garter snakes minnow meals equaling 5%, 10%, 15%, 25%, 35%, and 45% of body mass at 30°C. And to determine the effects of body temperature, we fed snakes minnow meals 25% of body mass at 15°, 20°, 25°, 30°, 35°C. For each meal treatment, we measured prefeeding (standard metabolic rates, SMR) and postfeeding rates of gas exchange. We found postfeeding metabolic profiles to be similar among the meal types with higher postfeeding peak rates recorded for the minnow meal and longer duration of elevated metabolism for the mouse meal. By increasing meal size, there was a corresponding increase in peak rates of  $\text{O}_2$  consumption ranging from 3.6- to 10-fold of SMR for 5% and 45% size meals, respectively. The duration of significant metabolic response also increased from 2.5 to 9 days, respectively, for the 5% and 45% size meals. An increase in body temperature resulted in an increase in both SMR and peak postfeeding rates. Over the range of body temperatures tested (15-35°C), peak rates increased from 2.7-fold to 7.3-fold of SMR. This study demonstrates for the eastern garter snake that meal type, meal size, and body temperature each have significant impact on the SDA response and thus on the energetics of this snake.

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Influences of wetland and landscape characteristics on the distribution of carpenter frogs in the northern extent of their range

The distribution of wetland breeding amphibians may be influenced by multiple habitat variables interacting at various scales. I applied a multi-scaled modeling approach to relate the presence and absence of carpenter frogs (*Rana virgatipes*), a species of conservation concern in Maryland, to several wetland and landscape characteristics. I also investigated relationships between wetland habitat and adjacent landuse conditions using a series of hierarchical path models. Breeding call surveys were conducted at 40 wetland sites to determine the presence of calling male carpenter frogs. I collected data on aquatic and terrestrial habitat using both on-site measurements and geographic information system analyses. Logistical regression modeling revealed that wetlands occupied by carpenter frogs were significantly more acidic, exhibited shorter hydroperiods, and had higher proportions of surrounding forest cover than did sites unoccupied by carpenter frogs. I also found significant hierarchical relationships between upland forest cover and wetland pH and hydrology. My study suggests forest cover adjacent to wetlands may serve a dual purpose by not only providing amphibians with upland habitat refugia, but also maintaining the chemical and hydrological processes within wetlands that are critical for the existence of many wetland biota.

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Cranial development in a miniaturized form of the salamander *Desmognathus quadramaculatus*: Role of temperature and thyroid hormone

In order to test the hypothesis that temperature and thyroid hormone (TH) interact to affect metamorphic changes in the plethodontid salamander, *Desmognathus quadramaculatus* we grew first and second year larvae (i.e., premetamorphic) in a two-factor experiment wherein temperature and TH were treatment factor. We grew larvae in temperature regimes (11 and 15) and two TH concentrations (control and 1.2 nM). Temperature treatment was via two refrigerators, and included a simulated winter (lowered 7 and 11 during winter months, and raised to original levels in Spring). Animals were scored first examined externally for metamorphosis based on gill reduction and labial fold absorption, and second doubly cleared and stained for observation of cartilaginous (alcian blue) and bony elements (alizarin red) determine if external morphology was reflected in cranial features. There was a high correlation between external metamorphic scoring assay and cranial metamorphosis. In general low temperate retards metamorphosis, and no TH effect was observed. For the cranial features that we examined (vomer, parasphenoid, maxilla, pterygoid and the

hyobranchial apparatus), high temperature caused salamanders to lose their vomerine teeth and develop vomerine bars; low temperature salamanders did not undergo this transformation. The maxilla develops at high temperature but not at low temperature. The pterygoid disappears at high temperature, and the hyobranchial changes from larval to adult morphology. There were no significant changes in cranial morphology induced by TH. This suggests that plethodontid larvae are insensitive to TH-induction of metamorphosis at early larval life history. Based on our growth data, we suggest that the use of the feeding system (i.e., the gape and suck apparatus) plays a role in stimulating cranial metamorphosis.

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Responses of male green frogs (*Rana clamitans*) to acoustic and visual stimuli

Acoustic information (the calls of neighbors and intruders) seems to be of primary importance to frogs in advertisement and territorial defense contexts. It is becoming increasingly clear that many species of frogs also use visual information to mediate encounters. The green frog, *Rana clamitans*, is a species that has been well studied in terms of how territorial males respond to the calls of other males. However, males of this species also exhibit a number of behaviors that add a visual dimension to their advertisement and aggressive displays. I used a modification of traditional field playback experiments to determine whether calling green frogs respond to visual stimuli. The first experimental trial was a mirror presentation in which the frog had an opportunity to respond to its own image. The second experimental trial added an acoustic stimulus (conspecific advertisement calls) to the mirror presentation. The mirror and the speaker were spatially separated so that males could only interact with one type of stimulus. Most males did not respond to the mirror presentation by itself, although a few males did approach and try to interact with their images. Males consistently responded when the advertisement call was broadcast. However, males spent more time trying to interact with their image in the mirror during this trial than with the speaker sound source. This suggests that while acoustic stimuli seem to be of primary importance in the behavioral interactions of male green frogs, visual information is assessed by residents as well.

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Microarray analysis identifies keratin loci as sensitive biomarkers for thyroid hormone disruption in salamanders (*Ambystoma*)

Ambystomatid salamanders offer several advantages for endocrine disruption research, including genomic and bioinformatics resources, an accessible laboratory model (*Ambystoma mexicanum*), and natural lineages that are broadly distributed among North American habitats. We used microarray analysis to measure the relative abundance of transcripts isolated from *A. mexicanum* epidermis (skin) after exogenous application of thyroid hormone (TH). Only one gene had a > 2 fold change in transcript abundance after 2 days of TH treatment. However, hundreds of genes showed significantly different transcript levels at day 12 and 28 in comparison to day 0. A list of 123 TH-responsive genes was identified using statistical, BLAST, and fold level criteria. Cluster analysis identified two groups of genes with similar transcription patterns: up regulated versus down regulated. Most notably, several keratins exhibited dramatic (1000 fold) increases or decreases in transcript abundance. Keratin gene expression changes coincided with morphological remodeling of epithelial tissues. This suggests that keratin loci can be developed as sensitive biomarkers to assay temporal disruptions of larval-to-adult gene expression programs. Our study has identified the first collection of loci that are regulated during TH-induced metamorphosis in a salamander, thus setting the stage for future investigations of TH disruption in *Ambystoma*.

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Changes in pheromone production in garter snakes (*Thamnophis sirtalis parietalis*) during hibernation

The red-sided garter snake (*Thamnophis sirtalis parietalis*) is a model organism for studying pheromone production in reptiles. In the northern part of its range (Manitoba, Canada), *T. s. parietalis* enters winter dormancy in late September and emerges eight months later in May. Upon emergence, males court females with robust, unequivocal behavior that is easily assayed in the field. However, courtship is only initiated if the characteristic pheromone blend (a series of long-chain saturated and unsaturated methyl ketones) is present on the female's skin. This pheromone is present in a complex mixture of lipids, and it is possible to biochemically isolate the pheromone. Previous studies only examined differences in female pheromone profiles pre- and post-hibernation. This study sought to determine if the pheromone changes over the course of hibernation. We collected female skin lipid extracts every

five weeks during winter dormancy in the lab and then used column chromatography and gas chromatography/mass spectrometry to examine changes in the pheromone profiles. Results to date suggest that skin lipid production dramatically increases at the onset of winter dormancy and then continues to increase throughout hibernation. This increase in lipid production may be initiated by a decrease in temperature. Upregulation of lipid synthesis at the beginning of hibernation could indicate immediate energy allocation to pheromone production before the onset of the eight month long aphagia experienced by these snakes. Changes in the ratio of saturated to unsaturated methyl ketones in the pheromone profiles will indicate either internal or *de novo* modification of the pheromone prior to emergence.

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The snake's forked tongue: An experimental test of the edge detection hypothesis

The forked tongue of certain squamates (varanid lizards, snakes) has been hypothesized to function in edge detection, but there is minimal supporting experimental evidence. If the tongue does function to detect two point sources of chemicals for simultaneous comparison of concentration/composition, then any disruption along the neural pathway from tongue tip to the CNS should disrupt edge detection. We tested the edge detection hypothesis in Pacific rattlesnakes (*Crotalus oreganus*) by unilaterally severing the band of nerves which pass ipsilaterally from the vomeronasal (VN) organ to the accessory olfactory bulb. Both before and after severing the VN nerves, all snakes were run through behavioral trails where their post-strike trailing behavior was recorded and scored for seven unique behavioral variables. Post-strike trailing in rattlesnakes is a predictable, stereotypic modal action pattern, so changes in any component of the pattern are easily detectable. We observed no differences in any of the behavioral variables recorded from before and after VN nerve severing. Our findings suggest that edge detection is not the function of the forked tongue. Rather, we propose that the forking of the tongue functions to increase chemical sampling area.

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#### A biogeographic context to new world venomous snake evolution

Coralsnakes (Elapidae) and pitvipers (Viperidae) are both associated with extensive New World radiations that likely originated from a single colonization by an Old World lineage of each group. These two radiations of venomous snakes show a number of significant evolutionary, distributional, and biogeographic parallels. Utilizing recently updated and estimated molecular phylogenetic topologies for both groups we examine major biogeographic hypotheses in the context of an approximated time scale for the evolutionary history of both groups. We compare and contrast major biogeographic events demonstrated by each group and highlight significant areas that require clarification before a more definitive estimate of comparative biogeography can be attained.

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#### Systematics and conservation of the genus *Ambystoma* in Mexico

Mexico presents a relatively high diversity of salamanders of the genus *Ambystoma*, with 16 endemic species mostly distributed along the Transverse Neovolcanic Belt, with transforming and also facultative and strict neotenic forms. Several factors such as habitat lost and alteration, emergent diseases or exotic species threaten most of the species. However, a major problem to preserve the diversity of Mexican *Ambystoma* is the unresolved systematic and taxonomy of the group, which has become a hard-to-resolve mess. We have analyzed the phylogenetic usefulness of different molecular markers, such as mitochondrial and nuclear DNA sequences. These data shows a very shallow interspecific genetic differentiation and fail to resolve most of phylogenetic relationships, presenting the existence of several non-monophyletic species. Apparently the taxonomic diversity of this group is overestimated and our results are more concordant with the existence of a few polymorphic species. Other possibility is that *Ambystoma* in central Mexico has experienced a recent, rapid radiation with not enough time to accomplish full lineage sorting. The use of faster markers, such as microsatellites, and a different point of view, closer to population genetics, will be useful to clarify this situation. Our preliminary results with microsatellites show different levels of genetic diversity among species, being larger

in a transforming population from central Mexico than in a neotenic and a peripheral population.

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Dietary exposure to trace metals in nursery-bound lemon sharks (*Negaprion brevirostris*) at Bimini, Bahamas

Arsenic, cadmium, lead, mercury, nickel, tin and uranium are non-essential trace metals (NTMs) and may be toxic to sharks at low concentrations, affecting growth and survival. Sharks are prone to NTM bioaccumulation due to their high positions in trophic food webs and long life spans. Increases in bioavailability and bioaccumulation of sediment associated NTMs into marine food webs have been reported following dredging and mangrove removal, activities which have been impacting a juvenile lemon shark (*Negaprion brevirostris*) nursery at Bimini, Bahamas, since 1999. Subsequently, in 2004 we investigated 16 metal concentrations in sediments ( $n = 29$ ), prey ( $n = 153$ ) and lemon shark muscle tissue ( $n = 12$ ) from the impacted nursery and an unimpacted control nursery, in order to elucidate and compare baseline metal contamination levels at Bimini. All NTM concentrations were higher in impacted nursery sediments, with significantly greater arsenic and mercury levels (Kolmogorov-Smirnov tests,  $P < 0.01$ ). However, prey NTM concentrations were similar in both nurseries, with some of the highest levels recorded in mojarras (Gerreidae), probably as a result of their benthic feeding habits. Transfer of metals into the food web may be delayed due to sequestration of metals in sediments and limited tidal flushing in the impacted nursery. Muscle tissue concentrations of cadmium and tin were greater in sharks from the impacted nursery, and mean lead concentrations in lemon sharks ( $7.60 \pm 1.77 \text{ mg kg}^{-1} \text{ dry wt}$ ) were higher than previously reported for sharks. As the dominant prey of juvenile lemon sharks, mojarras may be the principal contributors of NTM exposure in these sharks. Consequently, early life dietary NTM exposure in Bimini lemon sharks was calculated using daily ration estimates. These data suggest NTMs may contribute to reduced growth rates reported in lemon sharks from the impacted nursery, although further work is required.

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### Migration ecology of spotted salamanders on golf courses in southern New England

We assessed the emigration behavior of 108 radio-tagged adult spotted salamanders (*Ambystoma maculatum*) on three golf courses and two control ponds located in closed-canopy forests in southern New England. We also used drift fence arrays to monitor movements of juvenile amphibians across fairways. Maximum dispersal distances from the edge of control ponds were  $108.7 \pm 10.2$  m (SE, max = 247 m, n = 28), while salamanders emigrated much farther on golf courses ( $163.0 \pm 13.5$  m, max = 467 m, n = 65,  $p = 0.002$ ). We detected no differences between genders in emigration distances at control ponds (males: mean =  $99.5 \pm 17.4$  m; females: mean =  $119.2 \pm 11.6$  m,  $p = 0.34$ ), however females emigrated much farther on golf courses (mean =  $200.6 \pm 24.6$  m) than males (mean =  $143.7 \pm 15.4$  m,  $p = 0.045$ ). In Connecticut, 40% of 50 radio-tagged salamanders emigrated across fairways, with a mean dispersal across turfgrass of  $80 \pm 11$  m. At two golf courses in Rhode Island, 50% of 20 salamanders dispersed across fairways or fairways under construction. Although there was no difference in mortality rates of adult spotted salamanders on golf courses compared to control ponds, salamanders at one golf course were vulnerable to predation by common gartersnakes (*Thamnophis sirtalis*). Based on drift-fence array captures, we documented movements of juvenile amphibians across fairways, including spotted salamanders, wood frogs (*Rana sylvatica*), and American toads (*Bufo americanus*). Thus, our study suggests that fairways on golf courses do not represent an absolute dispersal barrier to pond-breeding amphibians. Individuals migrated across turfgrass, but exhibited strong preferences for forested habitats as non-breeding habitat. Our results suggest the retention of extensive forested habitats within the dispersal distances of adult and juvenile amphibians is necessary to insure long-term viability of amphibian populations on golf courses.

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### Facultative flattening of the trunk in swimming *Nerodia sipedon*

When watersnakes (*Nerodia sipedon*) swam they laterally flattened the rear half to two thirds of their bodies. Eleven adult snakes recorded swimming within 2-3 hours after capture and then photographed anesthetized and suspended in water and resting on a flat surface showed that the cross-sectional shape of the trunk of a swimming snake was significantly different from its resting forms. Longer-term captives were less likely to swim and swam at half the relative speed of snakes that were tested

immediately after capture. All of the adult snakes flattened their bodies when they swam. Relative velocities of neonate snakes approximated those of recently captured adults but their bodies were significantly less flattened. In recently captured snakes there was a significant positive correlation between extent of lateral flattening and relative swimming velocity. Despite smaller sample sizes there appeared to be no relationship between body shape and swimming velocity in long-term captives or neonates. Measuring drag on models of rounded and flattened body segments in a flow tank demonstrated that, keeping other variables constant, a laterally flattened body shape generates greater thrust and can enhance swimming speed. Body form in swimming adult *Nerodia* approached values obtained for preserved sea snakes and relative swimming velocities in *N. sipedon* approached or exceeded those reported for sea snakes and sea kraits.

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Spatial learning in the ground skink, *Scincella lateralis*

Spatial learning is the ability to learn the locations of important features in the environment such as food sources or retreats from predators. Many small lizards appear to run directly to retreats when pursued by predators; the only way they could know the locations of such retreats is through spatial learning. I tested the capacity of the ground skink, *Scincella lateralis* to learn the location of a retreat in a simple laboratory experiment. A lizard was placed in an observation chamber with two retreats and chased until it ran under one of the retreats. Eight trials were run: a decrease in the amount of time the lizard took to escape to underneath a retreat from the first through the eighth trial indicates spatial learning. Ground skinks were able to learn to escape to underneath either one of the retreats, but did poorly at learning to escape to underneath one specific retreat but not the other. However, if a lizard is placed in the observation chamber for 48 hours before testing, thereby gaining experience with the 'environment' in which it is tested, its ability to learn to escape to underneath one specific retreat improves significantly. These results suggest ground skinks are capable of learning the locations of retreats only within the parts of their environment with which they are familiar (such as their home range).

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**PAULY, GREGORY B.**

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Mating signal evolution and sexual selection in western toads, *Bufo boreas*

Anuran advertisement calls, the showy trains of peacocks, and the striking colors of many fish are adaptations for obtaining mates. These traits, however, can also have major costs such as attracting predators. Thus, how and why such traits evolve is a long-standing question in biology. Models that describe the evolution of these sexually selected traits are classified as either direct or indirect depending on whether the male trait and the female preference are co-evolving. The western toad, *Bufo boreas*, is unique in being one of the few species with among-population variation in the occurrence of a male mating signal, making it especially useful for testing for these underlying models of evolution. Here, I combine morphological and behavioral analyses to assess the evolution of the male signaling trait (the advertisement call) and the female preference in *B. boreas* and thereby test whether direct or indirect models are operating. Call surveys and a morphological study of over 800 specimens for the occurrence of vocal sacs, which are necessary for producing the long calls of most toads, reveal that only populations from the northeastern corner of the species' range in Alberta and northern Montana can call. I also determine the presence/absence of the female preference for the call using phonotaxis tests in which female responses to test calls broadcast from speakers at opposite ends of an acoustic chamber are scored. These tests demonstrate that females from the calling populations have the preference for the call. A non-calling population in Montana that is geographically and genetically close to these calling populations and two genetically distant non-calling populations will be tested in spring, 2006. The call production and female preference (phonotaxis) results will be interpreted using a recently generated intraspecific phylogeny to discriminate between direct and indirect models of sexual selection.

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New *Glanidium* species (Siluriformes: Auchenipteridae) from rio Corumbá, upper rio Paraná basin, Goiás State, Brazil

*Glanidium* currently houses seven nominal valid species. It is a monophyletic group based on the median portion of anterior proximal radials of anal fin joined to each other through ligaments. In recent samples at rio Corumbá, an affluent of rio Paranaíba, upper rio Paraná basin, conducted by Núcleo de Pesquisas em Limnologia, Ictiologia e Aquicultura and Furnas Centrais Elétricas, the new species was captured. Rio Corumbá seems to harbor some endemic species from

different orders, such as *Steindachnerina corumbae*, *Phenacorhamdia unifasciata*, and *Rivulus pictus*. It is attributed to a series of rapids which represent barriers to free dispersal of fishes between upper and lower parts of the basin. Currently, only *G. cesarpintoi* is recorded from the upper Rio Paraná basin. This species does not occur in the rio Corumbá drainage, nor the new species occurs in the remaining upper rio Paraná basin. It corroborates the hypothesis of the endemism of rio Corumbá region. Measurements and meristics were taken to describe the new species, in addition to osteological and muscle features. *Glanidium* n. sp. can be differentiated from *G. catharinensis*, *G. leopardus* and *G. ribeiroi* by body coloration pattern (homogeneous dark pigments on body dorsal surface vs. lighter dark blotched body); from *G. melanopterus* by fins coloration pattern, except caudal one (hyaline fins vs. dark fins); from *G. albescens* by pectoral-fin branched rays (5 vs. 6), and wider orbital diameter (18.6-23.4% HL vs. 15 % HL); from *G. cesarpintoi* and *G. bockmanni* by adult size (larger than 80.0 mm vs. shorter than 50.0 mm). In addition, *Glanidium* n. sp. can be distinguished from *G. cesarpintoi* by presenting adipose fin (vs. absent); from *G. bockmanni* by having more anal-fin branched rays (8 vs. 7), pectoral-fin spine with retrorse spinules on anterior margin (vs. antrorse), and other percents of body and head.

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### Conservation assessment and prioritization of areas in the Indo-Burma biodiversity hotspot

The extent and rate of natural habitat loss is increasing worldwide, but limited resources for conservation remain limited. This situation calls for novel approaches towards identification and prioritization (ranking) of areas for attention. The challenges in way of such prioritization are both practical and theoretical. Perhaps the most common practical hurdle is incompleteness of biological data, which makes comprehensive area prioritization a very difficult task. Here we use a combination of ecological niche modeling and algorithmic prioritization with two related objectives: (1) to evaluate the conservation efficacy of the current conservation area network in the Indo-Burma biodiversity hotspot, and (2) to find potential solutions for expanding the current network. Using distributional data for 186 species of amphibians and reptiles from Northeast India and Burma (Myanmar), we project potential geographic distributions using Maximum Entropy (Maxent) niche modeling. We then use these distributions to prioritize areas with a heuristic algorithm that seeks to maximize the representation of all species in the landscape using complementarity (uniqueness) and rarity as primary criteria. Our results indicate the utility of such methods for finding conservation prioritization solutions in data poor regions. Apart from providing an objective assessment of the existing protected area network in the region, the results draw attention to hitherto

overlooked areas in Northeast India and Burma that deserve special attention, both in terms of future surveys, as well as conservation effort.

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### Variation in food web structure along the longitudinal gradient of the Bladen-Monkey River, Belize

Using stable isotope analysis, food web structure was investigated at 5 sites spanning the longitudinal gradient of the Bladen-Monkey River drainage in southeastern Belize. Tissue samples from common plants, detritus, macroinvertebrates, and fishes were collected during December 2005 - January 2006. The most upstream site (Firetail Creek) had a relatively narrow channel, steep bed gradient, large coarse substrate, and closed canopy. Aquatic invertebrates and fishes from Firetail Creek appear to be strongly dependent on terrestrial food resources. The Upper Bladen River drains heavily forested terrain of the Bladen Nature Reserve and has a wider channel, more heterogeneous substrate, and receives more sunlight. The fish assemblage of the Upper Bladen contains more species and is dominated by cichlid fishes. Benthic algae and terrestrial vegetation both are important production sources for the Upper Bladen food web. The Middle Bladen River has a lower gradient, finer substrates, and a more impacted watershed than the Upper Bladen. The fish fauna is essentially the same as that from the Upper Bladen, but isotopic and apparent trophic differences were observed for some taxa. The Lower Monkey River is under tidal influence and has a broad channel lined with sedges and covered by little canopy. Sediments are very fine and diverse freshwater and estuarine fishes and macroinvertebrates inhabit open waters of the main channel, dense beds of floating plants, and lentic secondary channels. Consumers of the Lower Monkey River showed a broad range of isotopic signatures that reflect assimilation of carbon sources from diverse local production sources as well as marine sources consumed by coastal migrants. Marine fauna collected from adjacent coastal mangrove and seagrass habitats also were collected and analyzed in an attempt to identify trophic links with the Bladen-Monkey River system, and those findings will be reported.

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**PEÑA-LOYOLA, PAULA; MERINO-VITERI, ANDRÉS**

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Behavior and activity of a chytrid-infected population of one of the last jambatos (*Atelopus*: Bufonidae) from Ecuador

We studied an undescribed species of *Atelopus* from Morona Santiago Province in southeastern Ecuador, from November 2004 to December 2005. Focal observations and experimental manipulations were made during a 12 month period in order to determine time of maximum activity and to describe behavior. During 1366 hours of fieldwork, we observed 103 individuals (87 males, 14 females, and 2 juveniles); among them, were 7 amplexant pairs, observed between April to September, 2005. *Atelopus* sp., is diurnal and active from 5:45h to 19:40h. There were two periods of maximum activity, one at mid-morning and another in late afternoon. During, the activity period, frogs were on the ground; at night, they rested on leaves, from 0,30-2,15 m, above ground. In response to experiments, focal individuals displayed three classes of behaviors: vocalizations, limb signaling and repositioning orientation. Seventy calls of 8 males were recorded and both physical and spectral parameters were analyzed. Communication via acoustic signals was more predominant in this species, than visual signaling. Among 25 frogs recorded with clinical signs of the fungal disease caused by *Batrachochytrium dendrobatidis*, we made focal observations of 8 (7 males, 1 female). These frogs were found resting in abnormal positions on boulders along the river Napinaza rather than on leaves in the adjacent vegetation. Infected individuals showed lower feeding and vocalization rates than healthy ones; nonetheless, they moved (repositioning orientation) at higher rates, with no apparent prey stimuli or calls and/or presence of conspecific individuals. Poor reproductive associated behaviors, such as courtship, and failure to document egg deposition may be caused by the unhealthy condition of this population.

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Effects of artificial night lighting on reptiles and amphibians in urban environments

With the exception of negative consequences for sea turtles, data on the effects of night lighting on reptiles and amphibians are uncommon. We reviewed the available literature for urban species, which are most likely to be exposed to light pollution.

Enhanced lighting can facilitate foraging in edicarian species, but may also increase mortality or change the dynamics of interspecific competition. In amphibians, artificial light can also have behavioral and physiological effects, e.g., influencing larval growth rates and sperm production. Some diurnal species have been observed being active near artificial lights at night. Artificial lights can also provide basking sites for nocturnal species. We identified several general patterns: 1) Few studies on the effects of night lighting on herpetofauna are available. Positive effects are especially poorly studied; 2) Species vary in their sensitivity to light pollution, which may have no effect, benefit, or negatively affect a particular taxon; 3) Lighting conditions differentially affect various aspects of the biology of a given species. These effects can differ across life stages; 4) Indirect effects are likely to be common, such that benefits to one species may negatively influence another; and 5) The ability of artificial light to enhance the invasive potential of some species should be a source of broad concern. Lights associated with roads are also a potential source of concern, but we could find few studies directly evaluating this risk. A number of studies have identified alternative lighting methods that would reduce or eliminate the negative influence on sea turtles and also be acceptable to humans, but none have looked at effects on other taxa. Light pollution is a serious threat that should be considered as part of planning and management decisions in urban areas containing reptiles and amphibians.

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#### A curious muscle associated with the V4 pleural rib of cypriniforms

Ostariophysan fishes are noteworthy for the presence of the Weberian apparatus, a series of bones that interconnect the gas bladder with the inner ear. The literature is rich in descriptions of the hard elements of the apparatus including the highly modified ribs. Soft elements like the extrinsic muscles have received little attention and are the basis of this study. Twenty one species from five cypriniform families, Cyprinidae, Catostomidae, Cobitidae, Psilorhynchidae, and Gyrinocheilidae, and several outgroup representatives of Characiformes and Siluriformes, were dissected to describe and attempt to understand the function of the musculature attaching to the gas bladder and the elaborated pleural rib. In the cypriniform species examined, a muscle, the cleithropleuralis, interconnects the medial cleithrum with the ventral tip of the V4 pleural rib. A separate muscle, the swimbladder protractor, interconnects the ventral surfaces of the first three vertebrae with the cranial surface of the gas bladder. The cleithropleuralis is similar in cyprinids and catostomids but the swim bladder protractor was more robust in cyprinids. While the swim bladder protractor in silurids is a broad muscle covering the anterior end of the gas bladder and extending to the ventral surface, my findings for cypriniforms have shown it to be a centralized muscle attaching to only the anterior face of the gas bladder. Based on the position of the cleithropleuralis, I pose that it could be used to fine-tune the tension in the gas bladder external covering during vertical migrations for improved sound reception or possibly to provide a means of directional location of sounds.

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**PERSONS, A. KAREN**

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**Morphological disparity within the darter Subgenus *Nothonotus***

Geometric morphometrics were used to examine the morphological disparity exhibited by members of the darter subgenus *Nothonotus*. The bayou darter, *Etheostoma rubrum*, which is endemic to the Bayou Pierre system of Mississippi, and its sister taxa, *Etheostoma moorei*, which is endemic to the upper Little Red River of Arkansas were examined along with *Etheostoma rufilineatum*, a more widely distributed member of the subgenus. Although closely related, *E. rubrum* and *E. moorei* were expected to exhibit disparity arising from both clinal and latitudinal differences; however, they were not expected to exhibit a high degree of intraspecific disparity. Based on a variable latitudinal range, intraspecific disparity was expected to be exhibited by *E. rufilineatum*. Also based on geographic and clinal positioning, the three species were expected to exhibit interspecific morphological disparity.

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**PETERS, MAUREEN B.**

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**Genetic variation in the endangered Gila Trout**

Gila trout (*Oncorhynchus gilae*) was one of the first species to be protected under the US Endangered Species Act in 1973. Habitat degradation and introduction of exotic trout in the American southwest have resulted in declines in abundance and geographic range size. The recovery plan identified four original non-hybridized lineages in 1997, and hatchery propagation from these lineages has proceeded since. Currently, wild populations are managed by federal and state agencies as two recovery units representing the Gila and San Francisco River drainages. Gila trout exist in small, isolated populations and are thus susceptible to loss of genetic diversity through genetic drift and inbreeding. However, genes of the major histocompatibility complex (MHC) may retain high levels of genetic diversity despite reduced population size. The MHC is involved with pathogen recognition and is subject to balancing selection whereby genetic variation persists. In this study, we analyzed ten populations of Gila trout for genetic variation at exon 2 of the MHC class II gene and six presumably neutral microsatellite loci. Low allelic diversity at MHC was identified in Gila trout as a whole, and most populations were significantly divergent from one another. Furthermore, the sole (wild) population comprising the San Francisco River recovery unit is most divergent from all other populations at MHC. Comparative analysis of MHC and microsatellite loci revealed further information on population dynamics such as expansion, contraction, and the nature and magnitude of selection on MHC. These genetic data are intended to help guide hatchery propagation and repatriation of fishes to the wild.

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**PETERSON, JOHN D.**

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Sublethal effects of coal combustion residues on Southern Leopard Frog (*Rana sphenocephala*) growth and metamorphosis

Coal combustion residues (CCRs) have become a major global pollutant due to increased usage of energy derived from coal burning power plants. 57 million tons of CCRs, containing high concentrations of contaminants, are released into aquatic settling basins each year. Numerous organisms, including anurans, inhabit these basins and wetlands, which puts them in close contact with CCR contaminated substrates. Previous research has shown that CCRs pose major threats to wildlife and their natural environments due to the large amounts of trace elements found in these areas. While chronic exposure to CCRs is not always lethal, it has been shown to have a detrimental effect on development and morphology in larval anurans. In the current study, Southern Leopard Frog (*Rana sphenocephala*) tadpoles were exposed to CCRs and clean sand (control) substrates (48 tadpoles per treatment) during larval development and metamorphosis. When individuals reached key developmental stages (Gosner stages 37, 42, and 46) mass, total body length, and the number of days since hatching were recorded. Oral disc morphology was also assessed at Gosner stage 37. On average, tadpoles exposed to CCRs took significantly longer to complete metamorphosis (25% longer), weighed significantly less upon completion of metamorphosis (40% less), and were significantly shorter (12% shorter) when compared to control tadpoles. Oral malformations occurred in all of the CCR treated tadpoles while none occurred in the control. These malformations varied in severity from loss of the most anterior tooth row to loss of all tooth rows and the anterior jaw. When compared to studies on other anurans, *R. sphenocephala* appears to be more susceptible to CCR substrates during development. Changes in larval growth, development, and oral morphology may provide insight into the impact CCRs have on key bottleneck events in anuran life history.

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Inter-specific differences between two anuran tadpoles' susceptibility to *Batrachochytrium dendrobatidis* infection within a contaminated wetland

The amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) has been linked to amphibian population declines in Australia, Europe, Central America, and North America. It has been suggested that cofactors, like contaminants, may increase susceptibility to this fungus. For the past 25 years, amphibian populations native to the Savannah River Site (SRS), South Carolina have not experienced any inexplicable population decline events though chytridiomycosis was documented in three adult individuals (two American Bullfrogs, *Rana catesbeiana*, and one Southern Leopard Frog, *R. sphenocephala*) collected there between 1978 and 1981. Given that *B. dendrobatidis* was previously present on the SRS, we conducted a field survey to identify whether *B. dendrobatidis* is still present and whether infection may be linked to trace element contamination. In the summer of 2004, *R. catesbeiana* and *R. sphenocephala* tadpoles were collected from wetlands constituting a contamination gradient on the SRS. *Batrachochytrium dendrobatidis* infection was identified in 64% of the *R. catesbeiana* tadpoles sampled and histologically assessed (N= 50) from a site contaminated with mercury, copper, and zinc. No *R. sphenocephala* tadpoles from this site (N= 50) were found to be infected. These data suggest that *B. dendrobatidis* is still present in some wetlands on the SRS and is capable of infecting amphibians. The data also suggest that *R. sphenocephala* tadpoles may be resistant to *B. dendrobatidis* infection.

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If you bring them will they stay? A case study of alien Nile tilapia, *Oreochromis niloticus*

We studied the life-history of Nile Tilapia near two aquaculture facilities for two years in southeastern Mississippi. In 280 collections, Nile Tilapia ranked 6th in abundance overall, ranked 2nd in Robinson Bayou (inland, low-order stream), and 16th in Simmons Bayou (an estuarine tidal creek). The downstream effluent never dropped below 15.1C. Normal environmental conditions, the presence of the downstream thermal refuge, and the low salinity of our bayous all combine to provide a quality environment for escaped fish. Nile Tilapia exhibited year-round reproduction with increased intensity in March-May and in August-September.

Small juveniles were collected every month except March, and multiple size classes suggest successful recruitment. The smallest female with mature oocytes was 79.9 mm TL, and 50% of the females were mature at 113 mm TL, suggesting they can spawn in their first year of life. Nile Tilapia diet was separated from three native centrarchids based on cluster analysis, and sequential two-way nested ANOSIM indicted there was no seasonal difference, but there was a moderate size class and a strong species difference. SIMPER indicated distinct diets: bluegill and redear sunfish consumed chironomids and insects; largemouth bass consumed fish and insects; and Nile Tilapia fed most often on sediment resources like nematodes, rotifers, bryozoans and hydrozoans. Nile Tilapia had the highest frequency of mud, sand and detritus in their stomachs, suggesting they fed directly on bottom sediments. Collectively, these data support our contention that this alien species feeds at the base of the food web, is well adapted to survive, reproduce, and proliferate in non-native environments, and the life history metrics we measured are nearly identical to those reported in the literature from African environments. The philosophy that allows the escape of alien taxa into our present landscape, justified by the belief that species will not survive or become established, is fallible.

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### **PETRY, PAULO**

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#### **Gems in the trash can: New discoveries of *Phreatobius* (Siluriformes, Incertae Sedis) from leave-litter banks in the Rio Negro**

The genus *Phreatobius* was proposed by Goeldi in 1905 with the description of *P. cisternarum* collected from a water well in Marajó Island. The genus remains poorly known and its relationship to other catfishes still remains uncertain. Two new species of catfishes with external morphology and osteological characters that allows to assign them to *Phreatobius* were discovered inhabiting leave-litter banks along tributaries of the Rio Negro, extending the distribution of the genus within the Amazon basin. The two new species can be distinguished from *P. cisternarum* by differences in dorsal fin counts, number of caudal fin procurrent rays, anal fin counts, morphometric measurements and osteological characters. A discussion on the diversity and distribution of *Phreatobius* in the Amazon will be presented.

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An analysis of *cyt-b* mtDNA variation in the amphi-Atlantic goby *Bathygobius soporator*

Five species of *Bathygobius* are recognized from the Atlantic Ocean. Of these, two species are endemic to the western Atlantic and two others are endemic to the eastern Atlantic. Only the Frillfin Goby, *Bathygobius soporator*, is found on both sides of the tropical and subtropical Atlantic Ocean. A recent study of the Frillfin Goby comparing allozymes and cytochrome *b* sequences of specimens from the Brazilian coast and Rocas Atoll with a Bahamian population suggested that populations from the Bahamas and Rocas Atoll were genetically similar, but highly distinct from coastal Brazilian populations. We obtained partial sequences of the cytochrome *b* gene of specimens identified as *B. soporator* from Curacao, the Florida Keys and Guinea, West Africa. Specimens of *Bathygobius casamancus* from Guinea and *B. curacao* from Curaçao were used as outgroups. Comparison of our data with that from the Brazilian study revealed significant divergence between the Brazilian coastal populations, the Guinean samples, and another Caribbean clade (Florida/Curaçao) distinct from the Bahamian/Rocas clade.

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**PHILLIPS, CATHERINE T.**

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Acoustic signal divergence in *Cyprinella galactura*, the Whitetail Shiner

Acoustic signaling in anurans, insects, birds, and mammals has played an important role as an interspecific isolating mechanism and is also believed to be a mechanism of sexual selection in intraspecific mate choice. A similar mechanism in North American freshwater fishes has been virtually unexplored. Before the evolutionary significance of signal divergence in fishes can be determined, a detailed description of variation within and between species must occur. *Cyprinella galactura*, the whitetail shiner, is known to produce sounds during the breeding season and due to its disjunct distribution and complex acoustic repertoire, was the perfect model for a study of this type. Acoustic variation was examined within individuals, among individuals, and among populations. Significant population-level differences in temporal and spectral parameters were found. Furthermore, significant differences in divergence of courtship vs. agonistic signals were examined and the role these variations may play in the evolution of acoustic signaling is discussed. This study paves the way for further studies of signal variation within the genus *Cyprinella*.

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Seasonal microhabitat use by Texas rat snakes (*Elaphe obsoleta lindheimeri*) in eastern Texas

Rat snakes are common to most forested areas of the central and eastern United States, ranging from Maine to southern Texas. Given the climatic variation within this latitude/longitude gradient, differences in behavior and microhabitat use are expected. Radiotelemetry was used to investigate habitat use of the Texas Rat Snake (*Elaphe obsoleta lindheimeri*) on the Stephen F. Austin Experimental Forest in eastern Texas. Seven snakes (3 females, 4 males) were relocated several times weekly from April 2004 to May 2005 to quantify the period of winter dormancy and seasonal changes in microhabitat use. Snakes were tracked a total of 363 times resulting in 201 unique locations across all individuals. Findings show that rat snakes exhibited a sporadic winter dormancy, emerging during periods of warm weather. Rat snakes demonstrated a seasonal difference in arboreality, with the peak occurring from July to August. However, avian nesting did not seem to influence the climbing frequency of rat snakes.

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The age and growth of *Sphyrna lewini* and *S. mokarran* in southeastern U.S. waters

We examined the age and growth of the scalloped hammerhead (*Sphyrna lewini*) and great hammerhead (*S. mokarran*) off the southeast United States and in the eastern Gulf of Mexico. Our growth estimates for the scalloped hammerhead shark suggest slower growth than populations in the Pacific Ocean but faster growth than previously reported in the Gulf of Mexico. Our growth estimates for the great hammerhead are the first reported for this species. These results show that growth rates differ between these two species. The life history characteristics obtained as a result of this study suggest that the scalloped hammerhead and great hammerhead sharks are highly susceptible to exploitation by commercial fishing.

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### Evaluation of fatty acid signatures in diet analysis of elasmobranch fishes: A test using the Atlantic Stingray

To test the hypothesis that the fatty acid signature of a predatory elasmobranch could be used to reconstruct its diet, we examined the effect of two different diets on the fatty acid composition of the Atlantic stingray, *Dasyatis sabina*. Captive stingrays were fed diets of fish or shrimp for a one-month period. At the conclusion of the feeding trials, the stingrays were sacrificed and liver and muscle tissues were analyzed for fatty acid composition. Muscle had much lower lipid content than liver and the two tissues were significantly different in fatty acid composition. However, there was no significant difference in fatty acid composition between fish-fed and shrimp-fed stingray liver or muscle samples. Both fish-fed and shrimp-fed stingray tissues were significantly different than corresponding diet samples in fatty acid composition. Statistical analysis did not group stingray muscle tissues with the corresponding diets. These data suggest that fatty acid analysis may not be suitable for elasmobranch diet reconstruction.

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### Do neighborhood conservation areas work? A drastic reduction in lizard occupancy coinciding with improved habitat quality and surrounding development

As humans spread into large tracts of undisturbed lands, problems associated with maintaining and protecting local biodiversity in fragmented landscapes arise. In response, relatively small conservation lands are often set aside to protect individual species during large-scale land development. However, the question of whether these conservation areas are functioning as designed (e.g., maintaining viable populations) is rarely addressed. We monitored a population of sedentary, fossorial lizards (*Plestiodon* [= *Neoseps*] *reynoldsi*) and quantified vegetation changes in a string of neighborhood conservation areas ( $n = 6$ , ranging in size from 2.5-27.9 ha) to determine the value of these sites in protecting focal species. At the beginning of our study we used prescribed fire and selective canopy thinning to restore habitats to more natural states. However, we describe the rapid and catastrophic decline in relative density and habitat occupancy of *P. reynoldsi*, coinciding with improved habitat quality and surrounding development. We present testable hypotheses of the observed declines, and propose that indirect impacts from surrounding development (e.g., changes in soil hydrology) negatively affected this population. *P. reynoldsi*

requires well-drained, sandy soils, and the construction of nearby water-retention ponds or runoff from surrounding neighborhoods may have caused groundwater levels to rise, altering soil conditions. If small, sedentary, and secretive vertebrate species cannot survive in small conservation areas surrounded by development, then the usefulness and function of neighborhood conservation areas should be re-evaluated.

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### Shark movement and habitat use at Glovers Reef Marine Reserve, Belize

A six-year annual longline survey of the sharks and rays of Glover's Reef Marine Reserve, Belize documents the use of this oceanic atoll by at least twelve elasmobranch species, including early life-stages of Caribbean reef *Carcharhinus perezi*, nurse *Ginglymostoma cirratum* and lemon *Negaprion brevirostris* sharks and southern stingrays *Dasyatis americana*. Catch rates from the longline study were used to compare the species and age-distribution of sharks in different habitat types (shallow lagoon, deep lagoon, ocean reef). Nurse sharks dominated both shallow and deep lagoon catches, with smaller individuals more prevalent in the shallow lagoon. Caribbean reef sharks of all size classes dominated the ocean reef catches, but small juveniles were also common in the deep lagoon. An array of acoustic monitors throughout Glover's Reef was used to track the movements of tagged individuals of the two most common shark species, nurse and Caribbean reef sharks. Both nurse sharks and Caribbean reef sharks, although occasionally wide-ranging, exhibited site-fidelity to particular locations around the atoll. All sharks were most frequently detected at the site nearest their capture and visited up to 13 additional, usually neighboring, receiver sites less frequently. Although less than 6 % of the total area of Glover's Reef was within the detection range of this non-overlapping receiver array, most sharks of both species were detected somewhere within the array on an almost daily basis from May to October 2004, with no evidence of seasonal emigration of these two species away from the atoll over this period. Both species also moved widely throughout the 10 by 30 km atoll. The findings suggest that effective no-take marine reserves need to be large (boundaries of at least tens of kilometers) and encompass not only diverse habitats (ocean reefs, seagrass flats, lagoons) but also the areas that connect them (i.e. major channels).

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**PILLER, KYLE R.**

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Resource partitioning and morphometric diversity among silverside fishes (Atherinopsidae: *Chirostoma*), Lake Chapala

Adaptive radiations represent one of the most interesting evolutionary phenomena and in recent years, have received much study due to its perceived importance in diversification and speciation. Members of the genus *Chirostoma* (Actinopterygii: Atherinopsidae), a morphologically diverse genus of silverside fishes, are believed to be the result of an adaptive radiation. Lake Chapala, Mexico, the center of *Chirostoma* diversity, harbors eight sympatric species that have diversified in body shape and size and trophic specialization. This study was undertaken to assess whether trophically similar species of *Chirostoma* in Lake Chapala have converged on similar body morphometries. Landmark data for geometric morphometrics were gathered from 155 museum specimens from eight sympatric species of *Chirostoma* to determine if body shape and trophic position are linked and therefore likely important in the diversification of this group. The results indicate that there are significant differences in body shape among all Lake Chapala species of *Chirostoma* (MANOVA Wilks' =0.1504, F=30.578, p<0.0001). Canonical variates analysis indicates that piscivorous species (*C. lucius*, *C. sphyraena*, and *C. promelas*) and non-piscivorous species (*C. jordani*, *C. labarcae*, *C. consocium*, *C. chapalae*, and *C. contrerasi*) are completely separated in morphospace along canonical variates axis 1. However, there is a large degree of overlap among the piscivorous species, which all possess elongate jaws and bodies relative to all other species. Canonical variates axis 2 discriminates among some species within the non-piscivorous trophic guild, however there is some overlap in body morphometries of *C. chapalae* and *C. consocium*, likely associated with similarities in resource acquisition.

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Amphibian monitoring in the Barataria-Terrebonne National Estuary leads to a proposed expansion of geographic distribution for the Bird-voiced Treefrog (*Hyla avivoca*)

Currently, an acre of coastal wetlands is lost every 30 minutes in Southeast Louisiana. To reverse this natural disaster, restoration activities are being proposed that will divert water and sediments from the Mississippi River into adjacent swamps and marshes of the Barataria-Terrebonne National Estuary System. In an effort to document the environmental health of this endangered system, our lab has begun monitoring the reproductive status of fish and amphibians throughout the estuary. These data will serve as a baseline for comparison once proposed hydrologic modifications and restoration activities have been implemented. Seeking to obtain a

broad indication of reproductive health we have combined methods that document behavior, anatomy, physiology and molecular biomarkers. Here we present data on reproductive behavior, recorded on newly established call-survey routes, conducted according to NAMP protocols in Lafourche and Terrebonne Parishes. The upper site, near Choctaw, LA, is comprised of cypress-tupelo swamp with freshwater marshes that are connected to but minimally influenced by tidal fluctuations. The lower site, near Dularge, LA, represents some of the southernmost freshwater of the estuary with frequent brackish water influences from Lake De Cade and Falgout Canal. To date we have identified the calls of twelve anurans and collected two urodeles, confirming the expected range for most of these species. Additionally, we propose a revision in the geographic distribution of the Bird-voiced Treefrog (*Hyla avivoca*), to extend its range to include the Barataria-Terrebonne Estuary System. Funding was provided by USGS, NOAA, La Board of Regents and the Nicholls Research Council.

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**Impacts of introduced herpetofauna in the US Virgin Islands**

Island ecosystems are highly sensitive to the impacts of introduced species. Non-native snakes, lizards, and amphibians can introduce diseases into native populations and have other deleterious effects through predation, competition, and habitat manipulation. The US Virgin Islands, situated on the Puerto Rican Bank in the eastern Caribbean, has a long history of human impacts and species introductions. Two species, the Green Iguana (*Iguana iguana*) and the Red-footed Tortoise (*Geochelone carbonaria*) were historically introduced and have become naturalized with little apparent impact to the native ecosystem. Recent years, however, have seen the swift introduction of several highly invasive species that have proved to have severe impacts when introduced elsewhere, specifically the Cuban Treefrog (*Osteopilus septentrionalis*), Cane Toad (*Bufo marinus*), and Red-eared Slider (*Trachemys scripta*). The distribution of non-native herpetofauna on the islands of St. Thomas and St. John has been recorded, and potential routes of introduction and dispersal identified. The Cuban Treefrog is distributed widely across the islands, while the Cane Toad and freshwater turtles are more limited in range. Additional species are being identified, having arriving via cargo shipments. The implications are grim for native herpetofauna and other wildlife.

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### Explaining the morphological peculiarities of solitary island species of *Anolis* lizards

Communities of similar species often are ecologically and morphologically diverse due to interspecific competition. Conversely, solitary species are predicted to undergo 'ecological release,' expanding their habitat use and evolving towards energetically optimal morphologies. Schoener, Williams, Lister, Roughgarden, and others have documented patterns of greater sexual size dimorphism (allowing greater niche breadth within species) and energetically efficient body size in solitary species of West Indian *Anolis* lizards. These patterns have generally been assumed to be evolutionary responses to solitary existence, but this contention has not been tested in a comparative phylogenetic context. We use statistical analyses of an expanded data set of mainland-associated and West Indian *Anolis* to show that solitary island species do indeed display greater sexual size dimorphism and uniform size relative to *Anolis* in multispecies communities, but this pattern cannot be attributed to evolutionary response to solitary existence. We evaluate two alternative explanations, of ancient ancestral colonization and ecological filtering of suitable colonizers, and find that species with greater sexual size dimorphism and intermediate size may be more likely to colonize successfully. These results show that the existence of unusual characteristics in isolated species may require historical as well as ecological explanations.

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### New species of *Anolis* lizards from Peru

Recent fieldwork on the eastern Andean slope of Peru has revealed several undescribed species of *Anolis*. We describe two new species of phenacosaur *Anolis* from northern Peru. These species, one of which was originally allocated to *Phenacosaurus* (= *Anolis*) *orcesi* by Williams and Mittermeier, are members of the *orcesi*-group of phenacosaur *Anolis* but differ from other members of this group in color and scalation. We also describe two new green *Anolis* of the *punctatus* group: a large long-legged anole most similar to *A. huilae* of Colombia and a smaller form similar to *A. boettgeri* of Peru. We describe morphological characteristics of these species, make comparisons to similar *Anolis*, and present a phylogenetic analysis including the new species.

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The *Saurida brasiliensis* species complex revisited: Description of a new species and redescription of *S. parri*

J. R. Norman described in 1935 two new Atlantic species of the lizardfish genus *Saurida*: *S. brasiliensis*, based on one Brazilian and two Trinitarian specimens, and *S. parri*, based on two Angolan and ten Gabon specimens. William W. Anderson and collaborators decided in 1966 that the existing differences between their 125 specimens were insufficient to give specific status to both Atlantic populations and chose the name *Saurida brasiliensis* for the species that has received the common names of Brazilian or largescale lizardfish. After examining 253 specimens from all around the tropical and subtropical continental and insular shelves and upper slopes we propose that Norman was right when separated at the species level the American and African populations of the largescale lizardfish. We have also discovered a new species of this species complex, based on 13 Cuban and Bahamian upper slope specimens, which will be named to honor Dr. Bruce Thompson from the Louisiana State University. The three species can be separated on meristic (scale and fin ray counts) and morphometric grounds.

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The fall and rise of nearshore sharks in the southern California bight

The southern California bight has not been an exception to the global fisheries declines. In our nearshore environment, top down fisheries decimated the nearshore shark fauna and other apex predators in this ecosystem. For coastal elasmobranchs the most storied decline was for soupfin sharks (*Galeorhynchus galeus*) due to their exploitation during WWII. Prior to this fisheries exploitation (1930-1938) a mean of 235 (SE = 22) mt were landed annually. This stock was allowed to be exploited again with less than 50% (range 66-103 mt) pre WWII landings reported until 1985 at which point catches started declining precipitously ( $F_{1,9} = 83.47$ ,  $R = 0.950$ ,  $p < 0.001$ ) through 1995. Leopard shark (*Triakis semifasciata*), landings also declined dramatically during this period (1983-1996;  $R = 0.906$ ,  $F_{1,12} = 54.7$ ,  $p < 0.0001$ ). The exploitation of these sharks was a result of the crash of white seabass (Scianidae: *Atractoscion nobilis*) fishery and the exclusion of Californian fishers from Mexican waters, which increased pressure on our local stocks. Fortunately, gill nets and trammel nets were banned starting in 1994 in state waters. In spite of regional productivity problems associated with the warm phase of the Pacific Decadal Oscillation during the last three decades, all of the apex predators on our nearshore reefs have returned. Ten coastal fishery independent monitoring stations were sampled regularly by gill nets

from 1995-2004. Soupfin sharks ( $F_{1,8} = 8.63$ ,  $R = 0.720$ ,  $p = 0.018$ ) and adult leopard sharks ( $R = 0.870$ ,  $F_{1,8} = 24.8$ ,  $p < 0.0001$ ) have increased linearly since this fishery closure. This recovery was so dramatic that these fishes now appear in diurnal scuba transect programs where they had been absent for the prior three decades. The same trend ( $F_{1,8} = 16.8$ ,  $R = 0.823$ ,  $p = 0.003$ ) was also found for giant seabass (Polyprionidae: *Stereolepis gigas*). In fact, even the white seabass fishery has returned to its pre-crash California landings. Both fishery dependent and independent data sets indicate that nearshore elasmobranchs in southern California are still susceptible to exploitation without proper management and the single most important management action in southern California has been the removal of gill nets from the nearshore arena.

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**\*PORTNOY, DAVID S.; PIERCY, ANDREW N.; MUSICK, JOHN A.;  
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#### Patterns of polyandry in the sandbar shark, *Carcharhinus plumbeus*, in the western North Atlantic

Five species-specific microsatellite markers were used to examine patterns of polyandry in the sandbar shark, *Carcharhinus plumbeus*, in the western North Atlantic. Genetic polyandry was found in the majority of litters examined. In multiply sired litters the number of sires estimated ranged from 2 to 5 with an average of 2.3 males per litter. Most litters were characterized by high levels of reproductive skew, with individual sires accounting for 60% or more of the offspring. Regression analyses showed no significant relationship between female fork length and fecundity or female fork length and sire number. Analyses of the strength of selection for females to acquire multiple mates and males to limit the number of additional sires were carried out following Bateman's principles. Female fecundity had a weak relationship with the number of sires and both the standardized variance in reproductive success and mating success were low. This indicates that the acquisition of multiple mates may have little direct selective advantage to females. Male reproductive success showed a stronger, but inverse, relationship with the number of sires and the standardized variance in reproductive success was larger, indicating the ability to bias paternity may have significant selective advantage to males. These data, in light of past morphological and behavioral studies, suggest that intrasexual and intersexual conflict, as well as indirect female benefit, drive patterns of polyandry in elasmobranchs.

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## Widespread amphibian extinctions from epidemic disease driven by global warming

As the Earth warms, theory predicts, many species will disappear, often because of changing disease dynamics. Here we show that a recent mass extinction associated with epidemics is tied to global warming. Seventeen years ago in the mountains of Costa Rica, the Monteverde harlequin frog (*Atelopus* sp.) vanished alongside the golden toad (*Bufo periglenes*). An estimated 67% of the 110-odd species of *Atelopus*, endemic to the American tropics, have met the same fate, and a pathogenic chytrid fungus (*Batrachochytrium dendrobatidis*) is implicated. Analysing the timing of losses and using criteria of the Intergovernmental Panel on Climate Change (IPCC), we conclude with "very high confidence" (> 99%) that large-scale warming is a key factor. We propose that temperatures at many highland localities are shifting toward the growth optimum of *Batrachochytrium*, encouraging outbreaks. With climate change promoting infectious disease and eroding biodiversity, the urgency of reducing greenhouse-gas concentrations is now undeniable.

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## Systematics, evolution and biogeography of the *Etheostoma simoterum* species complex (Percidae: subgenus *Ulocentra*)

An investigation of meristic, morphometric, and pigmentation of nuptial males indicated that multiple species are present within the *Etheostoma simoterum* species complex. Unique combinations of breast, abdomen, caudal peduncle, mouth, dorsal

fin and lateral pigment characters indicate six morphologically diagnosable species restricted to the following drainages: 1. upper Holston and Russell Fork river drainages, 2. Tennessee River tributaries exclusive of the Duck and upper Holston rivers, 3. Duck River and tributaries, 4. Cumberland River tributaries on the western Highland Rim, 5. Cumberland River tributaries in the Nashville Basin, and 6. Cumberland River tributaries on the Eastern Highland Rim. Phylogenetic analyses of 1337 bp of mtDNA from 25 individuals representing all species of the complex described herein indicated that lineages within the complex had not reached coalescence, with the exception of *E. simoterum*. This incomplete lineage sorting would be expected due to the presumably recent speciation of these taxa and extremely large population sizes of most members of the complex. The overall phylogenetic and biogeographic pattern revealed by the analyses indicated that the Duck River endemic was sister to all other members of the complex. Relationships of the other species of the complex were largely unresolved with the exception of species from the Cumberland representing a clade sister to the species primarily restricted to the Tennessee River. Biogeographic concordance with other species of fishes and lack of coalescence of most lineages within the complex indicated that vicariance has been the predominant mode of speciation for the species within the *E. simoterum* complex. Distributions of other species found in the Cumberland and upper Tennessee but absent from the Duck River system support the hypothesized sister relationship of the Duck River endemic to all other members of the *E. simoterum* species complex.

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#### Diel movements of adult nurse sharks, *Ginglymostoma cirratum*, in the Dry Tortugas, Florida reproductive refuge

Adult nurse sharks in Florida are often found mating in shallow (< 1 m) areas in June and July. Results from telemetry show that adults of both sexes display consistent diel movements spending more time in the shallows at night. Sharks typically leave the shallows just before dawn (0600) and return at various times throughout the afternoon and evening with a peak of abundance around 0100. Some females stay in the shallow refuge all day and are seen by observers to move at times to slightly deeper water, particularly during afternoon low tides. Some movements away from shore are clearly to avoid shoaling after retreating tides. Attempts to predict these larger movements by correlating them with changes in temperature, tide, dissolved oxygen and barometric pressure have shown little positive correlation. Female areal movements during times of reproductive activity are apparently driven more by individual reproductive states that have a stronger influences on activities than abiotic factors. Male diel movements apparently follow female activities during this time.

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### *Atelopus* species skin secretions against the chytrid fungus

*Atelopus* is one of the most affected genera by the amphibian declines and extinctions. Emerging infectious diseases, especially chytridiomycosis have been linked with these declines and extinctions. This disease has been previously reported in species of *Atelopus*. These results are consistent with the hypothesis that chytridiomycosis is a serious threat to *Atelopus*. However, amphibians are known to secrete a wide range of chemical compounds in their skin to protect them against predators and microorganisms. Among these compounds are antimicrobial peptides, which play a role in protection from invasive pathogens such as *Batrachochytrium dendrobatidis* (*Bd*), the causal agent of chytridiomycosis. We examined the occurrence of the chytrid fungus in a population from southeastern Ecuador of an undescribed species of *Atelopus* and the activity of skin secretions of this species to inhibit growth of *Bd* in vitro. *Bd* was identified in skin scraped of four individuals. In addition, these frogs were found exhibiting clinical signs associated with chytridiomycosis in the field. One of these specimens was brought alive and the chytrid fungus was isolated and maintained in stock culture for fungicidal test. *Atelopus* secretions were tested against *Bd* culture to determine their activity.

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### Patterns of chytrid fungus infections in different regions of Costa Rica

*Batrachochytrium dendrobatidis*, the amphibian chytrid fungus seems to be a factor in amphibian declines throughout Central and South America. Although believed to be an introduced pathogen, it seems to be broadly distributed among Costa Rican ecosystems. Herein we describe a preliminary test on the distribution of this pathogen throughout the country trying to find some ecological patterns to its distribution. The 336 specimens of *Eleutherodactylus fitzingeri* deposited in the Museum of Zoology, University of Costa Rica, were checked for infections of this disease. Twenty-four of these had chytrid fungus in their skin. Significant differences were found when taking in account the slope where the animals were collected. A much higher infection rate is present on Caribbean specimens than on the Pacific. We further analyze these patterns using GIS correlating the different environmental factors to explore what could be causing this effect. Differences in patterns of rainfall and average hours of sunshine could be playing a significant role in these observed patterns.

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Snake species richness in relation to habitat in the post oak savannah of east central Texas

This project examined species richness and relative abundances in a heterogeneous landscape within the post oak savannah of East Central Texas. Snakes were sampled using funnel traps (with drift fences for terrestrial species) and hand capture from April to August of 2005 at a 1295 hectare ranch managed for wildlife habitat. Ten sites were sampled within the following habitat categories: upland woodland, prairie, riparian forest, and ponds. A total of 184 individuals of 15 species were observed or captured. The most abundant species were the blotched watersnake (*Nerodia erythrogaster*), western ribbon snake (*Thamnophis proximus*), and eastern coachwhip (*Masticophis flagellum*). The least abundant species were the brown snake (*Storeria dekayi*), speckled kingsnake (*Lampropeltis getula*), and eastern coral snake (*Micrurus fulvius*). The timber rattlesnake (*Crotalus horridus*), a threatened species, appears to have a viable population within the study area. Abundance and species richness varied according to each habitat, with riparian forest having highest collective abundance and species richness, and pond habitats yielding fewest individuals and species.

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Concordance with multimetric and multivariate analyses in assessment of fish assemblages

Fishery management agencies in North America predominantly use a multimetric index (IBI: index of biotic integrity) in assessing the biological integrity of fish assemblages. Although the use of multimetric indices has been frequently and critically evaluated, other approaches are available and under-utilized in North America. We assessed the fish assemblages of several lotic ecosystems using the IBI and multivariate analyses, for concordant results. The IBI produces scores that can be interpreted into integrity class categories (e.g., excellent, good, poor). Multivariate analyses result in assemblages with variation that differs among sites (outliers).

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How old are the Colubroidea? Estimating the timing and rates of divergence within the advanced snakes

Using a well-sampled mtDNA and scnDNA phylogeny and calibration references from the fossil record, we estimate the timing and rate of divergence of the major groups within the superfamily Colubroidea. The Colubroidea comprises the majority of extant snakes (2500 species) found on all continents except Antarctica and includes all species of venomous snake. To date, most studies attempting to infer divergence times in this group have relied on fossils alone or clock-like methods of analyzing rates of evolution. Using Bayesian and penalized likelihood methods of divergence dating and various fossil cross-validation procedures, we examine the correlation between the date of the earliest fossils found for particular groups and the oldest molecular estimation for that group, the association between origin of a group and paleoecology, and the tempo of evolution for major divergences within the Colubroidea.

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Behavioral consequences of rattle reduction in island rattlesnakes

Three island endemic rattlesnake species in the Sea of Cortés have reduced rattle morphology. However, the consequences of this morphological reduction for defensive behaviors have not yet been studied. We recorded the behavioral responses of *Crotalus catalinensis*, *C. lorenzoensis*, and *C. estebanensis* to approach and capture in the field, during experimental manipulation, and in response to escalating threat during a controlled test. We then compared these responses to those from their nearest mainland relative (*C. ruber* and *C. molossus*, respectively) and a more distant outgroup species (*C. atrox*). There was no significant difference in the frequency or duration of rattling behavior between island species and their relatives. Island species were more likely to flee than to remain motionless and presumably cryptic, and made more attempts to flee before coiling into a defensive posture. However, the sequence in which behaviors occurred did not vary significantly from mainland relatives. Thus, rattling behavior and the context in which snakes rattle appear unchanged in island species despite complete lack of sound production in some individuals (*C. lorenzoensis*, *C. estebanensis*) or in a species (*C. catalinensis*).

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Less yolk makes a bloke: Multiple, interactive modes of sex determination in an alpine skink

In all vertebrate species studied to date, an individual's sex is determined either by genetic factors (GSD) or by the environment (ESD), or in rare cases by a combination of both mechanisms. In the alpine skink *Bassiana duperreyi*, however, the sex of a hatchling is determined by three separate factors. First, these lizards have GSD (XX-females and XY-males). Second, they also have TSD, because the GSD system breaks down when eggs are incubated in cool nests. Such nests produce mostly male offspring. Intriguingly, sex in *B. duperreyi* is also affected by a third factor: larger eggs are more likely to produce female offspring. How do incubation temperature, sex chromosomes and egg size interact to determine offspring sex? Remarkably, egg size has a direct causal effect on offspring sex. Mothers produce variable sized eggs in a given clutch (average 22% intra-clutch range for egg mass), and smaller eggs tend to be sons rather than daughters. Experimental reduction of egg mass by yolk removal massively shifted offspring sex ratios towards males (89%, vs 55% in controls, 59% in sham-operated) at low incubation temperatures (characteristic of cool nests in the field,  $16 \pm 7.5^\circ\text{C}$ ) but not at high incubation temperatures ( $22 \pm 7.5^\circ\text{C}$ ; hot nests). Hence, the sex of an individual in this lizard population reflects a complex interaction among genes, incubation temperature and maternal yolk allocation. Existing paradigms on sex determination in reptiles may be too simplistic, and the possibility of widespread multifactorial systems requires further investigation.

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The "Carolina" Redhorse (*Moxostoma* sp.), an undescribed Carolina endemic

The "Carolina" Redhorse is a rare, undescribed member of genus *Moxostoma* (Catostomidae) restricted to the Pee Dee and Cape Fear river drainages in North and South Carolina. R. E. Jenkins recognized the species in 1995 and proposed it as sister to the Golden Redhorse, *M. erythrurum*, a widely distributed species occurring in the Mobile, Mississippi, Great Lakes, and Hudson Bay drainages, as well as on the Atlantic slope in the James and Roanoke drainages with a probable introduction in the Potomac drainage. No form similar to this distinctive redhorse was known south of the Roanoke drainage prior to 1995. While the "Carolina" Redhorse shares several features allying it to the Golden Redhorse (e.g., shape of lips, breeding tuberculation, nuptial and non-nuptial colorations, and spawning behavior), several anatomical and fixed genetic differences attest to its distinctiveness and validity as a separate taxon.

Since 1996, intensive sampling efforts have been mounted using backpack and boat electroshocking to refine knowledge of the range and age structure of this elusive species. These investigations found that the species is very rare and prefers larger bodies of water, appearing on shoals (to spawn) only very briefly compared to other species of *Moxostoma*. These factors may work jointly to reduce the vulnerability of the "Carolina" Redhorse to collecting techniques in wadeable areas and perhaps partially explain their rarity in collections. Here we present the history of discovery, current known distribution of this Carolina endemic, as well as preliminary genetic information concerning its phylogenetic placement within *Moxostoma* based on cytochrome-*b* and *S7* intron sequence data. Results of this genetic work indicate that the species may be introgressed or of hybrid origin.

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Bioeconomy of the shark fishery on the western coast of Baja California Sur, Mexico

In Mexico, the shark fishery is very heterogeneous since it is multispecific, a wide diversity of fishing gears, and artisanal and commercial fishermen are present. Thus, the fishery management is difficult. In the matter, Días-Urbe and Ramírez-Aguirre (2002) proposed the Importance Bioeconomic Index (IBI), which sort hierarchically the resources of a multispecific fishery based on the catch, value and fishing season. In the present work, IBI was modified adding the concept of Vulnerability, which involves anthropologic pressure and species fragility, to locate the most important bioeconomic fishing areas of the shark fishery at the western coast of Baja California Sur, Mexico. Using logbooks from 1996 to 2001 and a geographic information system we located, by its high commercial value and vulnerability, the areas in front and to the north of Magdalena Bay (25 °-26 ° N and 113 °-114 ° W) as prior and we recommend management steps.

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Anatomy and functional morphology of the feeding apparatus of white-spotted bamboo sharks, *Chiloscyllium plagiosum*

Anatomical investigation of the feeding apparatus in white-spotted bamboo sharks, *Chiloscyllium plagiosum* reveals many characters associated with inertial suction feeding such as labial cartilages to occlude the lateral portions of the gape and hypertrophied hypobranchial musculature to power hyoid depression against high negative pressures generated in the buccal cavity during suction feeding. Manual manipulation of the hyoid arch in these sharks identifies the medial

hyoidiomandibular ligament as a possible biomechanical link convergent with the mandibulohyoid ligament in bony fishes and aquatic feeding salamanders that couples lower jaw depression with hyoid depression. Together, the medial hyoidiomandibular ligaments and ceratohyals form force amplifying second order levers that – during initial hyoid depression – may assist in lower jaw depression by harnessing force generated by the coracohyoideus and coracoarcualis and transferring it to the lower jaw where it will assist the coracomandibularis in generating posteroventral rotation. Later in hyoid depression the ligaments and ceratohyals form force amplifying first order levers that rotate the proximal ends of the ceratohyals and transfer force to the hyomandibula resulting in ventromedial compression of the distal ends of the hyomandibula. This action also causes medial compression of the jaw halves and anteroventral movement of the jaws in a manner that differs from that reported in *Orectolobus maculatus*. The mechanics of the hyoid arch mentioned above may be beneficial to suction feeding by amplifying the force generated by the coracohyoideus and coracoarcualis and transferring it to skeletal elements of the buccal cavity that experience the most displacement during the expansive phase. This may allow *C. plagiosum* to rapidly depress the lower jaw and expand the buccal cavity against negative pressures that may be as high as 100kPa.

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#### An analysis of dietary preferences in five sympatric frog species

Anurans, as a whole, are considered to be dietary generalists. If this is the case, one might assume that frog species similar in size and occurring in similar habitats are competing with each other for the same prey. In this study, we examined the diets of five frog species to determine the degree of prey overlap. The species studied were *Acris crepitans*, *Gastrophryne olivacea*, *Hyla chrysoscelis*, *Pseudacris clarki*, and *P. streckeri*. These species appear to be relatively similar in size and are found occurring together in north-central Oklahoma. Stomach contents of museum specimens were identified to order or more specifically when possible. Prey length was measured if whole prey items were present. Snout-to-vent length and gape width of frogs were measured as these are two of the main morphological features which determine what a frog can consume. When diets were compared among frog species, only the pairs *H. chrysoscelis* & *P. clarki* and *H. chrysoscelis* & *P. streckeri* were not different from each other. There were no differences among four of the frog species in the length of prey consumed except between *G. olivacea* & *P. clarki* and *G. olivacea* & *P. streckeri*. *Hyla chrysoscelis* was not included in this part of the study due to the scarcity of measurable prey items found in stomachs of available specimens. All frog species were different from each other in snout-to-vent length except *G. olivacea* & *P. clarki*, and all five species were different from each other in gape width. These conclusions suggest that perhaps frogs are more specific in prey selection than previously believed in order to reduce competition with other anuran species. The species used in this study differ from each other in morphology, perhaps providing a functional explanation for how they avoid dietary overlap.

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**A new *Eremias* (Sauria: Lacertidae) from the Zagros Mountains, Hamedan Province, western Iran**

A new and distinctive form belonging to the genus and subgenus *Eremias Fitzinger*, 1834 is reported from the highlands of Alvand Mountains, Hamedan Province, western Iran at about 2700 m elevation. It is easily distinguished from all the other species of the typical subgenus (*E. velox*, *E. persica*, *E. strauchi*, *E. nigrolateralis*, *E. lalezharica*, *E. afghanistanica*, *E. regeli*, *E. suphani*, and *E. nikolskii*) by having a variable number of postmentals (4-5 pairs), smaller size, and distinctive color pattern. Furthermore, it can be distinguished by having a combination of characters against any of the species in the typical subgenus. Further work, using both morphological and molecular techniques, is now being carried out on this new form in order to determine its exact taxonomic and phylogenetic status. Systematics of the genus *Eremias* is shortly discussed.

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**Rediscovery of the Eastern Fire Salamander, *Salamandra Infracinnata* *Semenovi* (Caudata: Salamandridae), from Kurdistan Province, western Iran**

Based on extensive field work and research in the central and northern Zagros Mountains, Kurdistan province, western Iran, the presence of the *Eastern Fire Salamander*, *Salamandra Infracinnata Semenovi* Joger and Steinfartz, 1995 is reconfirmed. This subspecies mainly occurs in the alpine meadows at the elevations between 1200-1900 m, relatively close to the mountainous streams and brooks. Taxonomy and distribution of the eastern fire salamanders are shortly discussed and the importance of rediscovery of this taxon is explained.

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Population structure and hybridization of *Etheostoma caeruleum*  
(Actinopterygii: Percidae) in the Ozark Highlands

The rainbow darter *Etheostoma caeruleum* is widely distributed in streams of eastern North America. In the Ozark Highlands of Missouri and Arkansas, multiple lineages within this polytypic species have been identified from both morphological and genetic data. Mitochondrial data indicate that populations have pronounced phylogeographic structure among Ozark stream systems, with marked subdivisions between adjacent streams. Further, phylogenetic relationships are consistent with a combination of historical and present stream drainage connections. Mitochondrial data also indicate that *E. caeruleum* hybridizes with sympatric species, particularly *E. uniporum*. An additional molecular data set using microsatellites was generated to determine if the mitochondrial genetic diversity pattern was corroborated by nuclear data, and if nuclear introgression occurred among hybridizing species. Significant population structuring was found among sampled *E. caeruleum* populations, consistent with previous genetic work, which suggests that mitochondrial markers are reflective of the distribution of genetic variation in this species. This pattern confirms previous morphological and molecular data indicating that *E. caeruleum* populations are highly subdivided in Ozark Highland streams.

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Long term perspective of Lake Erie watersnake color polymorphism

The microevolutionary processes acting on color pattern of Lake Erie watersnakes (*Nerodia sipedon insularum*) have been well documented. Variation in color pattern is heritable and is influenced both by gene flow from mainland populations of *N. s. sipedon* and natural selection by visual predators within island populations. We used historic data collected prior to 1961 and recent data collected from 1980-2003 to characterize fine-scale spatial and temporal variation in color pattern. We integrated our results with previous allozyme-based estimates of  $F_{ST}$  to assess the degree to which fine-scale variation exceeds that expected due to neutral processes. Morph frequencies did not differ significantly within islands or between islands separated by short distances. Morph frequencies did sometimes differ significantly among more distantly separated islands and among sampling periods from 1980 to the present, but no more than expected given patterns of allozyme variation. In contrast, a marked change in morph frequency has occurred between historic (prior to 1961) and recent (1980-2003) samples. The cause of this change is unclear but may include changes in the strength of selection due to changes in predator assemblages and

visual environments or changes in rates of gene flow due to changes in island watersnake population size.

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Effect of habitat degradation on corticosterone levels and parasites in aquatic turtles

Habitat degradation is one of the primary causes for reptile declines. In the United States, over 53% of original wetlands have been destroyed due to human encroachment. Terrestrial areas adjacent to aquatic habitats are critical for many reptiles to complete their life cycles, yet these habitats are often not protected. In turtles, terrestrial habitat degradation has been shown to lead to abnormal population structures, reduced population size, and lower genetic variability, however, the effects on turtle health remain largely unstudied. In goal of this study was to examine the effects of habitat degradation on turtle glucocorticoid levels, and ecto- and hemo-parasites. During the summer of 2005, we trapped 434 turtles from 44 ponds with varying levels of terrestrial habitat degradation in IL. Baseline and stress-induced levels of corticosterone were measured from 200 slider turtles (*Trachemys scripta*). Additionally, we examined leech and hemoparasite prevalence and intensity on snapping turtles (*Chelydra serpentina*), painted turtles (*Chrysemys picta*), and slider turtles (*T. scripta*). The overall prediction is that habitat degradation will be associated with reductions in turtle health.

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Modeling critical breeding habitat and sexual dimorphism in the endangered spotted turtle (*Clemmys guttata*)

Identification and protection of critical habitats (e.g., breeding and nesting sites) are essential to species conservation. Previous studies have investigated habitat use and home range sizes of the federally endangered spotted turtle (*Clemmys guttata*), but components of critical breeding habitats have not been quantified. In species for which the breeding strategy involves male-male competition, males tend to be larger than females. Spotted turtles aggregate in spring to breed, which may facilitate male-male competition and female mate choice; but the details of the species' mating strategy are unknown. We are developing two models to examine critical breeding habitat and mating strategies, as indicated by sexual dimorphism, in spotted turtles. The predictive habitat model will quantify, using known long-term study sites and

new sites, environmental variables (e.g., water depth, canopy cover, vegetation stratification) of spotted turtle breeding sites, and can be applied in species conservation efforts. Spotted turtles show sexual size dimorphism with respect to facial and eye colour, and plastron shape, but not in regards to carapace length and width. Using morphometric analyses, we will examine the direction and degree of sexual dimorphism and make interpretations with respect to the species' mating strategy. From these morphology investigations, it may also be possible to sex juvenile turtles, which do not show secondary sex characteristics, and make inferences about the fecundity of females.

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Trophic basis of production and energy flow associated with emergence among assemblages of larval ambystomatid salamanders in forested ponds in southern Illinois

Larval amphibians transfer energy from freshwater to terrestrial ecosystems during seasonal emergences, but larval production and energy flow to adjacent systems are rarely quantified. During 2003-2004, we derived prey-specific assimilation efficiencies, conducted gut analyses, and intensively sampled ambystomatid salamander assemblages in four forested ponds to quantify energy flow associated with larval consumption and assess the importance of major prey types to production and emergence. We estimated that 2.5-17.2 g AFDM m<sup>-2</sup> yr<sup>-1</sup> of prey production was required to account for larval salamander production, which ranged from 0.8-5.3 g AFDM m<sup>-2</sup> yr<sup>-1</sup> among assemblages. Energetically important prey types varied among populations and ponds, with up to 88.5% of *A. opacum* production attributed to zooplankton, 84.2% of *A. maculatum* production attributed to aquatic insects, and 79.3% of *A. tigrinum* production attributed to amphibian prey. Overall, zooplankton accounted for 60.4-88.5% of salamander production in temporary ponds whereas aquatic insects accounted for 19.9-84.2% of production in permanent ponds. Emergences associated with larval assemblages represented 3.3%, 4.8%, and 8.2% of consumption and 9.9%, 15.8%, and 26.4% of production at three ponds that did not dry during larval development. Our study demonstrates that emergences of larval amphibians represent a significant pathway for energy flow from freshwater to terrestrial food webs. Quantifying the ecological roles of amphibians is important in light of amphibian declines, as this information furthers our understanding of the ecological consequences of these losses.

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### Color and pattern variation in the Peacock Bass *Cichla temensis* (Cichlidae)

The South American genus *Cichla* has a problematic taxonomy. Although taxonomists currently believe there are five species, additional undescribed species may exist. The taxonomy is further confounded by the existence of many strikingly different color and morphological pattern variants within *Cichla* and particularly *Cichla temensis*, the largest and most commercially important of the species. To elucidate the nature of these color and pattern variants, a multi-part study was performed between these patterns and gonad maturity. Specimens were collected in floodplain rivers within *C. temensis* native Amazon habitat in two widely separated regions; the Rio Igapo Acu (Rio Madeira drainage) and the Rio Caures (Rio Negro drainage). A graduated scale of color and pattern ranges was developed using a compilation of previously taken photographs from a large sample of over a thousand specimens of *C. temensis*, collected throughout its range. Freshly captured study specimens were graded according to this color scale, photographed, weighed, measured, sexed and GSI determined. Initial analysis of the data shows a strong relationship between color and pattern variation and GSI and indicates that the different morphs represent changes within individuals related to seasonal spawning cycles. This information may help to clarify some of the issues affecting the taxonomy of species in this genus, and their ecology and management.

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### Foraging success of cyprinids along a turbidity gradient

Increases in suspended sediment in clear water environments negatively impact freshwater fishes in various ways, including reduced spawning and foraging success. However, suspended sediment may not be detrimental to all fish species, in particular, those that live in naturally turbid environments. Today, some drainages with historically high turbidities (e.g., rivers of the Great Plains and Colorado River) tend to be clearer due to sediment trapping by dams and reduced flows. The loss of turbidity and the role it plays in the decline of fishes in these rivers has received little attention. Species within these drainages are hypothesized to have a number of morphological traits that allow them to be successful in turbid environments. These fishes may depend on high levels of suspended sediment for survival (e.g., feeding, reproduction, or protection from sight-feeding predators). I investigated the effects of turbidity on the foraging success of fishes from clear and turbid systems in

Oklahoma and Texas. My prediction was that as turbidity increased, feeding success of turbid-water fishes would be constant while clear-water fishes would decrease. Feeding trials were performed in 40-liter fish tanks at the University of Oklahoma Biological Station. Nine cyprinid species were tested for the number of bloodworms consumed in five minutes across five turbid treatments. Turbid-water fishes fed well in all treatments, but clear-water fishes ate significantly less at higher turbidities. These results imply that turbid-water fishes have an advantage in locating food in highly turbid environments. Thus, decreased suspended sediment loads in historically turbid rivers (via dams) may have reduced the foraging advantage of turbid-water fishes and contributed to their decline.

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### Gene expression in thermally stressed environments

Fishes in the genus *Gambusia* commonly thrive in environments that expose them to large fluctuations in temperature and oxygen availability. Diurnal temperature cycles may include changes of 20°C and seasonal temperatures may range from near freezing to approaching 40°C; however, it is not clear whether these populations respond to high temperature extremes via a chronic stress-response or if they have adapted to these extreme conditions. Populations of *Gambusia* spp. were collected from constant moderate thermal environments (i.e., springs) and thermally stressed environments (i.e., shallow rivers/creeks without shade in regions with ambient summer temperatures over 40°C). Fish were exposed to varied temperatures and quantification of the expression of genes involved in stress mediation was determined by real-time PCR. Additionally, analysis of protein coding Hsp sequences were compared for levels of variability and ratios of nonsynonymous to synonymous substitutions calculated to test the effects of natural selection. Results from this experiment elucidate to the adaptive significance of variation in gene expression in natural populations of organisms.

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### Constraint and the evolution of a Caribbean anole, *Anolis cristatellus*

A previously unexplored dimension of the anoline radiation in the neotropics is the importance of quantitative genetic constraint in morphological evolution. This study uses a phylogenetic approach to assess the importance of constraint on phenotypic differentiation of populations of the Puerto Rican crested anole, *Anolis cristatellus*. We find evidence that the form of constraint is conserved over evolutionary timescales

and furthermore that genetic constraint significantly influences the pattern of phenotypic divergence.

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**Geographic barrier to dispersal of *Tropicolotes* (Gekkonidae; Sauria)**

Genus *Tropicolotes* Peters, 1880 was ten species that disperse from North Africa to Middle East. Dispersal of two species is African-Asian, but dispersal of three species closed to North Africa and dispersal of five species closed to western Asia. For geographic barrier used the climate and ecological factors. But during this study affects of climatic factors as well elevation and temperature in each region from Africa to Asia is important rather than other factors. Results of geographic analysis have able divide into three parts that comprised of: I: ITCZ barrier avoid to dispersal of *Tropicolotes* from north-Africa to equator, II: Anatolia plateau extend to Zagros and Elburz MTs in Iranian plateau are important barrier to dispersal of *Tropicolotes* to high latitudes, III: Tibet plateau at the strongly barrier to avoid of dispersal of *Tropicolotes* to eastern Asia. In other hand, Indian rain before the Tibet plateau has the important role to avoid dispersal of *Tropicolotes* to Tibet plateau. Consequently dispersal of this genus is closed due to geographic changes during geographic evolution. Therefore a result of geographic analysis to barrier of this genus has shows dispersal closed to north hemisphere in tropic hot-dry climate. Stabilize dispersal of herpetofauna during evolutionary pathway at the results of Natural selection as well genus *Tropicolotes* due to climatic factors during climate evolution.

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**Management implications for squaretail coralgroupers, *Plectropomus areolatus*, in Pohnpei (Micronesia) from tagging surveys**

Throughout the Indo-Pacific, (fish) spawning aggregations (FSA) of squaretail coralgroupers, *Plectropomus areolatus*, are threatened by overfishing. Only two countries – Palau and Pohnpei (Micronesia) – have instituted protective measures for the species' FSA through commercial sales bans during parts of the reproductive season and marine protected areas. To investigate the effectiveness of area protection (no-take Kehpara Marine Sanctuary, KMS) for squaretail coralgroupers FSA in Pohnpei, 647 individuals were tagged with spaghetti-type tags, including 40 acoustically tagged sex-specified individuals at an aggregation site. Within a 12-

month period, 9% of all tagged fish were recaptured, with 32.7% re-captured within KMS by the investigators and an additional 43.1% captured outside the KMS by fishers within the reproductive period. Of those captured outside the sanctuary, 79.1% with known catch locations were taken within a 10-km area proximate to the FSA. Acoustic data suggest common migratory pathways for individuals to reach FSA sites and show high site fidelity, as well as inter-monthly and inter-annual return to the FSA by both sexes. Results indicate a high vulnerability of squaretail coralgroupers to overfishing during reproductive periods by the removal of individuals at FSA sites, along migratory pathways and areas proximate to FSA sites. Data further suggest that, within Pohnpei, management of squaretail coralgroupers could be improved by an extension of the existing sales ban and implementation of a catch ban corresponding to the actual reproductive season of squaretail coralgroupers and/or area protection that includes all FSA sites and respective migratory pathways.

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### Amphibian site occupancy in four hydrologic regimes in the Florida Everglades

The Comprehensive Everglades Restoration Plan (CERP) requires the use of indicator species to measure the success of restoration efforts. The Everglades amphibian community is an ideal ecosystem restoration indicator because amphibians are present in all habitats and under all hydrologic regimes. Randomly selected plots in four distinct hydrologic strata within the Everglades ecosystem were chosen to sample amphibians from July 2004 to August 2005. Three sampling methods (nighttime visual encounter surveys (VES), vocalization surveys, and trapping) were used to capture amphibians. Trapping was done with PVC pipe refugia and funnel traps that were checked during the day. We used program PRESENCE to estimate site occupancy of the amphibian species. This site occupancy model when applied to randomly chosen sites in a defined area can be used to represent an estimate of the proportion of area (PAO) occupied by a species. We detected fourteen amphibian species during VES, vocalization surveys and trapping, and were able to estimate site occupancy on seven of those species: *Acris gryllus*, *Hyla cinerea*, *Hyla squirella*, *Rana grylio*, *Rana sphenoccephala*, *Notophthalmus viridescens piaropicola*, and *Siren lacertina*. There was a distinct difference in detection of amphibians on the two dry sites

compared to the two wet sites. On the two dry sites, many species were detected immediately after the onset of the wet season and occurred for a short time period. On the two wet sites, few species were detected year round. Site occupancy rates for *A. gryllus*, *H. cinerea*, *R. grylio*, and *R. sphenoccephala* were all 100% for every site. The results from this project will allow managers to evaluate Everglades restoration efforts, establish restoration targets, and compare restoration alternatives.

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Variation in metamorphic timing can be induced by variation in density without difference in growth rate in the frog, *Rana utricularia*

Optimality models for understanding the timing of amphibian metamorphosis predicts that a growing larva will delay metamorphosis in order to take advantage of a good growth opportunity. Conversely, a deteriorating larval habitat is predicted to induce metamorphosis. We tested this hypothesis by growing larval *Rana utricularia* in 11 X 5.5 X 3.5 inch containers filled with 2600 ml of reverse-osmosis [RO] water that held 1, 2, 4, 8, 10, or 20 tadpoles. Every 3 days, tadpoles were fed a per capita 25 mg aliquot of a finely ground 1:1 mixture of rabbit chow and fish food flakes, i.e., the 1-tadpole treatment received a 25 mg aliquot whereas the 10-tadpole treatment received a 250 mg aliquot at each feeding. After 3 months, the aliquots were tripled. Three months after the food increases, one-half of the treatments were subjected to a food reduction that returned these treatments to a per capita 25 mg aliquot. Thus we used a full-factorial two-factor design manipulating density (6 levels) and food reduction (2 levels) for total of 12 treatments each replicated six times (for a total of 450 tadpoles in 72 containers). We analyzed metamorphic timing and mass of all transforming tadpoles with a two-way MANOVA with density and food as treatment effects. Inspection of growth curves and analysis of mean tadpole mass showed no significant differences in growth, as intended by the equivalent per capita food treatments. Food-reduction failed to induce differences in metamorphic timing. Tadpole metamorphic timing differed significantly when comparing the 4-tadpole with 20-tadpole treatments. This means that tadpole density can affect metamorphic timing without requiring a growth-rate transduction of tadpole density.

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Population history and genetic affinity of two populations of the U.S. endangered Dusky Gopher Frog

Anthropogenic habitat fragmentation and reduction are major causes of population declines and local extinctions. As habitat fragmentation and loss intensifies across the

landscape, population subdivision of non-human organisms typically occurs. The most severe consequence is complete geographic isolation of populations. Isolated populations tend to become inbred and genetically differentiated from each other. Two populations of the US Endangered Dusky Gopher Frog, *Rana sevosa*, exist. These populations have been geographically isolated by ca. 32 km for an unknown time, presumably less than a century. Long-term demographic data and genetic data exist for one population, whereas the other population was only recently discovered and has unknown demographic and population genetic status. The population with known status is somewhat protected because it is located in the De Soto National Forest, Mississippi. The other population is located on private land with multiple owners. Habitat surrounding the newly discovered breeding pond is not protected. Our research objectives were (1) to determine genetic variation in the newly discovered population and compare it to that of the population with known demographic and genetic status; (2) to test for severe, historic reductions in population size of the newly discovered population; and (3) to assess genetic affinities between the two populations. Genetic analyses were performed using genotypic data of seven microsatellite DNA loci for individuals of the newly discovered population (five eggs from every egg clutch deposited during two separate breeding seasons) and previously collected microsatellite DNA data of the other population. Results of this research will be discussed in the context of species management. One potential management strategy is to transplant eggs or larvae from the newly discovered population to historic breeding sites. These data will aid in our decision of whether or not sites are chosen to allow mixing of individuals of these two extant populations.

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No monster: Sighting of an anuran (*Bufo* sp.) in the deep water of Loch Ness

Video recordings made with a remote underwater vehicle in Loch Ness produced a serendipitous finding – the presence of a bufonid anuran resting on the substrate at approximately 95 m below the water surface. The recorded water temperature at that depth varied from 4-5 °C, and the pressure approached 10 atm. The frog appeared initially lethargic but moved in response to the presence of the remote vehicle. Although *B. bufo* is found in that region of Scotland and is known to over-winter in springs/ponds, this is the first record of this species, or any amphibian, inhabiting this depth of water. Similarly, while the ability of this species to overwinter at that temperature is not unusual, its ability to withstand high pressure for such an extended period of time is unprecedented. We will present video footage of this encounter, and welcome feedback from physiologists interested in studying this system.

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Feeding habits of the sandpaper skate, *Bathyraja kincaidii* (Garman, 1908), from central California, U.S.A.

The sandpaper skate, *Bathyraja kincaidii*, is a small deep-sea batoid that most commonly occurs from depths of 200-500m from the Gulf of Alaska to Baja California. As with most eastern North Pacific skates, few studies have been done on the life history of this species. Examination of 130 sandpaper skate stomachs collected from central California by the Southwest Fisheries Science Center (SWFSC) Santa Cruz Lab (SCL) from 2002 to 2005 revealed that like most other skates, this species has a generalized diet, feeding on many different groups of prey. They fed predominantly on invertebrates such as euphausiids, small shrimps, cephalopods and polychaetes. In addition, myctophids, rockfishes, crabs and mysids were also in the diet. Multivariate analyses were used to test for differences in both proportional weight and number of major prey groups (shrimp-like crustaceans, polychaetes, teleosts, small benthic crustaceans, crabs and cephalopods) by sex, maturity status and oceanographic season (Upwelling, Oceanic and Davidson Current). Diets were significantly different among seasons, explaining the largest proportion of the variance in the diet. All major prey groups, except cephalopods, showed differences among seasons. Diets also differed between maturity stages, which accounted for the next greatest proportion of the variance. Higher proportions of polychaetes, small benthic crustaceans and crabs were consumed by immature skates, while mature skates preyed more on shrimp-like crustaceans and teleosts. Feeding habits differed significantly between sexes, but only for weight data, and was driven by the higher proportion of shrimp-like crustaceans, small benthic crustaceans and crabs in male diets.

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Phylogeographic analysis of the federally endangered Etowah Darter

The Etowah darter, *Etheostoma etowahae*, is a recently described member of the *E. (Nothonotus) jordani* species group believed to be geographically restricted to the Upper Etowah River in Georgia. Small population sizes and restricted range present potential risks to the continued existence of this endangered species. The most geographically proximal records of the relatively abundant greenbreast darter, *E. jordani*, were reported from Stamp Creek (a tributary to the middle section of the Etowah River); however, in recent surveys *Nothonotus* individuals have been

documented from intermediate localities and appear to be morphological mixtures of *E. jordani* and *E. etowahae*. Two alternative hypotheses may explain these findings: these newly discovered localities may indicate syntopy and/or hybridization between these two species, or alternatively, morphological characters promoted in the formal species description of *E. etowahae* may be problematic and incapable of definitively identifying all *Nothonotus* specimens from the Etowah River. Either call raises questions as to the classification status of these newly documented populations and the true geographic ranges of these sister species. In this study we have sequenced 2019bp of mtDNA from 120 *Nothonotus* specimens to provide a means for genetic identification of *E. etowahae*, examine population structure, and redefine geographic distributions for each species. Phylogeographic analysis documents *E. etowahae* haplotypes in areas approximately 110 river kilometers downstream from where it was first described in 1993. *E. jordani* haplotypes appear to be allotopically distributed in four river systems. Surprisingly, little phylogeographic structure is found within either of these species throughout their respective ranges.

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### Movements of translocated and resident three-toed box turtles

Translocation of terrestrial turtles mitigates habitat loss, increases population size or genetic diversity, and establishes new populations. The success of many translocation efforts often depend on social and economic factors, but ecological factors may also affect translocation success. We used radio-telemetry to evaluate Three-toed Box Turtle (*Terrapene carolina triunguis*) movements before and after translocation from a continuously forested site to a highly fragmented site, and made comparisons to resident turtles. The average distance moved between consecutive 28-hour relocations (dismove) pre-translocation versus post-translocation depended on turtle origin. Turtles from the continuously forested site had similar average dismove to resident turtles at the fragmented site prior to translocation, but had increased average dismove following translocation. Translocated turtles traveled greater total distances, had greater net displacement, and greater home range size than resident turtles. Additionally, translocated turtles had directed movements, whereas resident turtles did not. We considered density or competition with resident turtles, habitat structure at the release site, and homing as potential explanations for the observed differences. Homing behavior or directed movement towards continuous forest adjacent to the release site may account for the movement patterns observed. Future translocations should consider the landscape context of the release sites as well as the landscape context of the original capture location.

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### Defining terrestrial habitat use and summer refuge sites of wood frogs in oak-hickory forests

The importance of terrestrial habitat for the conservation of pond-breeding amphibians has recently been emphasized in the literature. We examine the terrestrial habitat use of an isolated, relic wood frog (*Rana sylvatica*) population in Missouri. Wood frogs spend most of their life in moist woodlands, with yearly breeding events lasting only 2-5 days in temporary wetlands. Our study population is located at the extreme southwestern edge of the range in mature, oak-hickory forest. This habitat differs greatly from the boggy, boreal woodlands that occur throughout the majority of the wood frog range, which spans across Canada and the northeastern United States. We hypothesize that summer refuges with moderate microclimates may be an important habitat requirement in the southern portion of their range. We radio tracked 42 adult wood frogs as they emigrated from 3 breeding sites. The movement paths indicate that wood frogs in Missouri use rocky drainages as summer refuges. These drainages must therefore provide similar microclimates and resources as the forested wetlands used as summer refuges in northern portions of the wood frog range. In addition, we used conditional logistic regression to describe the microhabitat use of wood frogs at a 2 m scale. Light and humidity were important microclimate variables, with litter depth and canopy cover being important structural variables that likely create optimal micro-climates. Finally, we used univariate kernel estimation to describe the similarities and differences in movement distances between three breeding populations. We found that the distance between the breeding site and nearest drainage may be an important landscape complementation feature for predicting wood frog habitat use. Conservation of important terrestrial habitat for local amphibian populations is enhanced by knowledge of species-specific information. In addition, terrestrial habitat use may vary within a species at different locations within its range.

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### A first approach towards resolving systematic relationships among families of Gadiformes fishes using mitochondrial and nuclear genes

The order Gadiformes includes some of the world 's most important commercial fish species (e.g. Atlantic cod, haddock, pollock, silver hake, among others species). They range from Arctic to Antarctic waters in all oceans, occurring from mostly deep-sea benthic to coastal waters. Additionally, exist two estuarine species and one species occurs in fresh water habitats. These species present high vulnerability associate with some life-history traits such as their late maturation, extreme longevity, low

fecundity, and slow growth. Despite its commercial importance, the taxonomy of this complex group of fishes is poorly understood. Most of the information is available for the commercially important species, while for the vast majority of species in the order data is scarce, if anything. Most of the works done on the classification problems within the Gadiformes have been based on morphological characters. Currently, some authors recognize anywhere from 11 to 14 families, about 75 genera, and more than 500 species in the group. In 1948, wrote: "... a detailed revision of the gadoids is extremely necessary". Although there have been some efforts to sort the taxonomy of the Gadiformes, a consensus has still not been reached. Thus, 58 years later the revision asked for by Svetovidov is still as necessary. This provides an excellent opportunity to implement a molecular phylogenetics study comprising most of families in the order. For this purpose, we obtained nuclear (RAG1) and mitochondrial (12S and 16S) sequence from several genera in the group, attempting the widest taxonomic coverage possible. The results of our study represent the first attempt to resolve family level relationships using mitochondrial and nuclear DNA sequence data.

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Genetic and environmental sources of variation in growth between *Sceloporus* populations in Florida: faster growth from cooler environments

Plasticity in life history traits is often examined along elevation gradients or between distant populations where environments have obvious differences. Because the climatic gradient associated with latitude in Florida is less extreme, though still marked, it provides an opportunity to examine plasticity in traits at a finer scale. Using populations of *Sceloporus undulatus* and *S. woodi* from both north (cooler) and south (warmer) Florida, I examined the influence of environment and source population utilizing a common housing experiment. I incubated eggs and then raised hatchlings for 8 weeks under identical conditions, subsequently releasing them in the habitat from whence they came for a mark-recapture experiment. All populations had faster growth rates in the common environment than in their source habitats, but only *S. undulatus* populations grew significantly faster. Source population significantly affected growth rates in *S. undulatus* during the common housing experiment, suggesting a genetic component of growth that is different between these populations that are only 100 miles apart. Overall, individuals from cooler environments grew faster than individuals from warmer environments, whether measured while in their source habitat or in the common lab environment. Microhabitat temperature regimes and food availability were measured at each of the source habitats and compared with the constant regimes of the common environment in relation to growth.

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### Hybridization, extinction risk, and ecological correlates in the endemic Florida Scrub Lizard *Sceloporus woodi*

Recent attention has been focused on the ability of hybridization and introgression to cause extinction, especially when highly fragmented small populations of one species come into contact with a wide-spread congener, which is exactly the case with *Sceloporus* in Florida. The fence lizard, *Sceloporus undulatus*, is the wide-spread congener of the endemic Florida scrub lizard, *S. woodi*, which occurs in highly fragmented populations throughout Florida. We are collecting lizards from pure species zones and a suspected hybrid zone to determine the proportion of F1 and F2 generation hybrids and backcrosses of hybrids with each parental species within the hybrid zone. Thirty-five years ago, this hybrid zone was examined using a discriminant analysis on morphological traits. We plan on contrasting the discriminant analysis with our genetic data to determine the accuracy of this morphological approach, which will allow us to examine geographic changes in the hybrid zone over the last thirty-five years, estimate the velocity of introgression, and evaluate the potential for genetic assimilation of *S. woodi*. Environmental data (canopy cover, bare ground, temperature, habitat heterogeneity, and tree and shrub species) is also being collected across the ecotone with the GPS recorded point of capture for each lizard to examine ecological correlates with genealogical class. The environmental data will give us insight into habitat use by hybrids, potentially pinpointing habitat features that can be managed to change dynamics of the hybrid zones. Our hypotheses are that 1) hybridization is occurring, 2) the hybrid zone is narrow and stable, and 3) the environmental gradient explains the gradient of genealogical classes, and therefore the narrowness of the hybrid zone and the continuing distinctiveness of each species. Preliminary results suggest that hybrids occupy areas with higher mid-canopy heterogeneity than that found in *S. undulatus* habitat.

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### Resource use among sympatric gar species (Lepisosteidae) in the middle Brazos River and associated oxbows

The middle Brazos River, located in east central Texas, is a meandering lowland river that contains many oxbow lakes on its floodplain. Flood dynamics of the Brazos River are aseasonal, and due to this unpredictable hydrology, faunal exchange from lateral connection of the main river channel and oxbows is pulse like and only occurs during floods that may be months or years apart. From this study, resource use

among sympatric gar species (*Lepisosteus oculatus*, *L. osseus*, and *Atractosteus spatula*) was studied for a period of two years (May 2003 to May 2005), in which the first year was a relatively dry year (few lateral connections) and the second year was a relatively wet year (more frequent lateral connection). The study focused on habitat and diet partitioning among the three gar species between two oxbow habitats and an active channel site. Overall 684 gar were collected with experimental gillnets: 19 *A. spatula* (alligator gar), 374 *L. oculatus* (spotted gar), and 291 *L. osseus* (longnose gar). There was strong partitioning of habitat between spotted and longnose gar, in which 98% of spotted gar were captured in oxbow habitats and 84% of longnose gar were captured in the river channel overall. During the wet year, habitat partitioning was weaker with longnose gar, where 31% were captured in oxbows (compared to 3% during the dry year). Spotted gar distributions were not effected dry or wet years where 99% and 97%, respectively, were captured in oxbow habitats. Because there was such high degree of habitat partitioning, there was very little diet segregation between species. There was, however, a difference in diet composition between sites due to the differences in prey assemblage structures.

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Shorefishes of the tropical eastern Pacific: An online information system

In 2002 a CD-based dual interface (English/Spanish) information system on the Shorefishes of the Tropical Eastern Pacific was produced by the Smithsonian Tropical Research Institute. That has now been redeveloped as an online dual interface system powered by Discover Life ([www.discoverlife.org](http://www.discoverlife.org)). As well as providing the most current data available, this online system provides enhanced analytical capabilities over those in the original CD-based system. This online system will be demonstrated for the first time at the ASIH 2006 meeting. That system covers 1261 species, 494 genera and 141 families of shorefishes. Its facilities include various identification aids (2200+ color photographs that cover 83% of the species, text descriptions, interactive multi-entry keys, common name search, an engine that uses data on location and morphology, and comparisons of similar taxa). Links between taxa and relevant citations in the 1150 item library allow interrogation of that database. Other databases contain information on biological characteristics of all species: size, habitat, depth range, diet, reproduction, latitudinal/longitudinal range size, Cites/Redlist status. Database maps provide visualization of range distributions and latitude/longitude of collection-record sites. The map engine allows comparisons of ranges of multiple species; visualization of the distribution of species richness; the assembly of lists of species with chosen characteristics at single sites (user defined spatial scale) or of species shared/not shared between paired sites; and lists of local endemics (i.e. species found only in a selected area).

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## How many shorefishes in the tropical eastern Pacific?

The Tropical Eastern Pacific (TEP) is a strongly isolated biogeographic region with a high level of endemism among its modestly-sized (<1,300 species) known fauna of shallow-water shore-fishes. We examined accumulation curves of descriptions of these fishes, which began in 1758, to assess if they can be used to predict the total size of that fauna. The species description rate has remained fairly constant over the past century, and there are no signs that an asymptote is being approached in accumulation curves for groups of species that comprise the bulk of the fauna. However, curves of pelagic and multi-habitat species (22.5% of the fauna) may be nearing asymptotes, perhaps because those species are relatively easy to collect. Although these accumulation curves indicate that the total TEP fauna is distinctly larger than the presently known fauna, they do not allow prediction of that total. We extrapolated from body-size frequency distributions of different types of species among the known fauna to estimate how much larger the entire fauna might be. Poorly sampled areas of the TEP that represent priority targets for investigation include habitats below normal-SCUBA depth, two isolated island groups, and several continental areas with diverse and unusual environments. We used current levels of taxonomist activity to assess how long the description of known un-named species could take. The exploration work needed to assess the abundance of unknown species and provide a clearer indication of faunal size likely will take considerably longer.

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## Dietary analysis of the longnose skate, *Raja rhina* (Jordan and Gilbert, 1880), in California waters

The longnose skate, *Raja rhina*, is one of the most important incidental species landed in central and northern California demersal fisheries. However, life history information is extremely limited for this species and aspects of its diet and feeding habits are unknown. Feeding ecology studies can provide researchers with important insights towards understanding potential fishery impacts on marine systems. The primary objective of this study was to analyze the feeding ecology of *R. rhina* off the coast of central California. Specimens of *R. rhina* were collected between September 2002 and August 2003 from fisheries-independent trawl surveys conducted by the National Marine Fisheries Service, South West Fisheries Science Center (NMFS-SWFSC). Of 1,193 longnose skates caught, 527 were female and 666 were male. A total of 618 *R. rhina* stomach samples was processed, and all prey items were identified to lowest possible taxa. For every stomach, the percentage of each prey item by number (%N) and weight (%W) were calculated and averaged to obtain a

mean value. These measures were combined with the overall percent frequency occurrence (%FO) to determine the Index of Relative Importance (IRI), represented as %IRI. Results indicate that the five most important prey items were unidentified teleosts (31.6% IRI), unidentified shrimps (19.6% IRI), unidentified euphausiids (10.9% IRI), Crangonidae (7.4% IRI), and *Neocrangon resima* (6.0% IRI). *Raja rhina* diet was further analyzed through comparison of the following intraspecific variables: gender (male/female), depth (shelf/slope), and size class (<600 mm/>600 mm), using Morisita's Index of Overlap. This analysis indicates there is a high degree of overlap between gender (95.9%) and shallow depths (96.4%), while size classes overlapped very little (34.8%). Additional multivariate statistics, Principle Component Analysis and MANOVA, are currently being conducted to further assess potential differences in diet among intraspecific variables.

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#### Speciation and biogeography of *Haemulon* (Teleostei: Haemulidae) inferred from nuclear and mitochondrial genes

The new world genus *Haemulon*, collectively known as grunts, is comprised of 19 nominal species and occurs in tropical and subtropical reefs along both sides of the Americas. Fifteen species are found in the western Atlantic, and five in the eastern Pacific with one being shared by both regions. The main diagnostic character of *Haemulon* is the presence of scales covering the soft dorsal and anal fins. Even though most species are small, grunts are edible, valued as food, and some are commercially important. Aiming to elucidate the phylogenetic relationships between the species of *Haemulon*, we obtained a combined total of <1,800 base pairs from two mitochondrial genes (cytochrome b and cytochrome oxidase I), one nuclear intron (TMO-4C4) and one nuclear gene (RAG2) from all nominal species. Some of the previous morphology-based phylogenetic hypotheses, such as the close relationship among *H. aurolineatum*, *H. boschmae* and *H. striatum* based on fin-ray counts, were not supported. Our data also indicate that the trans-isthmian *H. steindachneri* is composed of two species, one in each side of the Americas, and we propose the revalidation of the Atlantic species. The closure of the Isthmus of Panama seems to have played a role in the diversification of *Haemulon*, however, many sister species pairs have completely overlapping geographical distributions, indicating that vicariance is not the main process driving speciation in this genus.

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Herpetofaunal diversity of four protected areas in upstate South Carolina

The upper piedmont and mountain regions of South Carolina have been exposed to decades of intensive logging and/or agriculture. Within the last eighty years, significant portions of these regions have been protected and allowed to reenter vegetative succession. Many of these protected areas have not been surveyed for herpetofaunal diversity. The purpose of this study was to develop a checklist of species occurrence and to calculate a measure of diversity for four parcels of protected land in the upstate of South Carolina. Two types of surveys were conducted over a three-month period during 2004. Coverboard surveys and time-constrained searches were conducted weekly or biweekly at all sites. Both the presence and number of each species of reptile or amphibian observed were recorded. The Shannon-Weaver Index of diversity was calculated for each site as a measure of species level diversity. A few species composed the numerical majority of observations, leading to a relatively low measure of species evenness at most sites, despite higher levels of species richness. All sites had similar level of species diversity, though different sites were occupied by different assemblages of species. Further, more extensive studies of the same sites are planned and will include auditory monitoring of amphibian breeding sites, road cruising surveys, the placement of pitfall trap/drift fence arrays, and increased coverboard monitoring.

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Age and growth of juvenile Bluefish in southern New England estuaries

Decreasing abundance of bluefish observed in recent years has led to an increased interest in better understanding the early growth of young-of-the-year (YOY) bluefish and the importance of estuaries in juvenile development. During the summer and early fall of 2004 and 2005, juvenile bluefish were collected by beach seine from 3 sites in Southern New England. Sagittal otoliths were used to determine birthdates and weekly growth rates for each fish. Field collections were coupled with laboratory validation experiments using tetracycline-injected fish. Birthdate back-calculations show 1 summer-spawned cohort present in both years with birthdates from late May to early July. A linear relationship was found between otolith radius and body length. This relationship was fitted to the Fraser-Lee, body proportional hypothesis (BPH) and scale proportional hypothesis (SPH) back-calculation equations. Validation studies show no evidence of uncoupling and that the Fraser-Lee equation appears to be most appropriate for juvenile bluefish. Average growth rate for juvenile bluefish in southeastern Massachusetts is 1.4 mm fork length per day, which was constant over the course of the summer. Juvenile growth rates did

not appear to vary between locations in southeastern Massachusetts or be influenced by size at juvenile metamorphosis.

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Trade in vertebrates: What is the potential for homogenization?

Biological homogenization decreases global species diversity through species extinctions and introductions. The live vertebrate trade contributes to homogenization as the primary pathway for vertebrate introductions. Successful establishment of vertebrates is determined primarily by the number of individuals released or release events, known as propagule pressure. Based on this concept, potential propagules and subsequent homogenization through introductions should be related to the number of individuals imported and species richness per vertebrate taxon in trade. We utilized a subset of the international vertebrate trade, United States importation/exportation data from 1970–2002, to estimate how many individuals and species for 5 taxa (amphibians, turtles, squamates, crocodylians, birds) were moved through this pathway. For each taxon, we plotted the cumulative number of species imported from 1970–2002, projected species accumulation to identify the point at which all species will have been traded, and regressed the cumulative number of established species versus the cumulative number of species imported. If the current exponential rate of species accumulation we found continues, we predict that the United States will trade all turtle, crocodylian, and squamate species in less than 75 years. The potential for homogenization through introductions is greatest for taxa with the highest proportion of their global species traded. We found an increasing relationship between the cumulative number of established species versus the cumulative number of species imported per taxon. Our results indicate that data from the live vertebrate trade can provide an informative and predictive framework for discussion of the relationship between trade and vertebrate introductions.

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Compensatory growth in the sandbar shark, *Carcharhinus plumbeus*: Fact or fiction?

Numbers of sandbar sharks, *Carcharhinus plumbeus*, in the Northwest Atlantic have experienced drastic declines since the early 1980,s reaching their minima during the early 1990,s. Catch rates in the early 1990,s were a mere 25% of those during the 1980,s. Such drastic reductions in other fish stocks have often caused compensatory responses, most notably the cod stocks in the Northwest Atlantic. Compensatory

responses in depressed populations may include decreased natural mortality, increased fecundity, or increased growth rates. Compensation for population fluctuations below carrying capacities have been recognized for many terrestrial and oceanic r-selected organisms, but few instances have been noted for K-selected species. Due to slow-growth and late maturity, compensatory responses in K-selected species such as the sandbar shark probably require generation-scale time periods to become evident. A previous age and growth study discovered slight increases in juvenile sandbar shark growth rates when vertebral centra samples obtained in 1980-81 and 1990-1992 were compared. The Virginia Institute of Marine Science shark long-line survey reported the lowest abundance of sandbar sharks in 1992. Animals pupped during this time may display greater differences in growth rates due to drastically reduced population size. Samples obtained over the 2001-2004 time period were compared to the aforementioned time periods to investigate potential compensatory responses in the sandbar shark population in the Northwest Atlantic.

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#### Site fidelity of water moccasins inhabiting a catastrophic environment: Results of an 11-year study

An 11-year mark-recapture study of water moccasins was conducted at Honey Creek, a limestone spring-fed stream with a channeled streambed in Comal County, Texas. Droughts and nine flood events during the study dramatically altered flow with floods raising water depth by five m. Fifty-seven snakes were marked along the 1564 m long study area during 57 searches. Marked snakes were recaptured 109 times. Subsequent analysis of capture/recapture data thru the 11-year period was used to a) describe the population size structure and sex ratio, b) determine whether this population was comprised of transients, and c) determine how this putative sit-and-wait predator used space in this linear and highly dynamic system. Thirty-nine snakes were deemed sexually mature, 14 were subadults, and 4 were juveniles. The sexes did not differ in recapturability but females outnumbered males (2.3:1). Adults were recaptured more frequently than young snakes. Twenty-one (37%) were not recaptured, and 25% were captured four or more times. Seventy-one % of snakes had tenure times in the system of 1 year or less, however, following this precipitous drop, the percent of snakes potentially available to be recaptured 2 to 11 years following initial capture declined modestly. Eleven years after marking, 12.5 percent of snakes potentially available for recapture were recaptured. Distances moved between successive captures and distances from the mean capture point showed that use of the area by snakes was not random. Distances moved did not vary with sex, number of times captured, or time between captures. Because snakes were found in a limited area through several major flood events, we posit that those able to do so, if displaced, quickly returned to their activity areas.

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### Finding Wright's Westbury

In three papers published between 1918-1919, famed Cornell University herpetologist Albert Hazen Wright described his capture of a rare bog turtle on August 13, 1916 at Westbury near Oswego, apparently in Wayne County New York while in the company of two soon to be eminent biologists and scholars. In his Notes on the Muhlenberg's Turtle, Wright (1918a) states that "At Westbury, N.Y. (west of Oswego, N.Y.) Messrs. F.P. Metcalf, Ludlow Griscom and myself took a specimen (carapace about 6 cm. long) in an open moor-like area on August 13, 1916." Notes on Clemmys (1918b) and Turtles and Lizards of Monroe and Wayne Counties, New York (1919), provides similar accounts. Biologists with the NYS Department of Environmental Conservation, the Fish and Wildlife Service and us could not determine site specific information on where Wright and spent this day in August of 1916. Testament to the site's indeterminate location can be found in David E. Collins's confidential field report (1989) to the DEC on his surveys of western and central NY bog turtle sites which states that "one site (Westbury) could not be located". After considerable research and field work, we captured a live bog turtle from a fen in Wayne County in the town of Westbury in June of 2004, roughly 88 years after Wright and his eminent companions made there only known visit to this site. This talk will rehearse the steps and mis-steps associated with what we believe to be the re-discovery of Wright's long lost Westbury site.

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### Deep coral bank fish communities along the southeastern United States continental slope

Deep-water coral habitats are scattered throughout slope depths (350-800 m) off the southeastern United States (SEUS). Deep corals contribute substantial structure and diversity to bottom habitats. In some areas (e.g., off NC) deep corals (nearly monotypic *Lophelia pertusa*) form high profile mounds, and in other areas (e.g., off Jacksonville, FL) they may colonize existing hard substrates. Data on the fish communities of deep coral ecosystems are lacking, especially from off the SEUS. We surveyed the fishes of deep coral banks along the continental slope between Cape Lookout, NC and Cape Canaveral, FL using the Johnson-Sea-Link submersible (2000-2005, 65 dives) and otter trawls. We have identified at least 80 benthic and benthopelagic fish species on and near coral habitats along the SEUS. The fish

assemblage on deep coral habitats differed from non-coral habitats in similar depths. The primary, coral habitat was dominated by *Laemonema melanurum*, *Hoplostethus occidentalis*, and *Beryx decadactylus*. Off reef, *L. barbatulum*, *Fenestraja plutonia*, and *Myxine glutinosa* dominated. Additionally, fish assemblages exhibited significantly (ANOSIM, Global R=0.64, p=0.1%) different geographic patterns with NC stations forming a distinct group that differed from two southern groupings (Central-off SC through northern FL, and Southern-off Cape Canaveral, FL). Species driving the assemblage off NC included *B. decadactylus* and *H. occidentalis*. Off SC through north FL, species drivers included *Nezumia sclerorhynchus* and *L. melanurum*. *Synaphobranchus* spp. and *F. plutonia* were drivers in the most southern site (Cape Canaveral, FL). Differences in fish assemblages seem to be most related to depth and the structure of coral habitat.

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### Migration and vertical movements of a tagged Atlantic goosefish on Georges Bank

Depth (pressure) and temperature measurements recorded on a data storage tag (DST) were examined from a single Atlantic goosefish, *Lophius americanus*, tagged on Georges Bank on 9 December 2003 and recaptured 192 days and 113 km away off Cape Cod, Massachusetts on June 18 2004. The monkfish exhibited a strong pattern of periodic vertical movements ranging from 4 to 209 m (mean=75 m) with durations of 96 to 912 minutes (mean 225 minutes). A total of 43 vertical movements were recorded averaging 1.6 movements per week. Two periods of frequent daily movements were recorded. The first period occurred over six weeks in February and March during a transition from deep (180 m) to shallow water (150 m), while the second period apparently occurred as the fish descended into the Great South Channel and then ascended up the western slope into the inshore waters of Cape Cod over a five week period in May and June. Vertical movements during the second period were consistently longer in duration (mean = 246 minutes) and higher in elevation (132 m), than those in the first period (mean duration = 179 minutes, mean height = 41 m, respectively). The rate of ascent and descent were similar with means of 1.0 m/minute and 1.2 m/minute, respectively. Vertical movements occurred primarily between 0000 h and 1200 h (81 %), with peaks at 0300 h and 1000 h. This data suggests that Atlantic goosefish exhibit at least three modes of movements: 1) gradual movements along the bottom contour, 2) more rapid movements involving short vertical hops of less than 10 m height, and 3) large vertical movements involving vertical jumps of 10-200 m and durations 8 hours. The latter pattern suggest extensive use of tidal transport mechanisms.

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Movements and body temperature variation in free-ranging midland painted turtles (*Chrysemys picta marginata*) in a north-temperate marsh on Beaver Island, Michigan

We used surgically implanted radio-transmitters to study body temperature ( $T_b$ ) variation and movements of Midland painted turtles over three summers (2003-2005) in a small north-temperate marsh system. On sunny days,  $T_b$  increased sharply during the late morning hours and then declined throughout the late afternoon, early evening, and early morning hours. Variation in  $T_b$  was relatively low on cloudy days. Mean daily  $T_b$  was positively correlated with mean daily water temperatures in all years. Mean daily water temperatures varied significantly among years and apparently as a consequence, mean daily  $T_b$  also varied significantly between 22 and 26 C annually. There were no differences in mean  $T_b$  between sexes within or between years. Turtles moved within relatively well-defined activity centers within the home range. Mean total daily distance moved (TDDM) varied between 81 and 110 m per day annually and was positively correlated with  $T_b$  in 2003 and 2004. We found no significant differences in mean TDDM among years or between sexes.

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Molecular phylogenetics and evolutionary diversification of labyrinth fishes (Perciformes; Anabantoidei)

Labyrinth fishes (Perciformes; Anabantoidei) are primary freshwater fishes with a disjunct African-Asian distribution that exhibit a wide variety of morphological and behavioral traits. These intrinsic features make them particularly well suited for studying patterns and processes of evolutionary diversification. We reconstructed the first molecular-based phylogenetic hypothesis of anabantoid intrarelationships using both mitochondrial and nuclear nucleotide sequence data to address anabantoid evolution. The mitochondrial data set included the complete cytochrome b, partial 12S rRNA, complete tRNA Val, and partial 16S rRNA genes (3332 bp) of 57 species representing all 19 anabantoid genera. The nuclear data set included the partial RAG1 gene (1494 bp) of 21 representative species. The phylogenetic analyses of a combined (mitochondrial + nuclear) data set recovered almost fully resolved trees at the intrafamily level with different methods of phylogenetic inference. Phylogenetic relationships at this taxonomic level were compared with previous morphology-based hypotheses. In particular, the enigmatic pike-head (*Luciocephalus*) was confidently placed within the *spiral egg clade*, thus resolving the long-standing controversy on its relative phylogenetic position. The molecular phylogeny was used

to study the evolution of the different forms of parental care within the suborder. Our results suggest that the evolution of breeding behavior in anabantoids is highly correlated with phylogeny, and that brood care evolved three times independently from an ancestral free spawning condition without parental care. Ancestral character state reconstructions under maximum parsimony and maximum likelihood further indicated that both bubble nesting and mouthbrooding have evolved recurrently during anabantoid evolution. The new phylogenetic framework was also used to test alternative biogeographic hypotheses that account for the disjunct African–Asian distribution.

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**Small fish in a big clade: A molecular perspective on gobioid phylogeny**

Gobies (Perciformes; Gobioidae) are small fishes normally between 4 to 10 cm (range 1 to 50 cm) inhabiting most freshwaters, brackish, and marine habitats with the exception of the Antarctic and Arctic Ocean and the deep sea. The suborder Gobioidae comprises eight families (Rhyacichthyidae, Odontobutidae, Eleotridae, Gobiidae, Kraemeridae, Xenisthmidae, Microdesmidae, Schindleriidae) with about 270 genera, and approximately 2200 species. They show a spectacular variety in morphology, colouration, behavior, and ecology. While gobies belong to one of the most species rich fish groups, roughly 10% of all ray-fined fishes are gobies, they are at the same time one of the least known. A robust phylogenetic framework for gobies, one of the most species rich vertebrate clade, is needed to tackle their evolutionary history (e.g. systematics, biogeography, species richness patterns, and modes of speciation). Morphology based phylogenetic reconstructions (e.g. vertebral and pterygiophore pattern, palatopterygoquadrate complex, sensory papillae pattern) have recently been complemented by molecular approaches. The high number of species, and the current lack of consensus regarding gobioid intrarelationships makes it difficult to design efficient sampling strategies to address their phylogeny. In an attempt to contribute towards the gobioid tree of life, we have obtained nucleotide sequence data of a 2200 bp region that includes the mitochondrial 12S rRNA, tRNA-Val, and 16S rRNA gene from over 250 species, complemented by nuclear DNA loci. While an attempt has been made to represent all major gobioid lineages, we focus mostly on the American seven-spined gobies (Gobiosomatini) and on European (East Atlantic, Mediterranean, Ponto-Caspian) gobies.

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### Reproductive habits of round gobies in the Erie watershed

The round goby (*Neogobius melanostomus*) is a small benthic species native to Eurasia. It has been introduced outside its native range to several different regions, most recently to the Laurentian Great Lakes. The fecundity and reproductive behavior of the round goby has been found to differ in the various habitats it has invaded. This study estimated the fecundity and reproductive potential of the round goby in both the benthic and lotic waters of Lake Erie through out the 2002 and 2003 reproductive seasons. In Lake Erie the average number of goby eggs per nest was approximately 1000 including immature and eyed up eggs. The average number of eggs per female during the breeding season was 217 counting both mature and immature eggs. The average fecundity for lake (161) vs. stream (87) gobies were compared as were gonadal somatic indices.

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### Habitat partitioning between the introduced round goby and native stream fishes in the Lake Erie drainage of Pennsylvania

Round gobies *Neogobius melanostomus* have been found to have detrimental effects on native fish populations in the Great Lakes Region. Preliminary research has implicated them in the extirpation of the mottled sculpin (*Cottus bairdi*) and the eastern sand darter (*Ammocrypta pellucida*), and the decline of the Johnny (*Etheostoma nigrum*) and Iowa darters (*Etheostoma exile*). Under experimental conditions, they have been found to prey on other benthic fishes. It is also suspected that they compete with native species for food and habitat. Although these preliminary studies suggest that round gobies are having negative effects on native fishes, no direct evidence has been documented. Habitat partitioning could give direct evidence of this effect. The purpose of this study is to examine partitioning between non-game native benthic Lake Erie (darters, madtoms, and sculpins) stream fishes and to determine if there was a shift in habitat usage of the native fishes when round gobies were present in Twenty-mile Creek, Lake Erie. Twenty-mile Creek is the largest of the eastern tributaries to Lake Erie in Pennsylvania. Previous studies have demonstrated that in the Pennsylvania waters of Lake Erie, Twenty-mile has the most diverse benthic fauna of any stream in this drainage. Also, a small waterfall prevents goby movement upstream, allowing us to compare areas where gobies are both present and absent. We electrofished 50m areas both above and below the waterfall. Percent composition, population estimates, and Simpson diversity indices were calculated for each site. The interaction habitat preference study was conducted by

three skin divers who began snorkeling at the downstream end of the sites and made their way slowly upstream. Following a benthic fish observation, a numbered, colored flag was secured into the stream bed at the specific locality of each of the fish. Flag color indicated the species of fish sighted. Following the snorkeling session, the following abiotic variables were recorded at each flag: depth (cm), water velocity (m/s), substrate size, distance from shore, and distance from the origin of the site. Preliminary analysis indicates that in the areas where round gobies were present, there was a shift in habitat usage by native fishes.

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#### Population genetics of Saltwater Crocodile (*Crocodylus porosus*) in Palau

The Saltwater Crocodile, *Crocodylus porosus*, is a wide-ranging Indo-Pacific species. The Republic of Palau is home to what appears to be one population of this species. We are presently conducting a molecular genetics study of the wild population in Palau to determine if Palauan crocodiles are composed of one or more separate species; if the population reflects the genetic influence of other crocodylian species, which may have been introduced into the population in the past; and to create a genetic profile of Palauan crocodiles. We compare the genetics of Palauan saltwater crocodiles to that of other crocodylians living within the natural geographic distribution of *C. porosus*: *C. mindorensis*, *C. novaeguineae*, and *C. siamensis*. A circa 620 basepair fragment of the mitochondrial control region revealed a single, unique haplotype among the 37 *C. porosus* individuals sampled on Palau, most closely related to a haplotype sampled in Australia. Microsatellite genotypic data at nine loci further reveals low levels of variation relative to populations on larger landmasses, including Australia and Papua New Guinea. Based on these preliminary results, the Palauan crocodiles represent a unique population of *C. porosus*, with no measurable genetic influence from additional crocodylian species introduced over the last 200 years.

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#### Reproductive allometry in the common map turtle, *Graptemys geographica*

According to optimal egg size theory, natural selection pressures balance the egg size/clutch size trade-off at a point where increases in maternal body size result in

increases in clutch size but not increases in egg size. Many turtle species show increasing egg size with increasing maternal body size, however. The anatomical-constraints hypothesis explains this pattern by hypothesizing that smaller females lay smaller-than-optimal eggs because of morphological constraints; larger eggs simply would not pass through the pelvic aperture and caudal gap of the shell. We examined relationships among female body size (measured as plastron length), clutch size, and egg size for a population of common map turtles (*Graptemys geographica*) on Presque Isle State Park in Erie, Pennsylvania. Correlation analyses were conducted using log-transformed data in order to address questions of isometry and allometry. Clutch mass increased isometrically with plastron length. Egg size and clutch size were both significantly negatively allometric in their relationship with plastron length. It appears that larger females split the increased reproductive allocation made possible by increased maternal volume devoted to eggs between increasing both clutch size and egg size, consistent with predictions of the anatomical-constraints hypothesis.

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Taxonomy and systematics of *Nemadoras*, a genus of Neotropical thorny catfishes (Siluriformes: Doradidae)

Eigenmann (1925) established *Nemadoras* for *N. elongatus* (Boulenger), type species, and *N. bachi* (Boulenger). Sabaj and Ferraris (2003) expanded the genus to five valid species, *N. elongatus*, *N. hemipeltis* (Eigenmann), *N. humeralis* (Kner), *N. leporhinus* (Eigenmann) and *N. trimaculatus* (Boulenger), and synonymized *N. bachi* with *N. humeralis*. Molecular evidence (Moyer et al. 2004) and new morphological data support the inclusion of *Opsodoras ternetzi* Eigenmann in *Nemadoras*. Recent museum and fieldwork uncovered a new species of *Nemadoras* in the upper Amazonas and Meta (Orinoco drainage) river systems. The new species is diagnosed in part by its tooth and barbel morphology and coloration. *Nemadoras* is tentatively diagnosed by a unique combination of characters: barbels fimbriate, teeth present in lower jaw (sometimes lost in adults), nuchal foramina present and enclosed by supraoccipital, epioccipital and middle nuchal plate, anterior nuchal plate absent or reduced and enclosed by supraoccipital and middle nuchal plate, middorsal and midventral accessory plates absent, and snout relatively short, rounded to weakly pointed (not long and conical). *Nemadoras* is one of few doradid genera in which the anterior nuchal plate is sometimes absent (others being *Physopyxis* and adult *Rhynchodoras*). Other interesting features include ontogenetic changes in tooth expression and convergences in color patterns with other syntopic doradids. These features along with the taxonomy and systematics of *Nemadoras* will be presented.

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### All catfish species inventory (ACSI): Midterm report

In September 2003 the National Science Foundation Biotic Surveys and Inventories Program funded the first Planetary Biological Inventory (PBI) entitled: All Catfish Species (Siluriformes) - Phase I of an Inventory of the Otophysi. The mission of this PBI project is to complete the classification of Siluriformes by facilitating the discovery, description and dissemination of knowledge of all species by a global consortium of taxonomists and systematists. Components of the project include exploration and fieldwork, taxonomy and classification, systematics and evolution, digital museums and libraries, new applications of technologies (HRXCT or 3D scanning) to morphological studies, publications, education and public outreach, conservation, and a variety of collaborative work and partnerships with other NSF funded projects. As of 1 March 2006 ACSI has 360 participants and correspondents (including 110 students) at about 180 institutions/organizations in 48 countries; and has contributed \$419,575 to participant research (44%), fieldwork (32%), and publishing (7%), and type imaging projects (17%) at a number of museums. Nearly 1,500 primary catfish types have been imaged at over 30 museums and 4,490 catfish images are available on-line to project participants. Highlights from ACSI's first half include the description of a new family of catfishes (Lacantuniidae) from Chiapas, Mexico, publication of a special 2005 issue of Neotropical Ichthyology (28 new species and one new genus resulting from 19 papers contributed by 30 authors), a near trans-continental expedition across Peru and Brazil (50-70 new catfishes collected by 29 participants from five countries), and submission of a molecular phylogeny (based on nuclear genes rag 1 and 2) for 35 of the 37 families of catfishes. A summary of ACSI's midterm progress will be presented as well as a call for new projects on poorly studied catfishes.

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### Phenotypic plasticity in *Rana clamitans* existing in fish and invertebrate dominated predator communities

Larvae of anuran species occur at different points along a continuum of water permanency, ranging from small ephemeral ponds to permanent water sources. Predator communities vary also along the continuum and can be placed into two major categories, with fish communities and fishless or invertebrate dominated predator communities. In some cases, larvae of a particular anuran species may inhabit a wide range of pond types and co-occur with a wide range of predator communities. Some species may alter their behavior and others will undergo morphological changes in response to certain types of predators. *Rana clamitans* is a species that is known to successfully inhabit a wide range of pond types including those with and without fish. We studied *R. clamitans* at six ponds, three fishless and three with fish. We found that *R. clamitans* larvae in the fishless ponds had significantly more tail damage than in the fish ponds indicating unsuccessful attacks by invertebrate predators in the fishless ponds. At the same time we discovered that the size of the tadpoles at a given Gosner stage was significantly larger in the fishless ponds and preliminary analysis indicate significant differences in body shape and performance. As discussed in previous findings, we suggest that these phenotypic differences are tradeoffs that may increase the fitness of individuals living in variable habitats.

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### Reversible pathways in polyploid evolution in vertebrates

Comparative genomics has revealed possible ancient genome duplication events in vertebrates. Studies of recent occurrence of polyploidy will facilitate understanding the nature of genome duplication in vertebrate evolution. Processes of polyploid evolution have largely been recognized as irreversible, as hybrid- or gynogens are evolutionary dead-ends or bisexual tetraploids are infertile crossing with diploids. Examples in fish, however, indicate reversible pathways in polyploid evolution. Tetraploid *Cobitis striata* is an allotetraploid originated from hybrids between diploid *C. striata* and *C. biwae*. Existence of quadrivalents with homeologous crossing-over suggests evolution of tetrasomy from 2+2 paralogues (counter-diploidization). *Cobitis hankuensis-longicorpus* complex is an all-female diploid-triploid hybrid complex which coexists with its parental bisexual diploid species. Experimental crosses

revealed the diploid hybrid is a mother of the triploid hybrid which lays haploid ova. Crossing the haploid ova with one of the parental species regenerates normal diploids. Both parental species and hybrids share a common mtDNA haplotype indicating the diploid parental species actually regenerates in nature. Counter-diploidization and regeneration of diploids indicate that polyploid evolution is reversible at various stages, just as any other evolutionary processes which are diverging but reversible.

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#### Demography of a chytrid-infected population of one of the last Jambatos (*Atelopus*: Bufonidae) from Ecuador

Accumulated scientific and empirical evidence demonstrate that frogs of the genus *Atelopus* have suffered the most dramatic declines and extinctions in the neotropics. From November 2004 through December 2005, we monitored a population of an undescribed species of *Atelopus* on the southeastern slopes of the Ecuadorian Andes. For 15 days each month we surveyed 12 transects of 100 x 2.5 m and 18 transects of 50 x 5 m, established on the shores of the stream and on the creek slopes, respectively. Individuals were photoidentified by their dorsal patterns, and we gathered data for sex, length, mass, activity, substrate, position in the transect, height above ground and distance to the river. Additionally, the presence of tadpoles was registered. Population dynamics were then correlated with environmental data: temperature, precipitation and relative humidity. On the shores we captured 181 individuals: 161 males, 19 females, 14 amplexant pairs and 1 juvenile; males showed strong site fidelity and their home range areas were calculated. Twenty-five individuals (22 males and 3 females, or 13,81%) were found with clinical signs of chytrid infection. On the creek slopes we found 14 males, 13 females and 11 juveniles; these frogs were as far as 70m from the stream and did not exhibit any abnormal behavior. One hundred and twenty-three tadpoles were found adhered to gravel and boulders on runs and pools of the stream from June to November 2005; 12.20% (n=15) showed varying degrees of depigmentation on tooth rows. Low population recruitment and high chytrid-related mortality is indicative of the critically endangered status of this population, requiring urgent conservation action.

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*Chaetostoma* (Siluriformes: Loricariidae), endemic and diverse: A new basal species from the highlands of Peru

With 43 valid described species, the genus *Chaetostoma* is one of the most diverse armored catfish genera. Forty-one species are distributed along the Pacific and Atlantic slopes of the Andes and two species on the slopes of the Guiana Shield. The extensive collections from Peruvian highlands at the Museo de Historia Natural of San Marcos University in Peru and the Academy of Natural Sciences in Philadelphia were studied. Nine valid described species were identified as distinct from each other based on the original descriptions and comparison with type material when available, and their distributions were plotted on maps. Four species from the Huallaga River basin were identified as new, increasing the number of species in this basin to five: two from Huánuco at 2000 m, and three from Tingo María at 600 m. Species within *Chaetostoma* are endemic to single drainage systems and restricted by elevation. The discovery of many species in sympatry suggests that there may be other undescribed species in areas where to date only single species are known to occur. The inclusion of one new *Chaetostoma* species on a preliminary phylogenetic analysis of the genus generated a single tree (CI=0.4189; RI=0.7245) based on 91 primarily osteological characters. This new species, from the headwaters of the Huallaga River (Huánuco), appears to be one of the most basal *Chaetostoma* species. The most strongly supported monophyletic group within *Chaetostoma* is based on two synapomorphies: the presence of a fleshy excrescence on the posterior tip of the supraoccipital and the low number (three to eight) of evertible cheek odontodes.

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Epidemiological risk of chytridiomycosis in amphibian communities of the Venezuelan Andes

Chytridiomycosis has been identified as one of the major forces driving population declines in amphibian montane species. However, *Batrachochytrium dendrobatidis*, the pathogenic fungus that causes this disease, is also known to persist endemically in some stable amphibian populations. What factors drive epidemic outbreaks of this disease is one of the most intriguing questions in amphibian declines. In the Venezuelan Andes, *B. dendrobatidis* was detected in three *Atelopus* species in 1988, just before their populations declined drastically. This pathogen persists today in bullfrogs (*Rana catesbeiana*) an invasive species recently introduced into this region. To evaluate the epidemiological risk that this disease represents to amphibian species

endemic to the Venezuelan Andes, we conducted a survey to determine the geographic distribution of *B. dendrobatidis* and its hosts, and estimated the prevalence and relative loads of infection in several species, using PCR assays. This pathogen was found in 13 species in an area of 62 km<sup>2</sup>. The high prevalence and loads of the pathogen in *R. catesbeiana* suggests that this exotic species is the most important reservoir, although its distribution is still restricted to a small area. Among the native frogs, *Hyla meridensis*, a species endemic to this region with the greatest habitat overlap with bullfrogs, showed the highest prevalence. Epidemiological implications are discussed in light of the potential dispersal of bullfrogs, an invasive species known to host this pathogen asymptotically.

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### Ontogenetic shifts in respiratory abilities of common mudskipper (*Periophthalmus kalolo*)

Mudskippers (family Gobiidae) are tropical, amphibious fishes capable of utilizing both air and water as a respiratory medium. Common mudskipper, *Periophthalmus kalolo*, inhabits mangal environments on Hoga Island, southeast Suluwesi, Indonesia. Although little is known about mudskipper life history, juveniles are thought to be more dependent on mangal tidepools than adults; presumably because post metamorphose juveniles are less effective at extracting oxygen from air. Empirical data, however, are lacking. We compared oxygen uptake of adult and juvenile *P. kalolo* in water and air to assess the potential respiratory basis for habitat partitioning in Hoga mangals. Aquatic and aerial respiration were examined using flow-through and manometric respirometry. Respective mass corrected oxygen uptake values for adults ( $\geq 1.8$  cm) and juveniles ( $\leq 1.7$  cm) were 0.332 ( $\pm 0.124$ ) and 0.344 ( $\pm 0.186$ ) mg/g/h in aquatic trials and 0.366 ( $\pm 0.196$ ) and 1.849 ( $\pm 0.811$ ) mg/g/h in aerial trials. While values were statistically indistinguishable between life stages in water and within adults between media (ANOVA;  $p \geq 0.687$ ), juvenile aerial oxygen uptake was significantly higher than adult values (ANOVA;  $p \leq 0.001$ ). Juvenile air to water uptake expressed as a ratio show four times higher oxygen air to water ratios measured in adults. Our values suggest that tidepool dependence of juvenile common mudskippers is not due to limitations in their ability to utilize oxygen from either medium, but more likely is related to attributes such as predation, dessication or the need to enter pools to excrete ammonia. Ontogenetic shifts in aquatic and aerial oxygen extraction abilities allow common mudskipper to partition their habitat and reduce cannibalism.

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**Intraspecific phylogeography of elassomatidae: A test of the interglacial refugia hypothesis**

Current understanding of freshwater phylogeography in North America has been largely restricted to studies of highland regions and constituent fauna. This study aims to detect and describe intraspecific diversity within sympatric lowland species (*Elassoma*) and compare patterns of variation associated with biogeographic boundaries. The physiography of the Coastal Plain provides a unique opportunity for phylogeographic investigations of freshwater organisms. Processes involving Neogene sea-level dynamics have been shown to strongly influence patterns of community evolution and speciation. The lowland fish fauna of eastern North America consists of multiple areas of endemism separated by historically inundated areas formed during the Eemian interglacial period. Clades within interglacial refugia should be more closely related to each other than to clades occurring in historically inundated areas. Physiographic features such as the Fall Line, Cody Escarpment, and Lake Wales Ridge provide a spatial template upon which comparative analyses of intraspecific variation can be imposed. These physiographic features are each associated with a biogeographic boundary and hypothesized interglacial refugia. Morphometric variables (18), meristic variables (21), and mtDNA sequence variation are determined for sympatric species of *Elassoma*. Refugia populations that predate the last interglacial seastand should be ancestral to those found within previously inundated areas.

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**Feeding habits of the hammerhead sharks *Sphyrna zygaena* and *Sphyrna lewini* in Ecuador**

Feeding habits in Ecuadorian waters of 156 specimens of smooth hammerhead shark *Sphyrna zygaena* (Linnaeus, 1758) and 91 specimens of scalloped hammerhead shark *Sphyrna lewini* (Griffith & Smith, 1834) were studied. The specimens were obtained from Ecuadorian small-scale fishing during 2003 at Manta, Ecuador. Of the smooth hammerhead stomachs examined, 143 contained food (92.3%), and 13 were empty (7.7%). This species fed on cephalopods, crustaceans, and fish, and using the index of relative importance (IRI), it was shown that *S. zygaena* has a preference for cephalopods such as: *Dosidicus gigas* (84.6%), *Sthenoteuthis oualaniensis* (6.7%), and *Ancistrocheirus lesueurii* (5.1%). Males and females of *S. zygaena* had similar diet and

trophic overlap. Diet variation by size in this shark was not significant. The trophic niche width was narrow, so *Sphyrna zygaena* is a specialist predator, whereas of the scalloped hammerhead specimens, 82 (90.1%) had food or partially digested remains in their stomachs, and 9 (9.9%) had empty stomachs. Of the prey species found, 39 were identified. The IRI index showed the most important prey were cephalopods: *Dosidicus gigas* (43%), *Mastigoteuthsi dentata* (11.9%), and *Ancistrocheirus lesueurii* (11%). *S. lewini* is a specialist predator that fed mainly during the night in the oceanic area. We found differences in diet between males and females, and variations in diet by size.

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Evolution of physiological changes in association with aposematism in poison frogs (Dendrobatidae)

Aposematism is defined as the nonrandom association of conspicuous coloration and noxious substances in a single organism. Several possible adaptations are thought to promote the evolution of aposematism. These include novel biochemical pathways for toxin acquisition, specialized feeding behavior, and metabolic adaptations. Pough and Taigen (1983) were the first to suggest the association between aposematism, diet specialization, and higher aerobic capacity in poison frogs. However, their analysis included only four taxa and did not take into account shared ancestry. Cryptic species were presumed to have low aerobic capacities, generalist diets and no skin alkaloids. We have extended such analyses to 36 species of across the poison frog family. By using a phylogenetic context, we have found a significant association between aposematism and higher aerobic capacity in poison frogs. This positive correlation supports the idea that physiological adaptations are a key evolutionary step between the sequestration of dietary alkaloids and the evolution of warning coloration.

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Oribatid mites: A major dietary source for alkaloids in poison frogs

Brightly colored poison frogs contain an alkaloid-based chemical defense that is dependent on a natural diet of alkaloid-containing arthropods. More than 800 individual alkaloids (organized into 24 different structural classes) have been documented in poison frogs. Identifying the specific arthropod sources responsible for this alkaloid diversity is necessary to understand the ecology and evolution of chemical defense. At present, certain species of ants, beetles, and millipedes represent the only known sources for poison frog alkaloids. The majority of alkaloids appear to

be derived from ants, suggesting that ants play a significant role in chemical defense among poison frogs. In this study, I report the presence of tricyclic, indolizidine, quinolizidine, spiropyrrolizidine, and pumiliotoxin alkaloids in several species of oribatid mites. I also present data on the presence of these alkaloids in the microsymbatric dendrobatid frog, *Dendrobates pumilio*, from locations in Costa Rica and Panama. In addition, I will also present quantitative data on diet for *D. pumilio* from these same locations, demonstrating that these species of mites are consumed regularly as part of the natural diet of these frogs. Although ants remain an important source for poison frog chemical defense, these findings suggest that oribatid mites now represent a new and significant source for alkaloids in poison frogs.

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Effects of food availability on RNA, DNA, and growth of naked goby, *Gobiosoma bosc*

We evaluated RNA, DNA, RNA: DNA ratios, and somatic growth of naked goby, *Gobiosoma bosc*, as measures of condition related to larval feeding conditions. Eggs were collected in the field using PVC pipe nest-traps, and were hatched in the lab, yielding cohorts of larvae that were randomly assigned to three feeding treatments in two replicate tanks per treatment. Goby larvae were fed rotifers, *Brachionus plicatilis*, at densities of 20, 200, or 1200 per liter (low, medium, and high, respectively). Prey densities were measured every eight hours and adjusted accordingly. The experiment consisted of two trials of 10 and 8 days duration, respectively. A total of 699 larvae were sampled, with one to five individuals per tank sampled daily for nucleic acid analysis. An additional one to four individuals per tank were sampled daily for length-weight measurements. Wild *G. bosc* larvae were collected using a light trap and analyzed as a direct comparison of growth and nucleic acid concentrations to lab-reared fish. Preliminary lab results indicated a declining trend for growth in length with decreasing prey densities over time. Both DNA and RNA concentrations differed significantly between all treatments (ANCOVA,  $p < 0.0001$ ), and showed declining trends with decreasing prey density over time. Mean RNA:DNA ratios showed significant treatment effects indicating declining trends with increasing food treatment (ANCOVA,  $p = 0.0411$ ). We are evaluating potential interactions and trade-offs within treatments, including: daily otolith growth; total, natural, and fishing (sampling) mortality; convergence of rations; and the distribution of RNA:DNA ratios.

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### Effects of haying and agricultural practices on the wood turtle, *Glyptemys insculpta*

The impact of agricultural practices on a population of wood turtles (*Glyptemys insculpta*) in southern Quebec, Canada was investigated. Of 30 turtles followed via radio-telemetry, 20% died as a result of agricultural activities. Annual survivorship (S) of adults was 0.904 and 0.868 and for juveniles it was 0.815 and 0.831 for 1998 and 1999, respectively. Among adults, survivorship of males and females did not differ. Of those turtles that survived, many had injuries inflicted by disc mowers and tedders. Adult mutilation rates were 90%  $\pm$  3% in both years; whereas, the maximum frequency reported for juveniles was 57%. A Carapace Mutilation Index (CMI) was derived in order to quantify the distribution and severity of injuries. CMI values for males, females, and juveniles were 0.20, 0.14, and 0.07, respectively. Only male and juvenile CMI differed significantly. Adults had significantly more carapace injuries and limb amputations on their right sides. This bilateral asymmetry of injuries most likely resulted from a combination of turtle flight behavior, hayfield-river orientation, mower type, and harvesting practices. We reiterate the recommendations of forage researchers: setting the cutting height of disc mowers to 100 mm (4 inches) increases harvest yields, reduces wear on machinery, and decreases soil erosion. A by-product of such a change in cutting height is that turtle mortality and injury rates also should be reduced, as wood turtle carapace height is < 87 mm. Without changes in agricultural practices, this population will be extirpated.

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### Cardiac response to bufonid prey in *Rhabdophis tigrinus* (Colubridae), a snake that sequesters dietary toxins

Animals that sequester dietary toxins for their own defense must be resistant to the normal physiological effects of those compounds. The Asian natricine snake *Rhabdophis tigrinus* sequesters steroid toxins from toads that have been consumed as prey, delivering the toxins through specialized integumentary structures known as nuchal glands. In most predators, including snakes that do not normally consume bufonid anurans, the bufadienolide steroids of toads exert a powerful, and sometimes lethal, cardiotoxic effect. To determine the effect of ingested toads on cardiac function in *R. tigrinus* we monitored four snakes by electrocardiography

following force-feeding with *Bufo japonicus*. A single individual of *Elaphe quadrivirgata*, which normally preys on nonbufonid anurans, also was force-fed *Bufo* for comparative purposes, and both *Rhabdophis* and *Elaphe* were force-fed *Rana* as a control. All snakes survived force-feeding of *Rana*. Although ingestion of *Bufo* rapidly led to death in *Elaphe*, all individuals of *Rhabdophis* survived the ingestion of toads, with little effect on electrocardiographic parameters. Previous studies have demonstrated that several other natricine species are resistant to the effects of ingested toads, as well as other toxic prey such as newts. These data suggest that generalized resistance to bufadienolides preceded and facilitated the evolution of toxin sequestration in *Rhabdophis*.

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#### Reproductive biology of species of *Bathyraja* (Chondrichthyes, Rajidae) on the Argentinean continental shelf

Skates have become the sixth most economically important fish resource (over a total of 46 commercial fish species) landed by commercial bottom-trawlers in Argentina. Biological data of skates (especially on reproduction) are needed to improve management of their fisheries. Despite the abundance and diversity of *Bathyraja* genus in Argentinean waters (eight species), very little is known about its basic biology and ecology. Specimens of *Bathyraja brachyurops* (n=383), *B. macloviana* (n=360), *B. albomaculata* (n=229), *B. magellanica* (n=120), *B. griseocauda* (n=88), *B. multispinis* (n=29), *B. cousseauae* (n=26) and *B. scaphiops* (n=16) were collected from research cruises carried out by the Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP, Argentina) since 2003. Study area extended along Argentinean continental shelf between 36°S and 55°S. Size at maturity of the four most abundant species was assessed from the allometric growth pattern of uteri, oviducal glands and clasper with respect to total length ( $L_T$ ). The length at which 50% of the skates were sexually mature ( $L_{T50}$ ) was estimated from a logistic ogive fitted to the data using maximum-likelihood approach. Females of *B. brachyurops* and *B. macloviana* matured at a larger size than males, while both sexes of the other two species appeared to attain sexual maturity at about the same  $L_T$ .  $L_{T50}$  in both sexes of the four species was achieved at >75% of the maximum  $L_T$  observed. Females carrying egg cases in their uteri (in different egg case formation stage) were found, and the date and geographic position of these females were recorded to identify egg-laying seasons and areas. Furthermore, egg cases were removed and preserved in order to describe them. Other reproductive characteristics of these species are being analysed. These preliminary results are part of an ongoing study about biology, ecology and biodiversity of species of *Bathyraja* on the Argentinean continental shelf.

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Acoustic differences between tree and mating calls in pine woods treefrogs  
(*Hyla femoralis*)

Anurans have four basic calls: advertisement, reciprocation, release, and distress calls. Advertisement calls often are termed mating calls, which have been intensively studied since the pioneering review by W. Frank Blair in 1958. However, male treefrogs also emit a diurnal tree call from the tops of trees during the breeding season. As dusk approaches, tree calls continue from lower in the trees, and if conditions are favorable, males jump to the ground and travel to a nearby breeding pond where they begin their repetitive mating calls. The function of tree calls remains unknown. By calling from treetops several hours before mating begins, males may attract either more females or more distant females, and also could deter other males from the area. We predicted that because tree calls and mating calls are broadcast at different times and may serve different functions, they may be acoustically different. We recorded tree calls and mating calls of the pine woods treefrog (*Hyla femoralis*) in Seminole County, Florida, U.S.A. We found few similarities between these two calls. While both calls are broadcast at similar frequencies (between 1500 and 5000 Hz), call duration and number of pulses varies. Tree calls are shorter, have fewer pulses, and more time between pulses compared to mating calls. In contrast, Blair noted that tree calls of *H. squirella* lacked a harmonic component, which increases in frequency in a mating call. To the best of our knowledge, our acoustical analysis of the tree call of *H. femoralis* is the first since Blair's 1958 sonogram of the tree call of *H. squirella*.

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Reproductive barriers among species in the *Fundulus notatus* species complex

We examined the strength of several pre and post-zygotic reproductive barriers among species in the *Fundulus notatus* species complex. Fishes in this complex are found throughout the Midwestern and Southern United States. The two most widely distributed members of this complex, *F. notatus* and *F. olivaceus*, occur throughout much of the Mississippi River drainage as well as the coastal drainages of the Gulf of Mexico. *Fundulus euryzonus* are more narrowly distributed and endemic to the Pontchartrain drainage in Louisiana and Mississippi. All members of the complex

have similar ecologies, and encounter one another in numerous contact zones throughout their ranges. There are numerous reports of hybrid individuals from contact zones, typically in low abundance. It is not known if this low abundance is due to prezygotic (eg. assortative mating) or postzygotic (eg. endogenous or exogenous selection against hybrids) barriers. The purpose of this study was to assess the strength of some of these barriers through mate selection (non-choice mating trials) and hatching success trials involving first and second generation hybrids in the *Fundulus notatus* complex.

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Overview of the Lithogeninae and a new species from southern Venezuela

The systematics of the loricariid subfamily Lithogeninae is reviewed. A third species was discovered from a single locality in the upper Orinoco River drainage of southern Venezuela and is the only lithogenine known from more than a handful of specimens. The new species shares with its congeners the trunk dermal plates reduced to three paired series, a bifurcate levator arcus palatini crest, expanded hyomandibula lateral lamina, and palatine sesamoid not reaching the nasal capsule, thus confirming its placement in *Lithogenes*. The new species is diagnosed among congeners by absence of odontodes on the proximal portion of ventral surface of the first pelvic-fin ray (vs. ventral pad covered with embedded odontodes along entire length); accessory premaxillary teeth absent; anal fin with intense pigment band along base and diffuse spot at midlength of fin rays (vs. pigment band at base absent, fin rays dusky, without distinct spot). Features of musculoskeletal anatomy hitherto unknown for lithogenines are presented, along with aspects of sexual dimorphism, and the anatomy of the reproductive and digestive systems that are unique or unusual among loricariid catfishes. Lithogenine loricariids share a number of unique features with astroblepid catfishes that are not observed to occur in other members of the Loricariidae, such as pelvic-fin morphology, pelvic musculature, and associated adaptations for climbing. Evaluated against the evidence supporting their phylogenetic placement as the sister-group to all other Loricariidae, exclusive of the Astroblepidae, these shared similarities suggest that the association with rocky habitats of headwater-stream systems and the ability to climb vertical surfaces may represent ancestral conditions for the lineage leading to the astroblepid plus loricariid catfishes.

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Chelonian illustration: The legacy of Schoepff's *Testudo terrapin*

Scientific illustration is an often neglected, but vital component of zoological investigation. It has evolved through a complex development of styles and techniques from cave art to modern photography. Originally appearing in paper form on hand-executed eleventh century manuscripts, most early images were exaggerated, seeking appeal with unrealistic stylized designs, sacrificing accuracy for socio-religious conformity. Organism's images were generally based on descriptions or legends. The resulting depictions bear witness, giving credence to inaccuracies, and myths. Early printed images engraved on wood, evolved to the steel or copper plates of Schoepff's *Testudo terrapin* (1792-1801), Shaw's *Testudo concentra* (1802) and Boulenger's *Malacoclemmys terrapin* (1889). Later examples [Latreille's *Testudo centrata* (1801), Holbrook's *Emys terrapin* (1842) and Wied's *Emys pileata* (1865)] illustrate the scientific method's influence paired with hand-colored realism. During this time, works written for public appeal increased and common animals such as *Malaclemys* were seen in a new light. Although images had been copied from earlier works since the 1600's, the practice became more rampant during this time with accuracy and detail decreasing dramatically. During the late 1800's, chromolithography, the first true color printing, was utilized widely, later augmented with labor saving photography in Hay (1905). Fewer illustrations were drawn from this time on due to the this, yet hand-drawn images remain an important documentation tool. More easily reproducible than photographs, they have a life to them, an embodiment and viewpoint of the artist. Images also serve as type specimens (neotypes), the case with Gray's *Chitra indica*, and Schoepff's *Malaclemys (Testudo) terrapin*.

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Morphometric variation of mountain catfishes (Amphiliidae, *Amphilius*) in Guinea, West Africa

Geometric morphometric techniques were used to examine intra- and interspecific variation among Guinean amphiliid catfishes. Specimens identified as three amphiliid catfish species, *Amphilius platyichir*, *A. rheophilus*, and *A. kakrimensis*, were collected in streams of the Fouta Djallon highlands and Zone Forestiere of Guinea, West Africa in 2002 and 2003. Principal components analyses of lateral body profiles and ventral images of the head, recognizing 15 and 9 landmarks, respectively, allows clear separation of two morphotypes. Specimens identified as *Amphilius platyichir* display a deeper body as well as a more pronounced notch in the branchial membrane than those identified as *A. rheophilus*. Specimens of *A. kakrimensis* are

similar in ventral head morphotype to *A. platyichir*. Variation in depth of the branchial membrane notch is also observed among specimens of *A. rheophilus*.

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A GIS-based examination of niche evolution in horned lizards (*Phrynosoma*)

Recent developments in biodiversity informatics have promoted new uses for museum specimen data to investigate factors influencing broad-scale ecological and evolutionary patterns. For example, the fundamental ecological niche of a species can be characterized by analyzing the association between species occurrence data and broad-scale environmental variables contained in geographic information systems (GIS) datasets. In this study, I applied a GIS-based approach to examine the evolution of the fundamental niche of horned lizards (*Phrynosoma*). Species in the genus *Phrynosoma*, which are distinguished by their flat body plan, cryptic coloration, and unique horn morphologies, occur from Canada to southern Mexico in habitats ranging from sparsely-vegetated lowland deserts to mountainous forests. I used species occurrence data in conjunction with 20 GIS environmental variables to characterize the niche of extant species of *Phrynosoma*. Using these results, I calculated niche overlap among species pairs and assessed the relationship between niche overlap and species relatedness in a phylogenetic context. Results suggest that niche overlap and phylogenetic similarity are not correlated and that niches are not consistently conserved among closely related species. This study offers an example of how biodiversity informatics can be applied to better understand evolutionary patterns and factors regulating broad-scale patterns of biodiversity. The integration of measures of phylogenetic relationships with species occurrence data offers a relatively new approach to the study of the niche in this group of morphologically and ecologically similar lizards, and may provide a framework for studying other groups. Furthermore, identification of the key environmental attributes that characterize species occurrences has conservation implications for protection of threatened species, such as the Texas horned lizard (*Phrynosoma cornutum*).

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The 'pseudo-craniovertebral articulation' in the deep sea fish *Stomias boa* (Teleostei: Stomiidae)

Many predatory deep sea fishes show adaptations in the feeding apparatus, e.g. an enormous gape, the acquisition of long daggerlike teeth and a very distensible stomach, to be capable of swallowing very large prey. These traits can be well observed in members of the orders Saccopharyngiformes or Stomiiformes. In the

stomiiform genera *Malacosteus* and *Chauliodus* a profound modification of the anterior vertebral column has long been known, allowing for extreme movements of the head during prey capture and swallowing. The present study gives a detailed morphological description of the stomiiform deep sea fish *Stomias boa* based on dissection, serial sections and clearing and double staining methods. In this genus the first two vertebrae are reduced. Instead of these in this region the notochord persists allowing extreme upward bending of the skull. To both sides of the notochord there exist large pads made of dense connective tissue. These pads, spanning from the first enlarged neural arches to the chordal sheath, embrace the protruding exoccipitals thus constituting a kind of double ball- and socket joints for the head. This 'pseudocraniovertebral articulation' is considered as functional substitute for the reduced two vertebrae. By the action of the strong epaxial musculature the skull can thus be extremely raised upwards further expanding the gape, which already is strongly expanded by the elongated lower and upper jaw bones. As a consequence of these adaptations most other parts of the skull are accordingly modified. The skull is compressed, the gills are relocated to the underside of the mouth and the modified hypaxial musculature participates in mouth closure.

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#### **SCHOBERND, ZEBULON H.**

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#### Species assemblages, distribution, and abundance of serranids in the South Atlantic Bight, 1973-2004

Spatial and temporal trends of serranids in the South Atlantic Bight (SAB) were analyzed from the 30+ year data set of a fishery-independent catch survey. Serranid catches in a bottom trawl (1973-1980) were dominated by sand perch, *Diplectrum formosum*; black sea bass, *Centropristis striata*; and bank sea bass, *Centropristis ocyurus*. *Diplectrum formosum* was found most often between 21-40 m, *C. striata* was found at 21-30 m, and *C. ocyurus* was found predominantly at 31-80 m. Trap catches (1988-2004) were dominated by *D. formosum*, *C. striata*, *C. ocyurus*, *Mycteroperca phenax* (scamp), and *Epinephelus morio* (red grouper). In trap catches, *D. formosum* was found most often at 31-40 m, *C. striata* at 21-30 m, *C. ocyurus* at 21-40 m, *E. morio* at 31-40 m, and *M. phenax* at 41-80 m. Overall, fishes were found in high densities near Onslow Bay, North Carolina, on reefs off the coast of central South Carolina, and near Cape Canaveral, Florida. Catches of red grouper, black sea bass, and sand perch were low in the early 1990s followed by increased catches later on, while bank sea bass catches showed the opposite trend. Only red grouper showed a relationship between trap catches and fishery landings from the previous or following year. Cluster analyses showed that *D. formosum*, *C. striata*, and *C. ocyurus* occurred in trawls together, as did *Serranus phoebe* and *Serranus notospilus*. *Diplectrum formosum*, *C. striata*, and *C. ocyurus* were also found together in trap catches, as were *M. phenax*, *Mycteroperca microlepis* (gag grouper), and *E. morio*, as well as *Epinephelus drummondhayi* (speckled hind) and *Epinephelus niveatus* (snowy grouper). Results of this study indicate locations of high abundance for several commercial species; this information should be taken into account in future fishery management decisions.

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Speciation in the North American genus *Dionda* (Actinopterygii, Cyprinidae)  
(II)

Most recognized species of the genus *Dionda* inhabit drainages of the Gulf of Mexico from central Mexico to southern United States, and were considered a monophyletic group based in morphology, osteology, and allozyme studies. A molecular phylogeny of species of *Dionda* was used to reconstruct their relationships and to infer biogeographic hypotheses based on one mitochondrial (Cyt-b) and three nuclear genes (S7, Rhodopsin, Rag1). The 14 species of *Dionda* analyzed were never recovered as a monophyletic group when species from other related genera were included in the phylogeny. One well-supported clade is formed by northern species of the current genus *Dionda*. All these species inhabit present or past tributaries of the Rio Grande basin from northern Mexico and southern USA. In this analysis the other group of species included in *Dionda* includes the Southern species of the genus plus *Codoma ornata*. One highly divergent undescribed species of *Dionda* is sister to this clade. All these species of the Southern '*Dionda*' clade inhabit headwaters of the Panuco-Tamesi drainage and coastal Nautla River and are closely related to the putative monotypic genus *Codoma*. This clade is the sister group to Mexican species of the genus *Cyprinella*, and is proposed as a genus endemic to Mexico.

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Effects of salinity on tadpoles of the green treefrog (*Hyla cinerea*) across local habitats

Saltwater intrusion is among one of the highly detrimental factors contributing to wetland loss in the Lake Pontchartrain area in southeast Louisiana. Studies have documented salinity effects on plant communities in southeastern Louisiana, but none has dealt with its effect on the anuran community. Salinity increases can have profound effects on the reproductive success of amphibians as well as the fitness of their progeny. However, the effect of salinity is unknown for any amphibian in this area. This study investigates the effects of various salinity levels on mortality, larval growth, and metamorphosis on one of the most abundant frogs (*Hyla cinerea*) in the Manchac swamp area. The Manchac Wildlife Management Area (MWMA) is located in the Lake Pontchartrain basin in southeastern Louisiana. Salinity tolerance was

determined using four clutches of eggs, two from intermediate salinity marshland sites and two from freshwater sites during different ontogenetic stages in a common garden experiment. For each clutch 20 tadpoles were reared in each of six salinity levels (2, 4, 6, 8, 10, and 12 parts per thousand) and a freshwater control. Preliminary data indicate that water salinity has a distinct effect on embryonic mortality. Salinity effect varied among populations and developmental stages. Salinity stress during the late larval stages (25–46) showed substantial influence on developmental rate. My data indicate that mean developmental time is longer than currently noted in literature, possibly due to salinity stress. In addition, weight and SVL are strongly linked and show similar trends among populations at metamorphosis.

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**SCHULTZ, ERIC T.**

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Sexual selection on birth date, birth age, and brood sex ratio in a live-bearing fish

Natural variability in breeding time provides an opportunity to examine the selective pressures that affect phenology. Prior research has revealed that breeding time is subject to selective conflicts between the energetic needs of adults and offspring, and between different seasons such as early-summer and overwinter survival. Less well appreciated is the conflict that can arise between male and female offspring such as when the mating success of males is affected by their birth or hatch date. Male dwarf surfperch (*Micrometrus minimus*) are mature at birth and they promptly inseminate newborn females. Under such conditions, male birth date affects mating success, which is also a function of female availability and the intensity of intrasexual competition for mates. I employed a game-theory model to predict the optimal distribution of male birth dates relative to female birth dates. Males are predicted to have an earlier average birth date than females. Observations of a dwarf surfperch population revealed that male birth dates were in fact shifted several days earlier than female birth dates. There were two causes of the sexual difference: males are born after fewer days *in utero*, and early-season broods are male-biased. A good empirical fit to predictions indicated that the selective pressures have been well characterized in the model.

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Diets of the alien snapper *Lutjanus kasmira* and native goatfishes in Hawai'i

The snapper *Lutjanus kasmira* (Family: Lutjanidae) was introduced to Hawai'i during the 1950's with the goal of enhancing commercial and recreational fishing opportunities. Although the species spread quickly throughout the archipelago and is abundant across a substantial depth range, it is not sought after as a food fish. Also, there is a widespread perception among the general public that *L. kasmira* is adversely affecting native species by preying on them or by competing with them for limited resources. No scientific evidence exists to support or refute these contentions, however. To address these concerns, we studied various aspects of the ecology of *L. kasmira* in relation to some key native fishery species. The present study focuses on dietary analysis of gut contents of *L. kasmira* and three native species of goatfish (Family: Mullidae): *Parupeneus multifasciatus*, *Mulloidichthys vanicolensis*, and *Mulloidichthys flavolineatus*. These fishes were selected as focal species in the study because prior studies indicated that they were ecologically similar to *L. kasmira* and thus might be among the species most likely to compete with it for food resources. Diets of *P. multifasciatus* were most similar to *L. kasmira*, in spite of the fact that our data indicate that these species feed at different times of day. Diets of the two *Mulloidichthys* species were most similar to each other; there is some indication that the diet of *M. vanicolensis* may be more similar than the diet of *M. flavolineatus* to the diets of *P. multifasciatus* and *L. kasmira*. Although it has been suggested that *L. kasmira* preys on native fish or crustacean resource species, neither suggestion was supported by our data. Ultimately, the results of this study do not provide convincing evidence of strong adverse effects on native fishery species through predation or competition for food.

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Population sizes of desert-breeding anurans

Determining population sizes of desert anurans is especially difficult because of the brief, erratic timing of standing water; the extremely rapid decline in numbers of adults at breeding sites following breeding events (sometimes orders of magnitude in 24 hours, if no rain the second night); and high numbers of species (up to seven at

some sites). We computed Lincoln-Petersen population size estimates of breeding aggregations of desert toads and spadefoots by collecting, marking, and releasing all anurans we could capture at a site; waiting at least an hour for anurans to commence calling and breeding again; then duplicating the collecting effort again to provide the two equal-effort sampling periods required for that estimator. On most nights, we could evaluate two ponds. We estimated as many as nine populations of five species at two sites in a single night (*Bufo alvarius*, *B. cognatus*, *B. punctatus*, *Scaphiopus couchii*, *Spea multiplicata*). Species aggregations sampled ranged from single-species populations of *S. couchii* or *B. cognatus* to five-species aggregations, with total aggregation estimates ranging from eight *B. cognatus* to 2937 individuals of five species. For large, multi-species aggregations, only rarer species were weighed, measured, marked and released; abundant species (more than 200 individuals) were just sexed, counted, and released, and recapture frequencies for the second sampling period estimated as the mean of all previous recapture frequencies for those species. Males appeared to meet the closure requirement better than females, who often were still arriving during the second sampling period; a third sampling at a given pond, delayed to allow females more time to arrive, would allow better quantitation of females. Handling the anurans during the first sampling period does not seem to discourage breeding, and may enhance it. This method has broad applicability for estimating population sizes of explosive breeding amphibians in many biomes.

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### Enhancing amphibian biodiversity on golf courses through use of seasonal wetlands

Ecologists generally recognize the value of seasonal wetlands, but these wetlands are often ignored in landscape management decisions and practices, including golf course design. We sampled the amphibians and reptiles that use wetland habitats on five golf courses for three years in the sandhills of South Carolina and Georgia, and compared these survey data to concurrent surveys at 11 nearby (off-course) seasonal wetlands. Two of the courses sampled had on-course seasonal wetlands, which allowed us to compare amphibian diversity on these courses to the other three courses that did not have seasonal wetlands. Permanent wetlands were more numerous than seasonal wetlands on the golf courses we sampled. However, greater amphibian species richness occurred at both off-course and on-course seasonal wetlands compared to golf course permanent lakes and ponds: 24 species were sampled at comparison seasonal wetlands, 18 species at the two courses with seasonal wetlands plus permanent aquatic habitats, and 11 species at the three courses with only permanent water. The permanent golf course wetlands harbored numerous fish species, and these wetlands contained only the few amphibian species that can tolerate fish. Much of the difference between the species lists for golf courses with and without seasonal wetlands results from the presence of amphibian species

that prefer fish-free wetlands on the courses that have seasonal wetlands, such as *Ambystoma opacum* (marbled salamander), *Ambystoma maculatum* (spotted salamander), and *Gastrophryne carolinensis* (eastern narrow-mouthed toad). These results demonstrate that the incorporation of seasonal wetlands into the design of the golf-course landscape would likely enhance amphibian biodiversity.

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### Terrestrial distribution of salamanders around an isolated wetland

Terrestrial habitats surrounding isolated wetlands are a critical resource for many pond-breeding amphibian species, yet few studies have examined the terrestrial distribution of post-metamorphic juveniles and adults. We used an encircling drift fence at a breeding pond in conjunction with partial fences at 90, 172, and 332 m from the wetland to estimate the distribution of adult marbled salamanders (*Ambystoma opacum*; 3 years) and mole salamanders (*A. talpoideum*; 1 year), as well the habitat use of juvenile *A. opacum* (1 year). In general the form of the distribution of animals was one of exponential decay, and not a normal distribution as has been reported previously. For juvenile *A. opacum*, 80% of newly metamorphosed animals dispersed to Zone 1 (10-89 m from the wetland boundary), 10% to Zone 2 (90-171 m), 6% to Zone 3 (172-331 m), and 4% to Zone 4 (beyond 332 m). Distribution of adult *A. opacum* varied among years, but an average of 27% (range 21-32%) occurred in Zone 3 or beyond in all years. Forty percent of adult *A. talpoideum* occurred in Zone 1, with 15%, 25%, and 20% distributed in Zones 2-4, respectively. Knowledge of the shape of the terrestrial distribution function is important due the strong influence it has on the buffer zone area required to capture 50% or 95% of the population. Our results indicate that, compared to a normal distribution, a distribution that mimics exponential decay may require a smaller area to protect 50% of the populations of these two ambystomatid salamander species, but a larger area would be needed to protect 95%.

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### Conservation of terrestrial habitat for California tiger salamanders (*Ambystoma californiense*)

California tiger salamanders (*Ambystoma californiense*) have recently been placed on the list of federally endangered species, thus increasing interest in how reserves should be designed in order to protect them. Our study uses an array of pitfall traps in order to capture *A. californiense* at varying distances from a vernal pool in which they breed. The density of adult salamanders decreases exponentially as a function of

distance from the pool, while the density of juveniles peaks at 100-300 meters from the pool before decreasing exponentially. These empirical density observations are compared with a mechanistic model predicting salamander distribution based on intraspecific competition. They are also combined with information on age-specific survivorship and fecundity of *A. californiense* generated by Trenham et al. (2000) to create a model that calculates the value of land at varying distances from the vernal pools in maintaining the *A. californiense* population. Capture data has also been combined with a number of GIS layers in order to determine *A. californiense* habitat preference based on a number of factors, such as density of gopher burrows, elevation, and proximity to old eucalyptus stands. Finally, *A. californiense* individually identifiable by PIT tags or digital photographs enable us to examine the directionality of *A. californiense* migrations to and from breeding ponds as both juveniles and adults. All of this information will be useful in planning reserves and for assigning mitigation costs when land near breeding ponds is disturbed.

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#### Alien vs. predator, energetics of the Everglades pythons

A breeding population of Burmese pythons is now established in the Everglades National Park. Hatchlings to 4.3-m adults have been captured in the park, mostly along major roads. Gut contents reveal that the Everglades pythons are feeding relatively frequently, chiefly on rodents and birds. In September 2005, an adult python was found dead after it had consumed a 2-m alligator. It is hypothesized that the python had eaten the alligator and then die due to complications stemming from digesting the alligator or from an encounter with another predator. Curious on whether Burmese pythons can digest alligators, we fed alligators to Burmese pythons and tracked gastric digestion of alligators by X-ray while measuring their metabolic rates. Elements of the alligator skull were still evident at 3 days postfeeding, with the last of the skeleton dissolved by day 9 of digestion. While digesting alligators, pythons experienced 8-fold increase in metabolic rate and maintained elevated rates of metabolism for 9 days. Using metabolic measurements taken during the digestion of rats and alligators, growth efficiencies from these meals, and assumptions of daily energy expenditures, we have modeled the growth and food consumption of the Everglades Burmese pythons. From hatchling, Burmese pythons in the Everglades could theoretically reach adulthood in four years. During that time an individual could consume 100 kg of food by feeding on 40 to 150 different prey items ranging from small rodents (deer mice, cotton rats) to large mammals (opossum, bobcat), birds (egret, ibis), and alligators.

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Long-term changes in snake populations at the Kennedy Space Center, Florida, 1977-2006

The Kennedy Space Center represents one of the largest areas of undeveloped habitat on the east coast of Florida. Starting in 1977, we began monitoring the numbers of snakes found along a standardized road transect, and continued that monitoring from 1977-1979 and from 1992-2006. Previous reports (through 2000) indicated a significant decrease over time in both total numbers of snakes and species richness, especially for two aquatic species (green water snakes and cottonmouths). Data from 2001-2006 showed a significant increase in numbers of snakes, presumably as populations recovered from a long-term drought in the late 1990s. Although there has been a recent increase in species diversity, neither green water snakes nor cottonmouths have recovered anything close to their former numbers. The reasons for these changes, as well as the impacts of road mortality will be discussed.

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The impacts of Hurricane Katrina on a population of yellow-blotched sawback turtles (*Graptemys flavimaculata*) in the lower Pascagoula River

The yellow-blotched sawback turtle (*Graptemys flavimaculata*) is a freshwater aquatic turtle that is endemic to the Pascagoula River system of southern Mississippi, USA. Population declines led to Federal listing as a threatened species in 1991, with the most robust population inhabiting the lower Pascagoula River in the vicinity of Vancleave, MS (approx. 24 river km from the Pascagoula River mouth). During the spring and summer of 2005, this population was the focus of an endocrinological /genetic study. In addition, turtles were paint marked after capture in order to get a current population estimate of *G. flavimaculata* in the study area. On August 30, 2005, Hurricane Katrina hit the Mississippi Gulf Coast, including our study site. This offered a great opportunity to understand the response of *G. flavimaculata* to one of the most severe natural perturbations in recorded history. This included approximately 190+ kph winds with a 3.6 to 4.5 m storm surge in the study area. In addition to the surge, the river remained at 3.0+ gauge m for 13 days, with normal river levels prior to the storm between 0.9 to 1.2 gauge m. On October 13, 2005, a one hour visual survey by boat through the study area yielded 8 individuals that were paint marked pre- Katrina. These turtles were spotted within the same areas where they were originally marked. For the visual surveys, the Schnabel population estimator was used and indicated a population size of 1203 (2339.1 to 732.0, 95% CI) individuals in a 2 km section of river. We now know that individuals were able to cope throughout the storm, as well as being able to maintain connection to their

home range. One issue that is yet to be resolved is the impact of the storm surge (saltwater intrusion) on the food base of *G. flavimaculata*, which includes gastropods and other aquatic macroinvertebrates.

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Is there population structure in the yellow-blotched sawback turtle (*Graptemys flavimaculata*) in a seemingly continuous environment?

The yellow-blotched sawback turtle (*Graptemys flavimaculata*) is a freshwater aquatic turtle that is endemic to the Pascagoula River system of southern Mississippi, USA. Population declines led to Federal listing as a threatened species in 1991, as well as being listed by the Turtle Conservation Fund/ IUCN as one of the 25 most endangered turtles in the world. However, no research has focused on the population structure of this species. Population structure will be assessed by using morphometric and genetic analyses (microsatellites). During the spring and summer of 2005, we conducted research at three sites in the Pascagoula River basin: (1) north of Hattiesburg, MS, on the Leaf River; (2) south of Leakesville, MS, on the Chickasawhay River; and (3) east of Vancleave, MS, on the lower Pascagoula River. An additional study site on the Pearl River was included using the sister species, the ringed sawback turtle (*Graptemys oculifera*), for morphometric and genetic comparison. Turtles were trapped by using basking traps attached to turtle basking structures. When later approached by boat, turtles were startled into the traps and quickly removed. Once removed from the trap, 1 mL of blood was collected, as well as morphometric data. Morphometric analyses of carapace length using a two factor ANOVA indicated that *G. flavimaculata* have significantly larger carapace lengths than *G. oculifera* ( $F_{3,316} = 10.86, p = 0.0011$ ). Additionally, there was a significant difference in carapace lengths between the three sites for *G. flavimaculata* ( $F_{3,221} = 3.76, p = 0.02$ ), with Vancleave females and males being the largest. Preliminary analysis of the microsatellite data for *G. flavimaculata* suggests that there could be genetic differentiation among the three different sites, with more extensive data to be presented.

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#### Reproductive dynamics of *Leucoraja naevus* and the role of oviducal gland

Rays are single oviparous species in which the egg production is limited by the ovarian and uterine capacities. They present external embryonic development of encapsulated fertilized eggs. The capsules are produced by the oviducal gland which also plays other important roles such as the production of egg jelly and sperm storage. Although it is generally admitted that spawning in rays occurs throughout the year, the temporal pattern of the reproductive output from mature females along the year is still uncertain for most of the populations. This aspect needs to be clarified to improve the knowledge on the behaviour of different cohorts in the population. This study presents results from the Portuguese project on the reproductive dynamics of *Leucoraja naevus* (Müller & Henle, 1841), using data on ovarian fecundity and on oviducal gland degree of activity, by month. Females in different maturity stages were continuously sampled from Portuguese commercial landings. Histological sections of the oviducal gland were performed in different zones: the proximal club zone, the papillary zone, the baffle zone and the terminal zone. Oocyte size-frequency histograms by month, particularly the relative frequencies of large oocytes (diam > 2.0 cm), indicated that egg-laying is not a continuous process along the year. The activity of different gland zones varied according to the level of maturation. In mature females before ovulation, the baffle zone, which secretes the capsule material, presented a high accumulation of secretions in the lumen. In the first two uterine stages, during which the formation of the capsule takes place, the club and papillary zones, both responsible for the formation of the egg jelly, were more active. Just prior the extrusion of the egg, it was observed a decrease in activity of the baffle zone and an increase at the terminal zone which secretes fibres deposited on the capsule's surface.

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#### Sperm aggregations in the spermatheca of the Red Back Salamander (*Plethodon cinereus*)

The spermatheca of *Plethodon cinereus* is a compound tubular gland that stores sperm from mating in early spring (March-April) to oviposition in summer (June-July). The seasonal variation of sperm storage in this species has previously been studied by light and transmission electron microscopy. In this paper, sperm aggregations, interaction of sperm with the spermathecal epithelium, and spermathecal secretions are studied using scanning electron microscopy. Within spermathecal tubules,

relatively small groups of sperm are aligned along their entire lengths in parallel arrays. This pattern is similar to other plethodontids with complex spermathecae. Lumina of spermathecal tubules are filled with secretory material in April prior to the arrival of sperm, and after sperm appear, a coating of secretory material persists on the apices of the spermathecal epithelium. Sperm peripheral to the central luminal mass can become embedded in the secretory matrix or pushed deeper into the spermathecal epithelium. The spermathecal secretions may serve to attract and prolong the viability of sperm, but sperm that become enmeshed in the secretions or epithelium are phagocytized. Sperm and spermathecal secretions are largely absent after ovulation and in summer months, and new secretory vacuoles are formed in fall, although mating does not occur until spring.

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Habitat but not body shape affects predator attack frequency on lizards in the Brazilian cerrado

Predators use characteristics such as pattern and shape in forming search images of prey, thereby influencing the evolution of prey morphology. In lizards, sit-and-wait foraging species are thought to have body shapes that enhance their ability to remain cryptic to predators. Structurally complex habitats provide more opportunities for prey to avoid detection, thus predator foraging efficiency is predicted to be higher in structurally simple habitats. I used clay lizard models to test whether predation varies among lizards with different body shapes and whether predation varies among habitats in the Brazilian Cerrado with different structural characteristics. Predator attack frequency was highest in the most structurally complex habitat, but the probability of being attacked was higher in more open microhabitats. Attack frequency did not significantly differ among the four lizard model shapes. Lizards and birds were the main attackers of models and attacks were primarily directed toward the models heads. My results demonstrate that predator-prey interactions are largely influenced by the environmental context and that body shape alone does not efficiently promote crypsis.

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Physiological differences among newts from ponds of different pH

We studied physiological responses of newts, *Notophthalmus viridescens*, from three high pH ponds in the Taconic Mountains (average pH=8.1) and three low pH ponds in the Green Mountains (average pH=4.6) of southern Vermont. After 10 days at pH=3.16, 69% of Green Mountain (low pH) newts survived compared to only 23% of

Taconic Mountain (high pH) newts. Plasma osmotic concentration, per cent body water, and oxygen consumption were measured in newts from both locations before (untreated) and after treatment for 4 h or 4 d in high pH or low pH. Newts from ponds of different pH exhibited differences in osmoregulation and metabolism. The plasma osmotic concentration and per cent body water of untreated newts taken directly from either high or low pH ponds did not differ. However, pond of origin, duration of exposure, and the interaction of pond x pH treatment contributed significantly to the variation in plasma osmotic concentration. The interaction of pond x duration of exposure and pH treatment contributed significantly to variation in per cent body water. The differences in osmoregulatory responses of newts were not reflected in metabolic differences. Under all treatments, newts from low pH ponds had higher oxygen consumption rates than newts from high pH ponds. It remains to be seen if the physiological differences among newts from different source ponds are due to evolutionary adaptation to different pH.

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#### Application of genetic forensic tools in shark fishery monitoring and law enforcement

Management of shark fisheries in the U.S. and some other countries includes national legislation aimed at preventing landings of species considered especially vulnerable to fishing. Additionally, trade in some of these species (basking, white and whale sharks) is also regulated on an international level due to recent CITES listings. Despite these well-meaning regulations, however, landings and trade of these protected species is suspected to occur due to continued strong market demand for fins, and difficulties in identifying detached body parts. To assist in law enforcement and general monitoring of shark fisheries, we have developed species-specific PCR primers and a rapid assay that currently identifies 28 shark species of regulatory and conservation interest. We will report on our current genetic forensic abilities and present case studies where these techniques have been used to assist law enforcement. Species landed and traded in U.S. fisheries include protected taxa such as dusky, night, sand tiger, bigeye thresher, white and basking sharks. These findings suggest that assessing the effectiveness of fishery regulations will benefit from broader scale monitoring of shark landings by species.

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Hyperdisparate headstanders and static slime suckers: Trends in morphological diversification within the Characiformes

Which anatomical and ecological factors drive some groups of fishes to diversify wildly in morphology while others rarely evolve new shapes? Previously I demonstrated that the morphological diversity of the headstanding characiform fishes in the superfamily Anostomoidea (Anostomidae + Chilodontidae) dwarfs that of the detritivorous Curimatoidea (Curimatidae + Prochilodontidae) and that the unequal diversities are best explained by an underlying shift in the rate of morphological diversification. Until now the absence of a phylogeny for the Anostomidae has precluded a detailed examination of the evolutionary history of these fishes and potential drivers of unequal morphological diversification have been elusive. By combining the recent reconstruction of the anostomid phylogeny (see the accompanying poster by Sidlauskas and Vari) with morphometric data from each species, I show that phylogenetic trends in morphological diversification have been very different in the two superfamilies. The Anostomoidea have evolved novel morphologies throughout their phylogenetic history while morphological innovation in the Curimatoidea is concentrated near the base of the phylogeny. A map of ecological and anatomical synapomorphies for both clades reveals a suite of characters that may have promoted morphological diversification in the Anostomoidea or restricted morphological change in the Curimatoidea. For example, the early evolution of a greatly lengthened quadrate in the Anostomoidea may have decoupled the joint of the lower jaw from the neurocranium and eliminated biomechanical constraints on certain jaw morphologies. Alternatively, the evolution of a detritivorous lifestyle in the Curimatoidea allows that clade to exploit a superabundant food resource and may have obviated further changes in jaw morphology. It will be necessary to examine other case studies to distinguish conclusively among these hypotheses, so I conclude by outlining a future study of characiform evolution on South America and Africa which will take advantage of parallel evolutionary events to help determine whether cranial decoupling, detritivory, or other aspects of morphology and ecology tend to promote or restrict morphological diversification whenever they arise.

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Phylogenetic relationships within the South American fish family  
Anostomidae (Ostariophysi, Characiformes)

Maximum parsimony analysis of a morphological dataset containing more than 100 characters has yielded the first phylogenetic reconstruction spanning the entire South American characiform family Anostomidae. The reconstruction includes 44 ingroup species representing all anostomid genera and subgenera. Outgroup comparisons include members of the sister group to the Anostomidae (the Chilodontidae) as well as members of the characiform families Curimatidae, Prochilodontidae, Characidae, Distichodontidae and Citharinidae. Most characters were discovered in the highly variable cranial skeleton; some characters were discovered in the axial and appendicular skeletons, pigmentation, and soft anatomy. Our results support the monophyly of a clade containing the genera *Anostomus*, *Gnathodolus*, *Pseudanos*, *Synaptolaemus* and *Sartor* (the subfamily Anostominae sensu Winterbottom) but our analysis supports a somewhat different set of relationships among the species within these five genera than Winterbottom proposed. *Laemolyta* appears to be the sister group to the above clade. *Rhytiodus* and *Schizodon* together form a well supported clade, as does a subgroup of the genus *Leporinus* characterized by a banded color pattern. Taken as a whole, however, *Leporinus* appears to be a grade-level concept and is not monophyletic. *Leporellus* appears to be the most basal anostomid genus. Some of the most remarkable morphological shifts in anostomid evolution are illustrated and discussed, including several instances of convergence or parallelism. Perhaps the most dramatic of these is the multiple evolution of a trough-like morphology of the ascending process of the anguloarticular, which occurs in two groups of species with subterminal mouths that are not hypothesized to form a monophyletic group under our reconstruction.

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**SIEGEL, DUSTIN S.**

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Sperm storage in *Agkistrodon piscivorus* females

*Agkistrodon piscivorus* is a common species in Southeastern United States. However, research on the reproductive biology of this species is very limited. As part of a comprehensive study of the reproductive life history of *Agkistrodon piscivorus*, areas of female sperm storage are located and identified using light microscopy and electron microscopy. From these techniques, the areas of sperm storage were found to be the utero-vaginal junction and the utero-infundibular junction. The sperm

storage tubules (SST) can be characterized as simple branched tubular glands and contain ciliated and secretory cells in an alternating pattern. Sperm are present in these SSTs in late July and specimens collected in August through November, prior to hibernation, also possess sperm. This leads us to believe that copulation occurs in late summer and fall, sperm is stored throughout the winter months, and ovulation and fertilization would therefore occur in the spring.

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**\*SIEGFRIED, KATE I.; SANZO, BRUNO**

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Testing methods for estimating natural mortality in fish populations: A simulation study

Natural mortality,  $M$ , is a life history parameter in most stock assessment models. Very often it is treated as a constant, but there are a multitude of methods available to estimate the parameter. We review the methods available since the review by E. Vetter in 1988, and test each method using a simulated population. Our simulation is based on parameters of blue shark (*Prionace glauca*) with three aspects to their natural mortality: density independent, size dependent, and age dependent components. We find that methods based on life history invariants perform poorly in comparison to methods based on size or age. We recommend a new assessment of the methods and combination of age- and length-based estimation techniques.

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**\*SIMPENDORFER, COLIN A.; WILEY, TONYA R.**

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Can habitat suitability models be used to help recover the smalltooth sawfish population?

The distribution of areas important to the conservation of the endangered smalltooth sawfish was examined using habitat suitability models that utilized data from public encounters and research surveys. Public encounter data indicated that there was a significant correlation between the occurrence of juvenile sawfish (<200 cm) and the presence of shallow depths (<90 cm), mangroves and shorelines, but not seagrasses. There were significant positive size relationships in the distances from mangroves, shallow depths and shorelines with the size of sawfish. Public encounter data and research surveys also indicated that juvenile sawfish less than 200 cm in length were most commonly associated with estuarine conditions. Habitat suitability models were constructed using the distances to mangrove shorelines, shallow depths, and presence of estuarine conditions. Models with all combinations of these three factors were constructed and assessed using cumulative frequency plots of distance between encounters and areas of high habitat suitability. The three-parameter model was

found to best represent the data. The model provided the best fit to data in areas south of 28°N where mangroves most commonly occur. The implications of the results for conservation planning for this endangered species will be discussed.

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**\*SIPIORSKI, JUSTIN T.; LYONS, JOHN; BURR, BROOKS M.;  
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Molecular characterization of a hybrid zone between the gars *Lepisosteus osseus* and *L. platostomus* in the Fox and Wolf River system of eastern Wisconsin

The gars *Lepisosteus osseus* and *L. platostomus* are known from the Fox-Wolf River system (Lake Michigan basin) in east-central Wisconsin, but many gars from this system have unusual snout dimensions and pigmentation patterns and cannot be clearly assigned to either species. In particular, some specimens have snout morphology intermediate between the typical *L. osseus* and *L. platostomus* forms, and some specimens with *L. platostomus*-type snout morphology have snout and dorsal spotting patterns more typical of *L. osseus*. *Lepisosteus osseus* is native to the Fox-Wolf system, but *L. platostomus* is thought to be a relatively recent invader, either through a historical natural connection during flooding between the upper Fox River and the Wisconsin River (Mississippi River basin), or via a canal connecting these rivers from the mid 1800s through 1951. We used morphological and genetic (partial cytochrome *b* and complete mitochondrial D-loop sequence data) comparisons between Fox-Wolf and Wisconsin River gars to determine if the unusual gars in the Fox-Wolf system were *L. osseus* X *L. platostomus* hybrids. In the Wisconsin River, snout morphology and pigmentation were clearly distinctive and as expected between specimens identified as *L. osseus* or *L. platostomus* based on cytochrome *b* and D-loop haplotypes. No intermediate morphology or pigmentation was found. However in the Fox-Wolf, specimens with either the *L. osseus* or *L. platostomus* haplotypes had a wide range of snout morphology and pigmentation, including intermediate forms. Some specimens with *L. platostomus*-type morphology and pigmentation had *L. osseus* haplotypes and vice versa. We conclude that many specimens in the Fox-Wolf are hybrids between *L. osseus* and *L. platostomus*. These are the first gar hybrids ever reported in nature.

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### Hidden diversity within the *Fundulus notatus* species complex in Mississippi

Topminnows (Family Fundulidae) include nearly 35 species that inhabit a wide range of habitats and environmental conditions. Members of this group have been the subject of much systematic research, although relationships among taxa and between subgenera are still not completely resolved. The *Fundulus notatus* species complex is comprised of the blackstripe topminnow (*Fundulus notatus*), the blackspotted topminnow (*F. olivaceus*) and the broadstripe topminnow (*F. euryzonus*). Within the complex, *Fundulus notatus* and *F. olivaceus* are the most widely distributed species, while *F. euryzonus* is endemic to the Lake Pontchartrain drainage of Louisiana and Mississippi. Taxonomy within the complex has remained stable since the description of *F. euryzonus* in 1981, although most researchers would agree that taxa within the complex may be polytypic. Research efforts within the DeSoto National Forest, Mississippi, revealed a unique form of the *Fundulus notatus* species group which is currently considered endemic to Mississippi. Examination of museum records (ca. 1,600 lots) to date suggests the form is restricted to the Pascagoula drainage occurring in at least 3 separate watersheds. Occurrence is generally limited to cool, flowing headwater reaches of small to medium-sized blackwater streams with extensive bank-side canopy development and a substratum comprised primarily of sand and woody debris. The new form is most similar in appearance to *Fundulus euryzonus*, but differs based on pigmentation characteristics (lateral stripe, median fins). It differs from *Fundulus olivaceus* and *F. notatus* in terms of meristic counts (dorsal rays) and pigmentation characteristics (dorsum spotting, lateral stripe, rictus pigment).

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**\*SMITH, GERALD R.; DOWLING, THOMAS E.; ESTABROOK, GEORGE F.**

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### Temperature and body mass influence rates of molecular evolution in cyprinid fishes

Variability in rates of molecular evolution compromises application of molecular rates to tests of the relationship of divergence and biogeographical events to geological events. The mass-specific metabolic rate hypothesis of Gillooly and others predicts that mutation and substitution rates are a function of body mass and temperature. We tested this hypothesis with genetic distances estimated from cytb

and ND4L sequences of 54 taxa of North American cyprinid fishes. Branch lengths from a maximum likelihood phylogenetic tree were compared with metabolic rates calculated from body mass and environmental temperatures. Tests of the predicted monotonic relationship between metabolic rate and change in mtDNA support the hypothesis that faster metabolic rate significantly corresponds to faster rate of molecular evolutionary rate in temperate minnows. Temperature and body mass account for 45% to 65% of the variation in substitution rate. Application of this approach to *Rhinichthys* shows rapid evolution in the east and southwest; slower evolution in the north.

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**\*SMITH, JEFFREY J.; GOODE, MATT; AMARELLO, MELISSA**

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#### Changes in desert lizard ecology before and after golf course construction

We characterized lizard activity and abundance on and between 80 rockpile plots before and after construction of a golf course in the Sonoran Desert near Tucson, Arizona. We observed 4032 lizards of 13 species during 192 survey-mornings. Construction of the golf course and associated roadways rendered only a few plots unusable by lizards, with many of the rockpiles being incorporated into the design of the course itself. We assessed how disturbances associated with golf course construction influenced lizard relative abundance, diversity, and habitat use. While pre- and post-construction surveys yielded similar numbers of lizards overall, changes in species composition were related to the degree of disturbance. We discuss how water availability on golf courses may enhance habitat for some lizard species in arid environments. We hope our findings will equip golf course designers and managers with information necessary to enhance or maintain golf courses as suitable habitat for lizards.

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#### Cryptic speciation of agamid lizards in the tropical savannahs of northern Australia: Phylogeography of *Diporiphora bilineata* and *D. magna*

The ability to identify species is an important prerequisite for many studies in evolutionary biology and ecology. The development of molecular ecology techniques have permitted the discrimination between previously unrecognised morphologically similar species. Labelled cryptic species, their existence can be explained by factors such as incomplete morphological differentiation following recent speciation or similar selection pressures in historically isolated lineages. *Diporiphora magna* and *D. bilineata* represent two morphologically indistinguishable

agamid lizard species that are widely distributed throughout the savannah region of tropical northern Australia. These species show an array of body size and patterning throughout their overlapping ranges, leading to taxonomic uncertainties and difficulty identifying species boundaries. We undertook a the first phylogeographic study of *Diporiphora*, in order to determine if these populations of *D. magna* and *D. bilineata* belong to a single clade or constitute a number of genetically distinct cryptic species. We collected lizards from throughout their distribution and sequenced a 1500bp region of mtDNA. Phylogenetic analysis revealed the existence of seven clades that show deep evolutionary divergences (uncorrected genetic distance 8-15%). A number of these clades also differ morphologically and in microhabitat use. Mantel tests showed that some aspects of morphology were significantly correlated to phylogenetic relatedness, however there was no correlation between morphology and habitat occupation when controlled for phylogenetic relatedness. These results suggest morphological adaptation to local microhabitats is unlikely and that other evolutionary processes have led to morphological differences between clades. Phylogeographic analyses suggest that these seven clades diverged, through isolation and/or local adaptation, from a more widespread species at least five million years ago. The results of our study suggest *D. bilineata* and *D. magna* represent a diverse species complex, highlighting the importance of phylogenetic techniques for understanding the evolutionary patterns of ecological and morphological diversity within widespread species.

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**\*SMITH, LORA L.; STEEN, D.A.**

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### Patterns of Eastern Tiger Salamander migration at a seasonal wetland in southwest Georgia

We examined breeding activity and migration patterns of eastern tiger salamanders, *Ambystoma tigrinum tigrinum*, at a drift fence around an isolated wetland in southwest Georgia. The study wetland lies within a landscape of fire-maintained longleaf pine savanna, mixed-hardwood forests and wildlife food plots, which allowed us to evaluate movement patterns within a complex habitat matrix. The adult breeding population ranged from 70 to 163 adults over three consecutive seasons and recruitment ranged from 27 to 741 metamorphs over the same period. The distribution of salamander captures around the wetland edge was non-random and appeared to be associated with distance to wildlife food plots. Most recaptured individuals entered and exited the wetland within 40 m of their original capture site both within and between breeding seasons (81 and 76%, respectively). Four radio-tagged emigrating salamanders moved up to 255 m from the wetland and inhabited burrows in forested land and wildlife food plots. Based on the extent of terrestrial movements by eastern tiger salamanders, our findings support previous work demonstrating that upland habitats surrounding wetlands are critical areas in

amphibian life cycles and that individual species may have specialized terrestrial habitat requirements.

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**SMITH, LORA L.; \*STEEN, DAVID A.; BROCK, JEAN C.; MILLER, GABRIEL J.; STERRETT, SEAN C**

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Spatial ecology and influence of predators on Gopher Tortoise nests and hatchlings

We examined survivorship, movements, space use and burrow use of Gopher Tortoise (*Gopherus polyphemus*) hatchlings in southwest Georgia. Forty hatchlings from 13 nests were radio-tagged and tracked for periods ranging up to 319 days. Thirty two hatchlings were located within predator exclosures and 8 were located at unfenced control sites. Survivorship at controls was 38% as compared to 78% in exclosures. Hatchlings monitored at least 90 days occupied a mean area of 26.41 m<sup>2</sup> and constructed their first and final burrows 7.35 and 12.19 m from their nest of origin, respectively. Over three years, nests in exclosures and controls experienced 40% and 80% depredation rates, respectively.

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Ecology and conservation of large terrestrial snakes in the longleaf pine ecosystem: Do upland snakes partition resources?

Surprisingly little is known about the habitat requirements of large upland snakes in the Southeastern Coastal Plain. In this study, we monitored snake populations in a longleaf pine forest in southwest Georgia for three years using snake trap arrays. We captured 354 individuals of 17 species; the most common species captured were black racer (*Coluber constrictor*; 82), coachwhip (*Masticophis flagellum*; 58), garter snake (*Thamnophis sirtalis*; 37), and eastern hog-nosed snake (*Heterodon platirhinos*; 37). Ten adult eastern kingsnakes (*Lampropeltis getula*) have been radio-tagged to determine home range size and habitat use and to describe winter refuge sites. Preliminary data indicate that southeastern pocket gopher (*Geomys pinetus*) runs, small mammal burrows, and stump holes are frequent refuge sites of this species. We plan to radio-tag adult coachwhips and Florida pine snakes (*Pituophis melanoleucus mugitus*) in 2007 to determine how these three large upland snake species partition longleaf pine habitat.

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**SMITH, WM. LEO**

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The advantages of combining morphological characters with DNA sequences:  
An example from the Percomorpha

During the last ten years, there has been a dramatic increase in the number of phylogenetic studies that have relied exclusively on molecular data. Many of these studies have been illuminating, but they have also produced some results that are at the very least unorthodox, if not bizarre. It has been shown that some of these problems can be solved by increasing taxonomic sampling and/or character sampling, to a lesser degree. Although the addition of morphological and behavioral characters has been paid much lip service with regard to resolving these problems, few large-scale studies of fishes have incorporated phenotypic data. I will show an example from my studies of mail-cheeked fishes that illustrates the power of combining phenotypic and genotypic data for approximately 100 acanthomorph species. This study, based on 197 phenotypic transformation series and approximately 4,200 base pairs from both the mitochondrial (12S, tRNA-Val, 16S) and nuclear (histone h3, 28S, TMO-4c4) genomes, resulted in relationships that are more consistent with the traditional view of mail-cheeked fishes than either the results from the morphological or the molecular analyses alone. The general pattern indicates that the sculpins and their allies form a clade with a series of scorpionfish, flathead, sea robin, etc. clades being resolved as a paraphyletic grade leading toward the sculpins. This study highlights the power of analyses combining genotypic and phenotypic data, and it should serve as a warning to researchers who rely on cladograms based exclusively on molecular or morphological data.

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Sampling the unsampled: cryptic coral reef fishes of Buck Island

Because cryptic fishes are difficult to accurately survey, they are undersampled components of coral reef habitats. Fifty-eight enclosed stations were sampled in shoreline, nearshore reef, lagoon, backreef, forereef, and bank/shelf habitats with an ichthyocide (rotenone) at Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands. Our samples included 228 fish species in 55 families, including 60 species previously unreported from St. Croix. Fish assemblages varied across habitat zones with the shoreline assemblage the most distinct. Only 8% of the species were present in all habitats. Multi-dimensional scaling plots of habitat characteristics and Bray-Curtis similarities of fish assemblages revealed similar patterns. Rotenone and visual census data were compared. While visual surveys accumulated more species per unit

of effort, rotenone samples accumulated more species by area. Only 36 % of the 228 species sampled with rotenone were visually detected, while 70% of the 115 species visually detected were also collected with rotenone. The use of rotenone is controversial but important for obtaining reasonably complete inventories of reef fishes.

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### Modeling hydrology and fish occurrence in isolated wetlands to identify wetland complexes for management

It is widely recognized that isolated wetlands are important habitats for a range of amphibian species and that their conservation will be essential in protecting amphibian diversity. However, a wetland-by-wetland approach to conserving and managing isolated wetlands is not likely to be an effective strategy because hydroperiods (the duration of surface water presence during the annual hydrological cycle) and the occurrence and types of top predators vary greatly among wetlands and among years within wetlands; and amphibian species are often adapted to specific hydroperiod and predator occurrence combinations and require adjacent uplands to complete their life cycles. Therefore, it is recommended that landscapes of isolated wetlands be protected and managed as units to provide the range of hydroperiod and top predator occurrences that support amphibian diversity associated with these wetlands. Operationally, land managers currently have little guidance in identifying and prioritizing isolated wetland landscapes for conservation purposes. We used information on the occurrence of surface water and fishes in 91 wetlands on the Upper Coastal Plain of South Carolina to generate classification tree models of hydroperiod and fish occurrence based on wetland habitat conditions and landscape position. We then hierarchically clustered wetlands based on their geographic location and assessed diversity in predicted hydroperiod and fish presence/absence within clusters to identify the spatial extent of wetland landscapes that would provide protection of the range of hydroperiod and fish presence/absence conditions found in these systems. The size of wetland landscapes identified as encompassing diversity of hydrological and predatory conditions among wetlands often closely corresponded to the area of small stream watersheds, but not all small watersheds contained the complete range of variation needed to conserve amphibian diversity associated with isolated wetlands. Our approach should provide land planners with guidance in selecting management units for isolated wetlands.

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**\*SOMMER, JULIE A.; GARCIA-DAVILA, CARMEN; ORTI, GUILLERMO**  
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### Population differentiation of *Prochilodus nigricans* (Prochilodontidae, Characiformes) in the Peruvian Amazon using microsatellite analysis

The large migratory detritivorous fishes of the genus *Prochilodus* are the most abundant and ubiquitous freshwater taxon living in South American Rivers. This continental distribution makes them ideal organisms to examine basin affinity and population structure. In this study we use microsatellites in *Prochilodus nigricans* from seven populations of the Peruvian Amazon and two outgroup populations of *P. mariae* from the Orinoco basin to assess levels of gene flow within and between these major basins. This analysis is part of an effort to investigate species boundaries with molecular markers, following the application of mitochondrial and nuclear DNA sequence data. The distribution of *P. nigricans* is associated with the Amazon River and its tributaries whereas *P. mariae* is restricted to the Orinoco. However, connections between these basins allow potential gene flow. Preliminary results of microsatellite genotypes suggest lack of differentiation among *P. nigricans* populations living in headwater tributaries of the Amazonas in Peru. AMOVA showed that 98% of the variation at two loci was within populations ( $F_{st}=0.02$ ). When all these headwater samples were grouped and compared to *P. mariae* populations from the Orinoco, AMOVA showed 90% of variation within populations (only 10 % of the variance explained between species, and  $F_{st}= 0.09$ ). These preliminary results are congruent with mtDNA and nuclear genealogies, suggesting extensive levels of gene flow among subpopulations and porous interspecific boundaries.

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### **SONG, JIAKUN**

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### Innervation, orientation, and homology of the cephalic lateral line pattern in gobies: A phylogenetic interpretation based on new keys from evo-devo studies

Patterns of the lateral line neuromast (sensory papillae) are important morphological characters in gobioid taxonomy. Complexity of the pattern, makes the phylogenetic interpretation of this character in systematic analysis of gobies difficult (Miller 2005). Recently, studies on gene expression, embryonic genes and postembryonic growth of the lateral line system reveal some mechanisms of the pattern formation. The new knowledge on the primordial migration, neuromast deposition, and the role of the glia-axon-lateral line precursors during the development that brings us to a new dimension of understanding the innervation and homology of the lateral line patterns. This study is following the timing and sequence of the lateral line nerve branching and the distribution/orientation of the neuromasts pattern formation, to analyze their adult patterns in thirteen species of gobioid fish (from five groups:

Rhyacichthyidae, Odontobutidae, Butinae, Eleotridinae, and Gobiinae). The results lead to a new proposal of homology of the mixed, reduced, longitudinal, and transversal patterns. A phylogenetic interpretation of the sensory papillae pattern in gobioid systematics is proposed.

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**SORRELL, GEOFFREY G.**

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### Diel activity patterns of *Bothriechis schlegelii* as indicated by predatory behavior

The nocturnal/diurnal dichotomy used to describe the activity of animals is often an oversimplification of nature. The literature available on *Bothriechis schlegelii* reports this species to be nocturnal. *B. schlegelii* is an ambush predator that preys upon a wide variety of vertebrates. The observation of diurnally- and nocturnally-active prey in the diet of this species indicates that this snake does not limit its predatory activity to a discrete period within a 24-hour cycle. The goal of this project is to define the diel activity pattern of *B. schlegelii* as indicated by the ability of individuals to respond to potential prey. I hypothesize that time of day influences predatory activity in *B. schlegelii*. A review of the literature leads me to predict that predatory activity will be greater at night. In situ prey introductions ( using *Norops limifrons*) were conducted with perched snakes. The response of each snake was assigned to one of two categories: 1) did not strike; 2) struck. Trials were conducted during the daytime (n=16) and at night (n=11). The results indicate that time of day has a significant effect ( $G=3.86, =0.049$ ) on the predatory activity of *B. schlegelii*, yet contrary to my prediction, more strikes were observed during the day. This study suggests that *B. schlegelii* has a greater temporal activity range than previously documented. Having the ability to take prey during both night and day increases the importance of the role of *B. schlegelii* as predator of small vertebrates.

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**SORRELL, GEOFFREY G.**

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### Patterns of use of anthropogenically-fragmented habitat by an arboreal pitviper

Loss of habitat has been identified as the most significant threat to biodiversity in the tropics. Conversion of forested habitat resulting from agricultural practices is a major contributing factor to this process. With the continued increase in human population, trends of habitat modification due to agriculture will surely continue. The fact that many species will survive only if they tolerate some level of habitat modification underscores the necessity for studying the ways in which wildlife respond to anthropogenic fragmentation. While many studies of fragmentation effects have focused on birds and mammals, few have focused on snakes, especially tropical

species. This study examines the effects of cattle production on habitat use of the eyelash viper, *Bothriechis schlegelii*. This work was done in western Panama, and the site is comprised of pastureland with islands of trees interspersed within a matrix of grasses and small shrubs. *B. schlegelii* is an arboreal species most common in lowland tropical forest. At this site *B. schlegelii* inhabits the isolated tree islands found throughout the pasture. The objective of this study is to determine what habitat variables limit the distribution of *B. schlegelii* in this fragmented landscape. Variables include island size, island isolation, vine coverage, presence of buttresses, and proximity to fences. Island area and vine coverage were positively correlated with snake abundance whereas island isolation had a negative correlation. Presence of buttresses and location of fences did not influence snake abundance. My results indicate that small pastures with scattered tree islands that maintain vine coverage provide some suitable habitat for *B. schlegelii*. This suggests that small-scale cattle production may be performed in a way that provides some of the habitat requirements necessary for sustaining *B. schlegelii* populations.

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The occurrence of juvenile white sharks (*Carcharodon carcharias*) in the northwestern Mexico

White sharks (*Carcharodon carcharias*) have been recorded throughout the North Pacific, from cold temperate coastal to tropical waters. In the Gulf of California, *Carcharodon carcharias* has been reported only in the southern part, close to the mouth of the gulf. In this study we report the characteristics of five juveniles white sharks caught by fishing vessel in the Upper Gulf of California during the summers of 2002, 2003 and February 2005; as well as the stomach contents of three of these sharks. Juvenile shark sizes ranged between 212 and 236 cm in total length (TL). The principal food items were bony fishes and rays (Rhinopterae). Additionally, five juvenile white shark jaws were collected at garbage dumps near a fishing village at the Pacific coast of the middle Baja California Peninsula. The calculated size of these juveniles ranged between 199 and 243 cm TL. The importance of the Gulf of California for this species will be discussed and some of the management issues in the region.

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**SPAETH, JOHN P.**

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**Spatial patterns and community associations of ecologically-similar fishes of south Mississippi**

The southeastern United States has the greatest freshwater fish diversity in North America. The potential for strong interspecific interactions are likely among community members within this region. To investigate community structure patterns and potential competitive relationships, monthly community samples were collected from 15 sites in 2<sup>nd</sup> to 4<sup>th</sup> order streams in the Pascagoula River drainage in south Mississippi. Assemblages remained similar within each stream and relatively stable over time at each site, despite disturbances. Abundance patterns of ecologically-similar fishes collected in allotopy and syntopy suggested that spatial segregation occurred at various scales. Dominant species-pairs of the genera *Ammocrypta*, *Percina*, and *Etheostoma* showed disparate community associations. The changes in abundance patterns observed when species-pairs occur in syntopy suggest potential competitive avoidance and calls for further investigation into patterns of resource utilizations.

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*Museum of Vertebrate Zoology, 3101 Valley Life Sciences Building, University of California, Berkeley, CA, 94720-3160, USA*

**Introduction and contributions of Joe Slowinski to the fields of herpetology and phylogenetics**

From 1985 to 2005, Joe Slowinski published over 46 articles and a book on the topics of herpetology, theoretical phylogenetics, genetics, ornithology, botany, and paleontology. Six of these articles were published posthumously. He performed research in the United States, the Neotropics, and most recently, the Old World Tropics. Joe's roots were in Kansas; he was fascinated with paleontology and discovered some fossils that are now displayed at the University of Kansas Natural History Museum in Dyche Hall. Although he was most well known to us as an avid herpetologist, he was equally famous for his work in theoretical phylogenetics. Joe published 16 articles related to molecular clocks, divergence times, alignments, patterns of speciation and diversity, and most importantly, several pre-eminent articles with Craig Guyer on tree shape (topology). Slowinski and Guyer recently were cited in Mooers and Heard (*Systematic Biology*, 2002) as having published papers that played an important role in inspiring and shaping the subsequent spread of research on tree shape. Joe's main love was herpetology, and he pursued this with a passion, publishing 28 articles on topics in herpetological ecology, phylogenetics and general herpetology. He especially liked the phylogenetics of the Elapidae and higher snakes. His dissertation was on coral snake phylogenetics and 18 papers since were about elapid and higher snake relationships. His passion for these fields is

reflected by his influence. Since his death, two funds have been established in his name, a book about his life is in the works, and three species have been named after him, including *Elaphe slowinskii*, *Bungarus slowinskii*, and *Cyrtodactylus slowinskii*. A yet unnamed frog also will bear his moniker. This year marks the fifth anniversary of Joe's death (12 September 2001). We hope to make him proud by presenting this symposium of talks by his friends and colleagues.

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**\*SPENCER, CAROL L.; TRUEB, LINDA; WAKE, DAVID B.; KOO, MICHELLE S.**

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**Herpnet: A new and improved one-stop shop for amphibian and reptile collections data**

The importance of museums and their collections to the study of biodiversity cannot be overstated. These collections provide critical data for addressing a diversity of issues, including phylogenetic, conservation, and biodiversity questions. The HerpNet database ([www.herpNet.org](http://www.herpNet.org)) combines amphibian and reptile museum databases from 51 museums throughout the world. Recently, we added 12 institutions, including five North American collections (Fort Hays State University, Santa Barbara Natural History Museum, University of Alabama, University of Alaska, Utah Museum of Natural History) and seven international collections (Australian Museum, Sydney; Chengdu Institute of Biology, China; Muséum d'Histoire Naturelle de la Ville de Genève, Switzerland; Raffles Museum of Biodiversity Research, Singapore; Royal Museum of Central Africa, Belgium; Staatliches Museum für Naturkunde Stuttgart, Germany; Zoological Institute, St. Petersburg). We received funding from GBIF (Global Biodiversity Information Facility) to database and georeference these seven international collections that have large holdings (> 425,000) of amphibians from rare localities (Africa, Australia, China, Eastern Europe, Southeast Asia, New Guinea, and Russia). In the near future, HerpNet will provide more than four million specimen-data records representing 700,000 unique localities worldwide. Currently, HerpNet provides coordinates for data from across the western United States. We will finish georeferencing all North American localities and international collections by September 2007. Currently the HerpNet data portal is being improved to make it easier for both researchers and the general public to use. New features available in the next year include: direct links to HerpNet data and maps from AmphibiaWeb ([www.amphibia.org](http://www.amphibia.org)), expert opinion maps from Global Amphibian Assessment, and the ability to search under synonymous taxonomy. Herpetologists, conservation biologists and museum scientists alike can use HerpNet data for a diversity of GIS, ecological, and phylogenetic research.

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**\*STAIGER, JENNIFER S.; BARICHIVICH, WILLIAM J.**

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### Terrestrial herpetofaunal community structure along a faunal break in north central Florida

The lower Suwannee River region of north central Florida is a biogeographically complex area. Several amphibian and reptile species reach the southern or northern (at least along the Gulf coast) limits of their ranges in the area, and it is also a zone of subspecific differentiation for several species. We examined the structure of terrestrial herpetofaunal communities at 10 sites along the Suwannee River in Lower Suwannee National Wildlife Refuge, Florida. Five sites were located along the north side of the river in Dixie Co., and five sites were located in Levy Co. south of the river. Thirty-four species were trapped at drift fence arrays in the 10 sites between May 2003 and February 2005, totaling 646 individual captures (recaptures excluded) over 381 array nights. We compare species diversity, capture rates, and similarity indices. Capture rate and species richness were lower at the northern sites, where 22 species of reptiles and amphibians were trapped, including five species not captured at the southern sites. Twenty-seven species were trapped at the southern sites, including eight not captured at the northern sites. The majority of captures were frogs (*Hyla squirella*, *Rana sphenocephala*, *Gastrophryne carolinensis*, *H. femoralis*), with two or three of these species contributing to the majority of similarity in community structure when comparing sites on the same side of the river. Some of these same species also contribute to the majority of dissimilarity when comparing sites across the river, likely due to differences in capture rates. Sites south of the river are more similar to each other in community structure than northern sites are to one another, despite the southern sites representing greater habitat diversity. Our analyses reveal possible differences in herpetofaunal community structure to the north and south of the lower Suwannee River.

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**\*ST.-AMOUR, VALERIE; LESBARRERES, DAVID**

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### The role of emergent infectious diseases in relation to fluctuating asymmetry in the green frog (*Rana clamitans*)

Amphibian populations are facing rapid declines and recent discoveries have shown that Emergent Infectious Diseases (EIDs) such as Ranavirus and Chytrid fungus are playing major roles. Although these diseases are involved in the decline of certain populations little is known about the effects of these EIDs in relation to development. Developmental stability can be measured using fluctuating asymmetry (FA) which is often used as a tool to measure stress and the overall fitness of organisms. The theory assumes that an organism presents mechanisms that control asymmetry during

development. Such mechanisms may be costly to the individual and when faced with other stressors it is believed that these mechanisms will suffer resulting in fluctuating asymmetry. Since secondary sexual traits are more costly than non-sexual traits we also expected to observe FA in the former rather than in the latter. Using genetic tools, several populations of green frogs (*Rana clamitans*) were analyzed for presence or absence of chytrid fungus as well as Ranavirus. Infected and non infected individuals were then measured to determine FA under the hypothesis that FA will be more likely to be observed in individuals infected by one or both of these diseases. Results showed significant difference in fluctuating asymmetry when comparing sexual traits among infected and non-infected individuals. This shows that not only are EIDs causing massive die offs they are also having a further reaching effect on the development of those individuals carrying the diseases.

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**\*STEELE, CRAIG A.; GIORDANO, ANDY; STORFER, ANDREW**

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### Comparative patterns of gene flow and dispersal in sympatric species of giant salamanders (*Dicamptodon*)

Few studies have examined how a common landscape affects genetic structuring of sympatric species. We present results from a study examining gene flow patterns between two species of sympatric stream-breeding salamanders: the Pacific giant salamander (*Dicamptodon tenebrosus*) and Cope's giant salamander (*D. copei*). Metamorphosis into a terrestrial adult is extremely rare in *D. copei*, while the opposite is true for *D. tenebrosus*. We predict that the different frequencies of terrestrial adults will affect relative rates of gene flow, resulting in higher levels of genetic connectivity among populations of *D. tenebrosus* than among populations of *D. copei*. Because migration between populations can occur either via direct overland dispersal or along waterways, we also test predictions that population structure in the two species is best explained by either overland dispersal or by stream dispersal. Movement between populations of *D. tenebrosus* is hypothesized to occur primarily by overland dispersal of terrestrial adults, resulting in patterns of population structure best explained by an isolation-by-terrestrial-distance model. In contrast, neotenic populations of *D. copei* individuals are constrained to their natal streams and migration among localities is predicted to occur primarily along stream routes, resulting in patterns of population structure best explained by an isolation-by-stream-distance model. Using microsatellite loci we test the general prediction that higher levels of genetic connectivity exist for metamorphosing populations of *D. tenebrosus* than for non-metamorphosing *D. copei* and test patterns of genetic structuring against the two dispersal models. Results from this project compare the dispersal capabilities and genetic structure of these two amphibian species and provide general insight on the influence of life history variation on genetic structure of populations.

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### Experimental evaluation of biases associated with sampling estuarine fishes with seines

Seines are commonly used to estimate the density and species richness of estuarine fishes. We evaluated the extent and causes of bias in estimates from seines using a series of field experiments in estuaries in southern California, USA. Seining in spatially paired areas that were either enclosed by block nets or not, revealed that seines used without block nets underestimated density (by 4 fold) and species richness (by 2 fold) relative to blocked areas. Seining in paired blocked areas with seines of two lengths revealed that net length affected estimates of density but not species richness: a 7.6-m-long seine produced 1.6-fold higher estimates of density than did a 15.2-m-long seine due to increased catches of demersal fishes. Paired sampling in blocked areas also revealed that many fishes, especially demersal species, initially evaded capture by the seine. Estimates of density, but not species richness, were significantly higher in areas swept 5 times by a seine than areas swept only once. Repeated seining (10 sweeps) through blocked areas revealed that the vast majority species (90% of species richness) and individuals of midwater fishes (92% of density) were captured within the first 5 hauls through the area; but only about 50% of the individuals of demersal species were captured after 5 hauls. A mark-recapture study in blocked areas also revealed lower probabilities of capture for demersal species relative to midwater species (30% vs. 70% respectively). Lower probability of capture for demersal species relative to midwater species biased estimates of community structure, but such bias can be corrected if it is measured. Overall, we found beach seines to be useful tools for estimating density and species richness of estuarine fishes, provided that their biases are accounted for.

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### Habitat use of sympatric rattlesnake species within the gulf coastal plain

The eastern diamondback rattlesnake (*Crotalus adamanteus*) and timber rattlesnake (*Crotalus horridus*) are sympatric throughout most of southern Georgia. We used rattlesnake sightings over a four-year period to quantify and compare habitat use by these two species in the Gulf Coastal Plain. Univariate statistics and logistic regression models indicated that *C. adamanteus* was a habitat generalist associated with a large, intact habitat matrix of both longleaf pine and mixed pine/hardwood forest. In contrast, *C. horridus* was closely associated with hardwood habitat and riverine systems, but not with roads and habitat edges on a large scale. These species may partition resources by disparate habitat selection. To effectively conserve and manage both species in the southeast, a habitat matrix of large intact patches of both

hardwood and pine forest may be necessary.

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**STEFFEN, JOHN E.**

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Carotenoid-based dewlap coloration correlates with male dominance over females in the Brown Anole, *Norops sagrei*.

Animals use a broad class of pigments to color their integument. One of the best-studied integumentary pigment classes are carotenoids. Carotenoids are a well-studied pigment class because they have been shown to act as honest indicators of signaller quality in fish and birds. Pteridines are a less studied integumentary pigment but which are relatively common in many animals. Few studies to date investigate the potential for pterin-based pigments to act as condition-dependent signals. Virtually no studies have investigated condition-dependent qualities of carotenoid- or pterin-based pigments in lizards. *Norops sagrei*, the Brown Anole, is an invasive lizard found throughout Florida and the southeast U.S. that possesses a throat fan (or dewlap) that is colored by carotenoids as well as pteridine pigments. I present data that show that carotenoid-based spectral properties (and not pterin-based spectral properties) indicate body condition. I also present results of natural experiments between males for dominance over females in which males that possess dewlaps with spectral qualities related to greater carotenoid concentrations have greater courtship success than males that have lower carotenoid concentrations. Pterin-based dewlap color did not correlate with dominance. Male and female Brown Anoles may detect this dewlap color variation and use it make decisions about choosing battles and mates.

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Latest battle in the “War Of The Iguanas”: Phylogenetic analysis of Iguaninae using multiple markers

Iguaninae is an ancient group with eight modern genera distributed throughout the Western Hemisphere and in the Fijian archipelago. Previous morphological and molecular studies of Iguaninae relationships have relied on incomplete sample sets that yield conflicting topologies. The subfamily collectively spans thousands of miles across multiple geographical boundaries, and exhibits a high degree of regional and island endemism. Because of its age and distribution, the group is uniquely suited to test biogeographic hypotheses, such as suggested occurrences of past refugia or relictual fragments. A well-supported phylogeny of this subfamily will also allow empirical evaluation of molecular clock models since it exhibits a wide spectrum of

lineage divergences against the well-studied Cenozoic geologic history of the neotropics. In order to generate a robust phylogeny we have collected DNA sequence data at four loci (2 nuclear and 2 mitochondrial) for all eight genera, including 28 of the Iguaninae species. Phylogenies generated from maximum likelihood analysis of separate data sets result in congruent phylogenies with varying levels of resolution. Results are discussed in terms of the phyllogeographic history of this subfamily, future direction for study, and conservation implications.

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The origins of a large-scale pattern of community structure in emydid turtle assemblages: Competition versus phylogenetic niche conservatism

Phylogenetic studies of community structure have often found that the failure of a lineage or lineages to disperse between regions can be related to geographic trends in community structure. However, such studies have often failed to explicitly consider the factors that prevent the key lineages from dispersing between regions. We consider a latitudinal trend in community structure in eastern North American that seems to be related to the failure of two lineages of semi-terrestrial emydid turtles to disperse into southern communities. We then examine the factors that might limit the southern distribution of these lineages. The two hypotheses that we focus on are competitive exclusion by southern emydid species, and phylogenetic niche conservatism (particularly phylogenetic inertia in environmental tolerances). The latter hypothesis is tested by using GIS niche modeling in a phylogenetic framework. The study fails to find support for the idea that the northern semi-terrestrial emydines have been competitively excluded from southern communities. Conversely, the hypothesis that phylogenetic inertia in environmental tolerances has limited the southward distribution of these species is strongly supported. This study demonstrates how using a GIS approach in a phylogenetic framework can illuminate the origins of broad patterns in the biogeography of lineages, which can in turn be related to geographic trends of community structure.

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### Invasion genetics of the Ponto-Caspian neogobiin Gobiidae

Two species of Ponto-Caspian neogobiins, the round goby (*Apollonia* - formerly *Neogobius melanostomus*) and the freshwater tubenose goby *Proterorhinus semilunaris* (formerly *P. marmoratus*), invaded the North American Great Lakes in 1990 via ballast water. Those species, along with other neogobiins - notably the monkey A. (formerly *N. fluviatilis*), racer *N. gymnotrachelus*, and bighead *N. kessleri* gobies - also have been highly invasive and successful in spreading throughout Eurasian freshwaters via canals and shipping. Here we compare and contrast levels of genetic diversity and divergence in invasive versus native sites from neogobiins throughout their ranges using nuclear microsatellite DNA variation, as well as mitochondrial DNA sequences from the cytochrome b and COI genes. The null hypothesis is that genetic variability in invasive sites is predicted to be relatively low and relatively uniform in composition in comparison with native ranges, reflecting the likelihood of only a few individuals becoming established. Conversely, higher genetic diversity may provide raw material for a species' invasive and establishment success. Our results show that a surprisingly diverse number of haplotypes characterize invasive neogobiin populations from all Great Lakes sites and many Eurasian locations analyzed, showing little or no founder effect in comparison with native populations. Additionally, results reveal significant differences among Great Lakes locations, suggesting that multiple founding sources and introduction events were involved. Also, the North American Great Lakes show regional distinctiveness in genotypes of the invasions, indicating considerable genetic structure. This high genetic variation likely led to the tremendous invasive success of the round goby in the Great Lakes. In addition, some genotypes already in the Great Lakes are also common in the Black Sea, suggesting that the round goby will likely become established in estuarine habitats along North American coasts - given transport and the opportunity. Such comparisons may allow us to predict the likely success of other invasive neogobiins in new habitats.

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### Comparative broad to fine-scale genetic patterning in smallmouth bass and walleye across the Great Lakes and beyond

Population genetic structure of walleye *Sander vitreus* and smallmouth bass *Micropterus dolomieu* are compared in order to evaluate historical and behavioral events that shaped their phylogeographic patterns. These species have very different ecological and behavioral repertoires but share similar distributions that center on

the Great Lakes, indicating a possible common vicariant history. In addition, understanding their demographic and habitat structure is essential for successful fisheries management and conservation of genetic diversity. Allelic length variation of ten microsatellite loci for walleye and eight loci for smallmouth bass are analyzed for evidence of broad to fine-scale population structure among spawning locations throughout the Laurentian Great Lakes and outlying populations. Results reveal that walleye have moderate to high levels of genetic diversity within spawning groups, whereas smallmouth bass display more moderate genetic variation but greater divergences among locations (about twice those of walleye). Evidence for both species suggests relatively high levels of fidelity among spawning groups, as well as pronounced divergences among lake and river populations. Both species show distinct genetic breaks between the upper and lower Great Lakes, with primary barriers at Lake St. Clair, the upper Mississippi River System, the Ohio River system, and Lake Ontario. At fine scales, they display similar patterns with marked divergences among sites in eastern Lake Erie, as well as marked differences between the eastern and western basin locations. Smallmouth bass show evidence for isolation-by-geographic distance (as measured by shortest waterway connections) that is absent in walleye. Results from both species thus reflect their different ecologies and behavior, and support evidence for natal site fidelity. These patterns appear to have been present since the early formation of the Great Lakes. Conservation strategies should focus on maintaining these fine and broadscale genetic patterns.

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### Satellite tagging of pelagic sharks off eastern Australia

The movements and behaviour of pelagic sharks were studied using direct satellite tracking tags and pop-off archival transponding tags (PSATs) deployed off the central east coast of Australia from commercial longline vessels. Eight blue sharks were tagged with direct satellite tags, mostly Wildlife Computers SPOT or SPLASH tags, and five blue sharks were tagged with PSATs. One each of shortfin mako, common thresher and bigeye thresher were tagged with PSATs. Tracks from SPOT tags were up to 137 days duration. One blue shark double tagged with a SPOT and PSAT died soon after release, and two others only transmitted for 6 and 11 days. The PSATs collected data for up to 180 days and there was evidence that some tags were bitten off, presumably by other sharks. Blue sharks remained in the general Australasian region for the duration of the tracks and those fitted with direct satellite tags transmitted nearly every day. Regions of high residency where the sharks were clearly not in transit were identified from the tracking data. The physical and biological characteristics of these areas were obtained from remote sensing data and we attempted to identify regions of local productivity that cause aggregation of blue sharks and to characterize their biotic and abiotic features. The PSAT data from blue sharks showed they usually spent 20-30% of their time in the 0-10 m depth strata,

with about 5% of their time spent down to 600 m depth and with some dives deeper than 600 m. Most time was spent in the 17.5-20.0 degrees temperature range. The PSAT data from the other pelagic sharks also showed time spent at depth down to about 600 m but the thresher sharks, particularly the bigeye thresher spent less time at or near the surface.

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The skates of Alaska: Distribution, abundance, and taxonomic progress

Historically, skate populations in the eastern North Pacific and Bering Sea have been inadequately studied and inaccurately represented because of incomplete taxonomic knowledge and difficulties in obtaining accurate species identifications. As a result of collaborative efforts among many taxonomists and fisheries biologists, recent NMFS bottom trawl survey data reflect great improvements in the reliability of skate identifications, and have been instrumental in the description of new taxa. A data set compiled from the catch records of bottom trawl surveys from 1999-2005, including the Gulf of Alaska, Aleutian Islands, and eastern Bering Sea, gives a comprehensive overview of the skate fauna of Alaska. This data set includes a total of 14 recognized species of skates and at least one undescribed form, all of which are documented by photographs and represented by voucher specimens deposited at the University of Washington Fish Collection, as well as other collections around the country. With these reliable species-level identifications, the distinct species assemblages associated with each geographical and bathymetric region of Alaska have been identified, and patterns of overall skate diversity and abundance in the eastern North Pacific and Bering Sea are beginning to emerge. Moreover, catch data from NMFS bottom trawl surveys are being used to evaluate new sources of skate distribution data, including species-specific catch data now being collected by North Pacific groundfish observers

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Fishes of Georgia atlas project

Although Georgia is ranked among the top five U.S. states in richness of freshwater

fishes, no comprehensive distributional atlas is available to document this fauna. Detailed distributional data is necessary for environmental review and conservation assessments, and is a great aid to the accurate identification of fishes. We are developing an online atlas of Georgia's freshwater fishes. The atlas will include small watershed (HUC 12) distribution maps and a photograph for each of the approximately 290 fishes that regularly or occasionally occur within the freshwaters of the state. Primary sources of fish distribution records will include The Georgia Museum of Natural History, The Georgia Dept. of Natural Resources, regional and national museum collections, unpublished research findings and primary literature. A large component of this project will involve pulling these records into a single database and verifying questionable records. To date, our database includes 6645 collection records from 3705 unique localities (sites). Sample sites are clustered in North and SW Georgia, and we plan to make additional collections in under-sampled areas during summer 2006. The database includes records for approximately 287 recognized native and 11 introduced species. Only four described species are truly endemic to the state, but many other described and undescribed species have a large proportion of their range in Georgia. Approximately one-third of the fauna is considered imperiled, and at least 6 species may be extirpated. Our poster will include sample maps, sample photos, and a preliminary list of Georgia fishes by major basin.

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Control and containment options for a Georgia population of Asian swamp eels (*Monopterus* sp. cf. *M. albus*)

The Asian swamp eel is an exotic, invasive species that has been introduced in the southeastern U.S. on at least four occasions. Populations are known from Florida (Homestead, North Miami, and Tampa), and Atlanta, Georgia. The Atlanta population was introduced into at least one pond at the Chattahoochee Nature Center (CNC) in the early 1990s. The CNC has direct outflow connections to the Chattahoochee River through an adjacent marsh. Therefore, recent studies have focused on control and containment options for this population. Swamp eels are obligate air-breathers, protogynous hermaphrodites, and can travel over land and live in a variety of habitats, making them excellent invaders. Swamp eels have been discovered in marsh areas of the Chattahoochee River adjacent to the CNC, although to date, no eels have been found upstream or further downstream. These marshy areas are inundated during high flows and are included in the downstream flow of the river. We studied the biology and ecology of this population and investigated physical and chemical methods for removal and/or eradication. Eels are actively reproducing in three CNC ponds and possibly in the marsh. Diet appears to consist

mostly of invertebrates but does include some fish (including other swamp eels). Physical removal methods included electrofishing for adults and sub-adults and leaf-litter traps for juveniles. Laboratory studies on effectiveness of antimycin suggest that removal using this chemical is not a viable option, as swamp eels appear resistant. An integrated approach of containment and control involving physical removal and restructuring pond outflows appears to be the best current management plan for addressing this particular population of exotic invaders.

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Genetic variation among members of the *Craugastor (Eleutherodactylus) podiciferus* species complex

The Neotropical anuran genus *Eleutherodactylus* represents the largest extant vertebrate genus with over 700 described species. Despite this diversity, little is known regarding the evolutionary relationships among many of the more ubiquitous members of the genus. The *Craugastor (Eleutherodactylus) podiciferus* complex represents a group of polymorphic direct-developing frogs that inhabit the highlands of Costa Rica and Panama. This putative species is considered common from 1100-2600m and is found in this elevational band of suitable habitat throughout the Cordilleras de Tilarán, Central and Talamanca. Its unique distribution presents several interesting questions concerning the initial dispersal and present day gene flow of the species, given the extensive geographic barriers that separate many of the populations. The complex is presumed to contain multiple taxa, but difficulties in identification and the previous consideration of small sample sizes have hindered the recognition of unique species within this group of anurans. The present research aims to elucidate divisions within this complex via the use of molecular markers and extensive sampling from localities throughout the range of *C. podiciferus*. Through the examination of nucleotide sequence divergence, the genetic dynamics of both disjunct populations and the species as a whole are tested. Because the IUCN lists this species as vulnerable, there exists an urgent need for the clarification of specific boundaries in order to formulate more appropriate conservation measures for the complex.

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### Evaluation of neodymium-iron-boride magnets on demersal longlines

The U.S. Atlantic pelagic longline fishery primarily targets Swordfish (*Xiphias gladius*), Yellowfin Tuna (*Thunnus albacares*), and Bigeye tuna (*Thunnus obesus*) in various areas and seasons. Secondary target species include Dolphin (*Coryphaena hippurus*), Albacore Tuna (*Thunnus alalunga*), as well as several species of pelagic sharks and several species of large coastal sharks. Although some sharks such as the Shortfin Mako (*Isurus oxyrinchus*) are a commercially valuable secondary species, many non-commercially valuable sharks are captured as bycatch during pelagic longline fishing. Such bycatch has several negative impacts including but not limited to: (1) removal of ecologically important species with no little commercial value, (2) reduction of fishing efficiency aimed at target species by reducing the number of hooks available to target species while occupying hooks, (3) reduction of fishing profits associated with commercial fishing through increased gear costs associated with lost hooks gear resulting damage by sharks. In an experiment to reduce these impacts, neodymium-iron-boride magnets were deployed on demersal longlines at South Bimini, Bahamas. The magnets used in this evaluation did not produce aversive behavior in captive Yellowfin Tuna and Cobia (*Rachycentron canadum*). The localized magnetic field permits a single demersal line to have both controls and treatments. This line consisted of fifteen gangions with 16/0 steel circle hooks and hook event timers. Seven gangions on this line were fitted with magnets. All hooks received the same type of bait, were rebaited at the same time of day, and were monitored at 4 hour intervals for shark catch. During two sets, we report fewer sharks were caught on magnetic treatment gangions when compared to control gangions. In a separate observation, we report that two tiger sharks (*Galeocerdo cuvier*) were captured within the same three hour period when undersized magnetics were used. A third tiger shark was also captured on a control gangion within the same period.

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Evaluation of Semiochemical Shark Repellents on Demersal Longlines  
International concerns have been raised about apparent population declines of large pelagic fishes including predatory sharks that are ecologically and commercially important. A major contributor to the international population decline of large pelagic predatory sharks is commercial pelagic longline fishing targeting tuna and swordfish (Faltermann & Graves 2002; Peel et. al. 2003; Uozumi 2003; Kerstetter 2004). Beerkircher et. al. (2002) suggests that Carcharhinid sharks comprise the largest

portion of shark bycatch during U.S. commercial pelagic longline fishing with blue sharks, *Prionace glauca*, comprising the greatest biomass of any bycatch species. As a potential means to reduce this shark bycatch, we have evaluated semiochemical shark repellents at South Bimini, Bahamas using demersal longlines. The semiochemicals used in this evaluation study did not produce aversive behavior in captive Yellowfin tuna, (*Thunnus albacares*) and Cobia, (*Rachycentron canadum*). Five demersal lines were set, with three lines dedicated as controls. Each line consisted of fifteen gangions equipped with 16/0 steel circle hooks and hook event timers. Adequate spacing between control and treatment sets was allowed to reduce the effects of chemical plumes. All hooks received the same type of bait, were rebaited at the same time of day, and were monitored at four-hour intervals for shark catch. Results demonstrated significantly lower shark catches on treatment lines as compared to the control lines.

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**SUDKAMP, MITCH; \*WOOD, ROBERT; NEELY, DAVID; RAY, JEFFREY;  
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USA*

Phylogeography of the Flathead Chub (*Platygobio gracilis*) based on ND4, ND5 and Cyt b sequences

*Platygobio gracilis* is composed of two subspecies, *Platygobio gracilis gracilis* and *Platygobio gracilis gulonella*, that are currently distinguished using morphological criteria. It's distribution stretches from northern New Mexico and Texas, north to British Columbia and Alberta, Canada with a large zone of hypothesized intergradation that stretches throughout most of the Missouri River drainage. Cytochrome B (cyt b) (1140 bp), ND4 and ND5 (3903 bp) mitochondrial genes were sequenced and aligned for 30 individuals of flathead chub from throughout this range, along with seven outgroup taxa. Phylogenetic and phylogeographic analyses of these data sets (cyt b and ND4/ND5) failed to produce any significant structure either within or between the subspecies of this taxon. In fact most individuals failed to group by either geographic location or existing subspecific taxonomy with any partition or combination of these data. The results of this study along with implications for the management of this species will be presented and discussed.

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### Dispersal and demographics of the American Bullfrog in arid valley habitats

Intentionally introduced into the western U.S., the American Bullfrog (*Rana catesbeiana*) has negatively affected native aquatic amphibian and reptile populations throughout the region. In 1999, we drained ponds and successfully removed bullfrog populations from most of Buenos Aires National Wildlife Refuge, Pima County, Arizona. Over the subsequent 9 weeks, we found migrating bullfrogs at these and other ponds and pools up to 11 km from presumed off-refuge emigration sources. In 2000, 2002, 2003, and 2004 we cohort-marked bullfrogs at the presumed sources, and kept refuge ponds free of bullfrogs by collecting any that arrived. In dry summers (2000, 2002, and 2004), we recovered marked bullfrogs at 3.2 and 6.4 km dispersal distances, and found no bullfrogs farther into the refuge. During a wet summer (2003), we confirmed marked frogs at 9.6 km and presumed migrants were seen >11 km from known source populations. At two normally dry sites ca. 3-4 km from sources, immigrants grew so rapidly, that, two months after pond filling, the site ostensibly resembled an established, breeding population. In 2003 and 2004, using program Remark, we estimated bullfrog population sizes in five ponds and Arivaca Lake. Population sizes ranged from 21 in a new perennial pond to 6045 in an established perennial pond (stock tank). There were an estimated 4435 frogs in Arivaca Lake, a decades-long established population. Our data suggest that bullfrog removals must occur on a landscape scale (>10-km radius) if they are to succeed. Caution must be exercised in evaluating bullfrog population status using visual surveys, as some transient populations can appear to be established and reproductive, based on different size classes of frogs observed.

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**SULIKOWSKI, JAMES A.**

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### From histology to hormones: Advances in the study of skate reproductive biology and the potential use in conservation management

Information regarding sexual maturity and reproductive cycles in skates has largely been based on gross morphological changes. For example, past studies have used structural endpoints, such as clasper length in males, ovary weight in females, or gonadosomatic index (GSI), to help assess reproductive status in these species. In contrast, few studies have used histological changes or circulating steroid hormone concentrations as endpoints to establish when skates become reproductively capable

or to determine reproductive cyclicity. The present study summarizes our current knowledge of histological and hormonal analyses in skate reproduction. This study also offers information that analysis of circulating steroid hormone concentrations, as a conservation management tool, may provide a means to determine size at sexual maturity and to assess reproductive cycles without the need to sacrifice the animal.

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Reproductive cycle of the blacknose shark, *Carcharhinus acronotus*, in the Gulf of Mexico

The reproductive periodicity of blacknose sharks, *Carcharhinus acronotus*, in the northern Gulf of Mexico was determined by examining reproductive tissues from specimens collected monthly from 2002 through 2005. Monthly changes in shell gland weight, right ovary weight and ovarian follicle diameter were assessed for 74 mature females. Temporal changes in testes weight, testes width and percent of mature spermatocysts were examined for 64 mature males. Trends in female reproductive tissues suggested an annual peak in reproductive activity during June and July, while trends in male parameters suggested an annual reproductive peak during May and June. Although male and female reproductive activity peaked in different months, a strong synchronicity existed between the percent of mature spermatocysts and the diameter of the largest ovarian follicle. Based on these results, the mating season of blacknose sharks lasts from mid May to July in the Gulf of Mexico. Maximum embryo sizes were observed in May which suggested that partition occurs during late May or early June. Results indicate that blacknose sharks have a clearly defined annual cycle in the Gulf of Mexico. This conclusion is further supported by the complete absence of gravid females without vitellogenic ovarian follicles among all mature females examined.

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**SUTHERLAND, RONALD W.**

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Herp conservation hotspots: Delineating the highest priority sites for amphibian and reptile conservation

Reptiles and amphibians do not often receive as much attention as birds or rare plants when public or private land conservation groups set priorities for future projects. At least part of the reason for this discrepancy is the lack of conveniently

packaged information on the current distribution of rare herp populations. When faced with a similar difficulty, the ornithological community had the foresight to establish a system for designating Important Bird Areas (IBA), which are defined as localities of high value to preserving bird biodiversity. I propose that US herpetologists design a similar system for identifying and delineating Herp Conservation Hotspots for each state. Canadian herpetologists have already implemented a plan for describing Important Amphibian and Reptile Areas (IMPARA). However, the Canadian IMPARA system and the original IBA regime will both end up including substantial fractions of already protected parks, preserves, and wildlife refuges in their portfolios. I suggest it may be more useful for the herpetological community to focus our energies on identifying those unprotected privately owned sites which are of highest priority for amphibian and reptile conservation activities. Groups or individuals designating lists of Herp Conservation Hotspots would certainly need to use caution in order to avoid either alienating landowners already friendly to conservation, or attracting the attention of unscrupulous collectors to the rare herps found on these sites. If such pitfalls can be avoided through careful design, I believe a Herp Conservation Hotspot designation-system for private lands would prove very useful for enhancing the protection of habitat for declining reptile and amphibian populations.

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**SUTHERLAND, RONALD W.**

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The use of trained dogs to detect rare native snakes

Herpetologists often have a difficult time locating many species of snakes in the field, due to the cryptic nature of these secretive reptiles. Although there are several relatively productive techniques available for catching snakes, such as road-cruising, funnel traps with drift fences, and artificial cover items, all of these methods have their respective flaws. Many snake researchers have long wished for some kind of magic snake-finding device that would enable the efficient, reliable capture of their target snake species. Trained snake-detecting dogs might provide this magic solution. With their superior olfactory abilities, dogs have proven capable of locating many other kinds of wildlife, and potentially may be able to track down numerous snakes that human searchers would be unable to find. In order to test the hypothesis that dogs can be used to find wild upland snakes, I began training a pair of snake-detecting dogs in 2003. After two years of training, one of the dogs achieved a small measure of success in 2005, finding three species of native snakes, including the rare northern pine snake and southern hognose. In my presentation I will describe the methods I have used for training dogs to find snakes, and offer generous suggestions for alternate training techniques that may prove even more successful for other researchers. I will also provide the results of formal testing of the dogs' snake-detection capabilities (scheduled for completion May 2006). After discussing my own work I will briefly review the status of other snake-detecting dog projects that are now underway in other parts of the world, and conclude with a preliminary

evaluation of the utility of this approach for finding snakes.

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Survivorship estimates of three life stages of the Houston Toad (*Bufo houstonensis*)

Although the Houston Toad has been endangered for over three decades, few data have been collected regarding the population dynamics of the species. From 2001 – 2005, an extensive study focusing on all life stages of the Houston toad was conducted at the Griffith League Ranch (GLR) located in Bastrop County, Texas. Egg strand numbers were estimated using 4 techniques. A set of concentric drift fences with pitfalls were placed around *B. houstonensis* egg strings in 2002 and 2003 and 657 post-metamorphic juveniles were captured, marked, and monitored for 13 weeks. Survivorship from egg to metamorph was estimated to be 0.473 and 0.4 from metamorph to 13 weeks. A linear regression predicted survival through adulthood for these cohorts to be 0.0002. Drift fences and pitfall traps along with breeding pond surveys were used to capture adult Houston toads. During the study, 194 adult *B. houstonensis* (168 M : 26 F) were captured and marked with PIT tags. Sampling effort remained constant among years, yet toad captures declined. A Cormack-Jolly-Seber mark recapture model was fitted to the data along with a model without time-specific survival probabilities. A likelihood ratio test determined no significant difference between the models ( $\alpha = 0.05$ ,  $2 = 4.21$ ). Yearly adult survivorship during the study period was estimated to be 0.24.

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**\*TANG, QIONGYING; LIU, HUANZHANG; MAYDEN, RICHARD L.; XIONG, BANGXI**

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Comparison of evolutionary rates in the mitochondrial DNA cytochrome b gene and control region and their implications for phylogeny of the Cobitoidea (Teleostei: Cypriniformes)

It is widely accepted that mitochondrial DNA (mtDNA) control region evolves faster than protein encoding genes with few exceptions. In the present study, we sequenced the mitochondrial cytochrome b gene (cyt b) and control region (CR) and compare their rates in 93 specimens representing 67 species of loaches and some related taxa in

the Cobitoidea (Order Cypriniformes). The results showed that sequence divergences of the CR were broadly higher than those of the cyt b (about 1.83 times). However, in considering only closely related species, CR sequence evolution was slower than that of cyt b gene (ratio of CR/cyt b is 0.78), a pattern that is found to be very common in Cypriniformes. Combined data of the cyt b and CR were used to estimate the phylogenetic relationship of the Cobitoidea by maximum parsimony, neighbor-joining, and Bayesian methods. With *Cyprinus carpio* and *Danio rerio* as outgroups, three analyses identified the same four lineages representing four subfamilies of loaches, with Botiinae on the basal-most clade. The phylogenetic relationship of the Cobitoidea was ((Catostomidae+ Gyrinocheilidae) + (Botiinae + (Balitorinae+ (Cobitinae + Nemacheilinae))))), which indicated that Sawada's Cobitidae (including Cobitinae and Botiinae) was not monophyletic. Our molecular phylogenetic analyses are in very close agreement with the phylogenetic results based on the morphological data proposed by Nalbant and Bianco, wherein these four subfamilies were elevated to the family level as Botiidae, Balitoridae, Cobitidae, and Nemacheilidae.

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**TAYLOR, EMILY N.**

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Effects of castration on body fat, growth rate, and home range size in free-ranging male rattlesnakes

Testosterone levels in male rattlesnakes are generally very high during mating seasons, and may be one physiological mechanism responsible for sex differences in body size and composition. In many animal species, testosterone promotes somatic growth and lipolysis while inhibiting lipogenesis. Also, male rattlesnakes often exhibit larger home range sizes than females, especially during the mating seasons, which may result from high testosterone levels in mate-searching males. We captured 14 male Western Diamond-backed rattlesnakes (*Crotalus atrox*) at a field site in central Arizona in spring 2003. We castrated seven of the snakes, performed sham surgeries on the other seven, and monitored them with radiotelemetry for two years. We collected blood samples and measured the body mass and SVL of the snakes several times during the experiment. At the end of the experiment, snakes were collected and sacrificed. Abdominal fat pads and the fat-free carcasses were weighed. We estimated the total and active season home range size of each snake using minimum convex polygon and fixed kernel methods. We found that castration did not affect growth rate, suggesting that testosterone may not be the primary physiological factor governing male-larger sexual dimorphism in rattlesnakes. However, castrated males had significantly higher wet fat mass and percent body fat than sham males. Increase in body fat is a common effect of castration in males of many animal species, and may result directly from the decrease in levels of testosterone or indirectly via behavioral changes due to castration. A surprising result was that castrated males had much larger home range sizes than sham males (2-3 times larger, depending on the method used). These results must be interpreted with caution because

measurement of testosterone levels in blood samples showed that testosterone levels were reduced but not eliminated in castrated males.

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Integration of historic and recent data for population dynamics modeling of spiny dogfish in the Northeast Pacific

The spiny dogfish, *Squalus acanthias*, has a long history of exploitation in the Northeast Pacific. Landings rose to a peak of over 50,000 mt in 1944 but have remained below 10,000 mt since 1950. Fishery statistics, biological data, and dorsal spines for ageing were collected in the 1940s and a tagging study was conducted. Information for the recent decades includes the same data types with the addition of bycatch data from observer programs and abundance indices from surveys and fisheries in the US and Canada. This paper describes an age-structured metapopulation model which integrates the historical data with the more recent sources. The metapopulation framework allows the modeling of declining abundance indices in inside waters of the Puget Sound along with stable indices in coastal waters. Uncertainty in the estimate of current depletion is discussed, and the implications for conservation and management of this long-lived, late-maturing species are considered. The use of alternative measures of population status, including reproductive value, is proposed.

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**TAYLOR, MICHAEL S.**

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Genetic variation in color vision proteins corresponds with microhabitat in the Neotropical goby genus *Elacatinus*

One of the largest genera of Caribbean fishes is the goby genus *Elacatinus*, which occupy a diverse array of reef microhabitats. Despite the ecological differences, many species are characterized by a brightly colored lateral stripe. The most common lateral stripe color is yellow, which is the likely ancestral state, with subsequent changes to blue or white. Lateral stripe color differs between sister taxa, which suggests that coloration may function as a mate recognition cue. Recognition of potential mates could be visually enhanced by "spectral tuning" of the opsin proteins responsible for color vision. Spectral tuning, the replacement of key amino acid residues in the protein, alters the wavelength absorbed by opsins in an additive, predictable manner. To determine whether spectral tuning corresponded to lateral stripe coloration in *Elacatinus*, I sequenced rhodopsin, and short and medium wavelength opsins, from more than 30 taxa. For a few taxa, either rhodopsin or short

wavelength opsin were found to evolve under positive selection acting on tuning sites. However, spectral tuning did not correspond to lateral stripe coloration; instead, genetic variation corresponded to microhabitat differences between taxa. This result suggests that spectral tuning may enhance visual acuity associated with the ecological niches occupied by different species of *Elacatinus*.

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**THACKER, CHRISTINE E.**

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Gobioid molecular systematics: A look back and a long view

With more than 2000 species, many of which are reduced and/or simplified morphologically, the perciform suborder Gobioidae has long been considered a challenging group for systematists. Since the last gobioid symposium in New Orleans in 1996, the use of DNA sequence data for gobioid systematics has increased dramatically, resulting in new hypotheses of relationships for all gobioid groups. One prominent conclusion from studies of molecular phylogeny is that the more speciose gobioid groups (Eleotridae and Gobiidae) are paraphyletic with respect to the smaller gobioid families (Xenisthmidae, Microdesmidae, Ptereleotridae, Kraemeriidae and Schindleriidae). I review the various hypotheses of gobioid interrelationships based on morphology and DNA sequence, and present a new overall phylogeny for Gobioidae, including consideration of outgroup relationships.

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Population structure of Pacific *Gnatholepis* species inferred from microsatellites

Individuals of two closely related species of goby, genus *Gnatholepis*, were sampled across the South Pacific and screened for eight microsatellite loci to determine the level of genetic structuring among the populations. The two species differ ecologically, with *G. anjerensis* inhabiting shallow lagoons while *G. scapulostigma* primarily occupies deeper water habitat outside of lagoons. A prior study using mitochondrial genes failed to illuminate a great degree of population structuring among *G. scapulostigma* and only slightly more structure among *G. anjerensis*. However, analysis of microsatellite loci for these species has proven to elucidate population differentiation greater than that detected with mtDNA sequence. A considerably greater amount of structuring among populations of *G. anjerensis* than *G. scapulostigma* was revealed, although distinct populations of *G. scapulostigma* are now evident. This discrepancy may be attributed to their differing habitat preference.

Both species experienced population expansion in the Pleistocene, and it is postulated that the greater degree of structuring found in *G. anjerensis* populations is associated with habitat loss due to fluctuations in sea level.

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A test of vicariant patterns in southeastern Australia in multiple sympatric *Hypseleotris* species

A key tenet of vicariance biogeography is that species with similar distributions should show congruent biogeographic patterns. Here we test this hypothesis in southeastern Australia in the genus *Hypseleotris* with a phylogenetic analysis using cytochrome *b* for 179 individuals from five species. Three or four *Hypseleotris* species are usually sympatric within each of three biogeographic provinces: Eastern (EP), Murray-Darling (MDP) and Central Australian (CAP). At many localities it is possible to collect all three or four species within the same seine hauls. Each species has broad environmental and physiological preferences which allows them to be abundant and broadly distributed. Phylogenetic analysis resolves the five species into four major groups: two clades of *H. klunzingeri*, one consisting of individuals from EP, plus two northern MDP localities, and the other including the remainder of MDP localities, along with CAP individuals. The other two clades include a mixed *H. galii*/*H. sp. 3* Murray-Darling clade, with EP and MDP lineages mostly segregated and differentiations in populations spread along EP, and a mixed *H. sp. 4* Lake's and *H. sp. 5* Midgley's clade, with a more mixed phylogenetic distribution of geographic localities. Additionally, three *H. sp. 3* Murray-Darling individuals fall outside their primary grouping, indicating the possibility of mitochondrial introgression among species, and/or retained ancestral polymorphisms in some *H. sp. 3* Murray-Darling populations. The overall picture demonstrates that despite their common distributions, each species has its own unique biogeographic pattern, suggesting that the causes of biogeographic movement within each species did not effect each species equally. Alternatively, it may also be possible that each species undertook similar movements, but there was uneven persistence of their genotypes.

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A world-wide generic revision of the family Aulopidae (Aulopiformes, Synodontoidae)

This family has long been considered to consist of a single genus, *Aulopus*, even though Starks (1924) erected *Hime* for the widespread Pacific species *japonica*. Also generally ignored is Whitley's 1931 name *Latropiscis*, erected for *Aulopus milesii* (= *purpurissatus*). Examination of considerable new material has resulted in the following generic classification for the family: 1) *Latropiscis*, monotypic for the Australian endemic *purpurissatus*, 2) *Hime*, six Indo-Pacific species, 3) *Aulopus*, two Atlantic species and two Pacific species, and 4) new genus, two Pacific species. Distinguishing characters for this classification include: fin ray, vertebrae and scale counts, pyloric caeca presence, size, and number, body and fin proportions, fin placement, fin ray filamentation, sexual dimorphism and body color, and cephalic pore system development.

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A new species of flagfin from Australia and New Zealand with comments on the genus *Hime* (Aulopiformes, Aulopidae)

The family Aulopidae is widespread in both the Atlantic and Pacific, found primarily on shelf and slope habitats. Although all species are often considered to belong to a single genus, *Aulopus*, there remains disagreement over generic placement of certain species. In addition, as more materials have become available for examination, we conclude that the family is more speciose than presented in most literature. We recognize a new species from northern New Zealand waters and some seamounts of the Tasman Sea, including Lord Howe Island, Australia. This form had been recognized as *japonica* in some references, but is quite distinct from 'true' *japonica*, differing in color pattern, and body and fin proportions. It also has more distinctive sexual dimorphism than *japonica*. We place this species in the genus *Hime* along with selected Indo-Pacific forms. We distinguish *Hime* from other genera of the family by a combination of meristics (fin rays, vertebrae, pyloric caeca), body morphology (fin positions, head proportions) and development of the cephalic pore system.

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### Phylogenetic utility of 96 new nuclear DNA primers across the turtle tree of life

Phylogenetic utility of 96 new nuclear DNA primers across the turtle tree of life  
Phylogenetically informative markers are often developed for a narrow set of closely related species or populations. How well do the DNA primers developed for a single species maintain their phylogenetic utility for a broader set of taxa? To investigate this issue, we designed oligonucleotide pairs to prime 96 nuclear loci in the western painted turtle (*Chrysemys picta belli*) and tested them across a panel of turtles sampled from across the turtle tree of life. Primers were constructed by utilizing end sequences from a Bacterial Artificial Chromosome (BAC) library constructed from *C.p. belli*. These sequences were compared to existing GenBank sequences in order to gauge homology. Primer pairs were designed for 48 end sequences that showed high homology (e-value < 10<sup>-5</sup>) to GenBank sequence, and for 48 end sequences that showed little or no homology to GenBank sequences; the former are putative coding sequences, the latter are non-coding. All primer pairs were then tested across the selected panel of 25 phylogenetically representative turtle species by PCR. Primer pairs which reliably produced single PCR products were classified as 'working' and were mapped onto an existing turtle phylogeny in order to estimate the evolutionary time over which primer pairs work and to investigate the pattern of fall-off in overall number of working primer pairs. Limited sequencing was performed using working pairs in order to verify single copy status, assess broad phylogenetic utility by forming expectations of substitution rate, and directly test phylogenetic utility in a small clade of turtles. Additional possible applications of these primer pairs are also discussed.

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### Observations of pedal luring in *Gastrotheca cornuta*

Many amphibian species are nocturnal, arboreal, fossorial or highly secretive, making the observation of behaviors such as courtship, breeding, intraspecific competition and prey acquisition very difficult. A digital video recorder and a camera with motion-sensitive and infrared capabilities were used to film the nocturnal activities of a captive group of horned marsupial frogs (*Gastrotheca cornuta*) over several weeks. The frogs were captured on film engaging in pedal luring on numerous occasions. After visually orienting toward potential prey (crickets), they began quickly undulating and vibrating the toes of their rear limbs in an apparent attempt to lure

potential prey to a more proximal position. Although this behavior has previously been observed in species of several groups of frogs including *Ceratophrys* and *Phyllomedusa*, it has not been documented in *Gastrotheca*. Further use of this technology would enable more to be learned about the natural behaviors of these otherwise difficult to observe animals.

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Aristotle's observations on the foraging interactions of the Red Mullet (*Mullus surmuletus*)

Red and striped red mullets (*Mullus* spp), sometimes called goatfish, are famous food fishes in the Mediterranean, from ancient times up to the present. They are known as goatfish because of the two stout barbels they possess under their chins, which give them a goat-like beard; in fact, Pliny says that these mullets are distinguished by a double beard on the lower lip (Natural History, Book IX, 30). Pliny also identifies several varieties of the red mullet as some of the best food fish and even describes some of the sauces the epicureans of the day recommended with its consumption (Book IX, 30). Seneca (Ep. 95) tells of a large mullet given to the emperor, Tiburius. While they are renowned for the table, Aristotle makes no mention of this fact in his observations of the red mullet (triglacaron; in Attic Greek) in his History of Animals (HA). Among other things, Aristotle discusses the fact that the red mullet has a diet consisting of sea-weed and shellfish (HA 591b12), occurs in lagoons (598a20), and describes some characteristics of its spawning (543a5, 570b25). Most remarkably, Aristotle also describes its interactions with another fish, the sargue or bream: The sargue or sargos identified by Aristotle is most likely a sea-bream of the Sparidae family, most likely one or more of the *Diplodus* spp, e.g. *Diplodus vulgaris*, *D. sargos*, *D. annularis*. The remarkable accuracy of Aristotle's observations of the co-foraging of *Mullus* spp. with breams will be discussed in light of field observations in Lesvos, Greece, the location where most of Aristotle's work in zoology took place, carried out in 2005.

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Movements of adult, metamorphic, and translocated metamorphic tiger salamanders on Long Island

Understanding the characteristics of ponds and vernal pools utilized by amphibians, as well as the upland habitats used throughout the year, is essential to the

conservation and proper management of these species. The long-term survival of the New York State endangered Eastern Tiger Salamander (*Ambystoma tigrinum tigrinum*) is of special concern due to rapid development of its last remaining habitats on Long Island. A radio-telemetric study is currently underway at the Brookhaven National Laboratory on Long Island, New York. Data were collected from 2004 to 2006 at four pond locations. Twenty-three adults and thirty-three metamorphs have thus far been captured and implanted with transmitters. Adult animals spent an average of 47 days and metamorphs 23 days in burrows between surface movements. Single night movements ranged from 7 to 237 m for adults and from 4 to 269 m for metamorphs. Implanted animals have been lost due to predation, loss of transmitter signal, or are still being tracked. Ten of the metamorphs were translocated 1500 m from one breeding pond to another, but none survived beyond 93 days. Single night movements for these metamorphs ranged from 5 to 289 m, with individuals moving in random directions from the release point. Based on our findings, we feel that the current 100-foot buffer zone for wetlands and aquatic breeding habitats and the corridors to maintain connections with adjacent areas beyond 500 feet are insufficient to maintain breeding populations of Tiger salamanders in NYS, nor does it appear that metamorphs can be successfully transplanted as a management technique.

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It's raining caudates and frogs: ontogenetic and interspecific variation in migratory responses to climatic factors among pond-breeding amphibians

Many pond-breeding amphibians from temperate regions undertake overland migrations to reproduce in aquatic habitats. In turn, their offspring metamorphose and emigrate to upland, terrestrial habitats. The phenology of these migrations has been documented for many species and in many regions of North America. Similarly, the migratory responses of amphibians to climatic factors have been studied extensively. However, timing of migration varies among species, among years, and with latitude within a single species. Thus, in order to compare among-species variability in migratory responses to climatic factors, several species must be examined contemporaneously at a single geographic location. We examined the diel patterns and daily variability of migratory movements of adult and juvenile amphibians in response to climatic cues at an isolated wetland in South Carolina, USA. Of the eight species we observed, *Ambystoma talpoideum*, *A. tigrinum*, *Bufo terrestris*, *Hyla gratiosa*, *Pseudacris crucifer*, *P. ornata*, *Rana sphenocephala*, and *Scaphiopus holbrookii*, all migrated almost exclusively at night with the exception of recently metamorphosed *B. terrestris*, which frequently migrated diurnally (> 50% of captures). Additionally, we correlated daily captures of adult and juvenile *A. talpoideum*, *A. tigrinum*, *B. terrestris*, and *R. sphenocephala* to maximum and minimum daily temperature, number of previous days without rain, total rainfall in the previous 24 hours, and interactions of these variables. Rain was often the most important predictor of amphibian captures. However, species differed in their

response to climatic factors and rain explained little of the observed variance in captures of *B. terrestris*. We suggest that variation in the risk of desiccation and predation among species likely contributes to observed migratory patterns. Changes in regional weather patterns may have important species-specific consequences for amphibians that rely on suitable climatic conditions to successfully complete their breeding and juvenile migrations.

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**\*TOLLE, AMANDA E.; WAGNER, WILLIAM E.**

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### Convergence of calls of two toads in areas of sympatry

When two closely related species have overlapping ranges, females may have difficulty discriminating between conspecific and heterospecific signals, particularly if conspecifics and heterospecifics produce similar signals. There are three hypotheses for how the calls of a given species should differ between allopatric and sympatric populations: (1) calls of the two species may be more different when sympatric because costly heterospecific matings favor reproductive character displacement; (2) calls of the two species may be more similar when sympatric because of hybridization; and (3) calls of the two species may not differ between sympatric and allopatric populations because the two species do not interact. Molecular studies have found that hybridization occurs between *Bufo americanus* and *B. woodhousii* where their ranges overlap. Males from allopatric and sympatric populations of both species were recorded to determine how calls differed between allopatric and sympatric populations. It was found that the calls of *B. americanus* and *B. woodhousii* converge in areas of co-occurrence. Within each species, most call characters examined differed between allopatric and sympatric populations, and the calls of the two species were more similar in sympatry than in allopatry. The converging values for the calls in the sympatric populations suggest either the presence of numerous hybrids with intermediate call types and/or extensive bidirectional introgression. It is unclear if females are making mistakes in mate choice by choosing heterospecific males or if females are unable to make a choice due to scramble competition among males. Further study into this system must be done to determine the causes and nature of hybridization.

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### Population state of *Atelopus exiguus* in the South Ecuadorian Andes

Amphibian decline is reported in tropical and temperate zones, including different altitudes. In Ecuador, these declines are reported since late 80 and early 90. Around 25 species of anurans have declined, being *Atelopus* one of the genus more affected. Of the 18 known species for the country, 11 have declined in the last 15 years, as is

the case of *Atelopus exiguus*. Along with *A. mucubajiensis* from Venezuela, *A. exiguus* is the only high altitud species of this genus that still remain in natural environments. *A. exiguus* is endemic of the South Occidental mountain range of Ecuador. It inhabits the paramo and subparamo and is associated to rivers and creeks where they were very common. During the 80 the population start to decline and since 1995 no individual was observed until September 2004, were few individuals have been reported. Our study is determining the state of the population of *A. exiguus* in the Mazan Forest. 29 individuals are observed until now, 19 adults (one gravid female) and 10 juveniles. Neither eggs nor larvae have been observed. All the individuals were found exclusively at the Mazan Forest, suggesting that this is the only location where they inhabit now.

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### **TORKI, FARHANG**

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A new species of Genus *Eirenis* (Serpentes: Coluberidae) from Zagros Mountains, Lorestan Province, Iran

A new species of coluber snake of genus *Eirenis* is described from the Sepidkoh region in Zagros Mountains, between Khorramabad and Kohdasht, Lorestan Province, western Iran, elevation 1350 m. The new species differs from its known Iranian congeners with 17 midbody scale rows in having more than 250 ventrals, square loreal scale, without any pattern on neck, head and body. Notes on ecology and distribution, of the new species and key to the Iranian species of genus *Eirenis* is provided.

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### **\*TORNABENE, LUKE; VAN TASSELL, JAMES**

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Morphometric analysis of the Atlantic species of *Bollmannia* (Teleostei: Gobiidae)

The genus *Bollmannia* Jordan is composed of fourteen nominal species, five from the Atlantic Ocean. The original description of *B. litura* is inconsistent with the meristics of the holotype, mainly in the counts of the second dorsal and anal fin elements. The original description of this specie was previously used to differentiate this specie from *B. communis*, *B. eigenmanni*, *B. boqueronensis* and *B. jeannae*, but the meristics of the actual holotypes show overlapping between these species. These discrepancies have led to the American Fisheries Society invalidating *B. jeannae* and *B. litura* as unique species in the 6th Edition of Common and Scientific Names of Fishes, where as Fishbase invalidates only *B. jeannae* and the California Academy of Science, Catalog of Fishes, still recognize both *B. litura* and *B. jeannae* as valid. In this study, we used morphometric analysis to determine if anatomical differences exist between

*B. communis*, *B. eigenmanni*, *B. litura*, *B. jeannae* and *B. boqueronensis*, which would allow us to reconcile the species status. Through the use of TPSdig software, we were able to place digital landmarks on photographs of cataloged specimens of each species, as well as the respective holotypes to make accurate morphological measurements for the basis of comparison. The results of this experiment should provide the information necessary to resolve the status of the Atlantic species.

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**TORNICK, JAN K.**

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Nest guarding and aggression in the Red-backed Salamander, *Plethodon cinereus*

A great deal is known about aggression during territoriality in *Plethodon cinereus*, however aggression during nest guarding is less well studied. Few studies have examined how variables such as clutch properties, sex of intruders, or body condition of the mother affect aggression during clutch defense. Parental care theory predicts that large broods, representing a sizable reproductive value, should elicit greater parental efforts than small broods. In addition, maternal aggression should be directed only at conspecifics that pose a threat, since *P. cinereus* is densely populated and accidental encounters occur frequently. Although female red-backed salamanders are known to cannibalize eggs, it is less clear whether males also cannibalize. Finally, mothers in good condition should be able to defend the nest more effectively than mothers in poor condition. Three hypotheses were tested: 1) females should be more aggressive when defending a nest containing a large number (10) of eggs than a nest with fewer (4) eggs; 2) females should be more aggressive when defending a nest against female conspecifics than against males; and 3) females in better body condition should be more aggressive during nest guarding than less fit females. No significant difference was found in defense of large vs. small broods, or against female vs. male intruders. No relationship was found between any measure of body condition and aggressive behavior, although there was a trend towards those in poor condition being more aggressive. However, brooding females were significantly more aggressive than non-brooding females (evidence of egg rather than nest-site fidelity); and also significantly more aggressive than female and male intruders. This study suggests that other factors such as hormones may determine the level of aggression in female red-backed salamanders during nest defense.

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### Land use influences on survival of spadefoot metamorphs from playas in the Southern Great Plains

Habitat fragmentation and degradation is a major threat to amphibian populations and this threat is prevalent across the Great Plains. Playa wetlands are the primary breeding sites of Southern High Plains (SHP) amphibians, and agricultural practices that dominate the landscape may exasperate stressors naturally experienced by these amphibians. Playa wetlands are ephemeral habitats that fill via stochastic precipitation events and amphibian breeding success depends in part on hydroperiod timing and duration. Cultivation increases sedimentation in playas, reducing their hydroperiod and possibly breeding success of amphibians. Additionally, agriculture can fragment the landscape, possibly causing inbreeding depression. Tilling the upland may also degrade estivation habitat. Spadefoot toads are often the most prolific breeders in playas employing an r-selected reproductive strategy, and their metamorphs are often the most abundant vertebrate on the landscape after emergence. Given the importance of metamorphs in recruitment into the breeding population and the possible threats of agriculture, we tested for differences in apparent survival between populations emerging from playas in cropland and grassland landscapes using Pollock's robust design. In 2003 and 2004, we chose 6 playas in cropland and 6 grassland landscapes that filled with water following spring thunderstorms. Because rate of first capture was very high and recapture rate very low, we could not use all 24 datasets to make comparisons between land uses. We found no differences in end of season apparent survival between populations from cropland and grassland playas. However, apparent survival was generally low and highly variable. Our study reveals current estimators for r-selected amphibians with a life history strategy of remaining above ground for a short time period are inadequate for obtaining accurate survival estimates.

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### Evolution and biogeography of Andean lizards in the genus *Stenocercus* (Squamata: Iguania)

The South American iguanian lizard genus *Stenocercus* includes 58 species occurring mostly in the Andes and adjacent lowland areas from northern Venezuela and Colombia to central Argentina at elevations of 0–4000 m. Limited taxon or character sampling have characterized all previous phylogenetic analyses of *Stenocercus*, which has repeatedly been proposed as sister taxon to the *Tropidurus* Group. In this study, I use molecular and morphological data to (1) infer the phylogenetic relationships

among most species of *Stenocercus*, (2) perform explicit statistical tests of previous phylogenetic hypotheses, and (3) infer the ancestral distribution of *Stenocercus*. Using parsimony and Bayesian analyses, monophyly of this genus is strongly supported with a dataset of 32 species of *Stenocercus*, 12 outgroup taxa, and 1641 bp of mtDNA. Molecular data also are used to analyze evolutionary relationships within *Stenocercus* with a Bayesian approach based on mixture models, which accommodate variability in the parameters of the rate matrix across sites. Morphological data were obtained from 55 species of *Stenocercus* and one outgroup taxon; polymorphic and continuous morphological characters were coded using step matrices with frequency parsimony, and gap-weighting methods, respectively. Parsimony and Bayesian analyses were performed with a combined dataset of 55 ingroup taxa, one outgroup taxon, and 1764 characters. All analyses support a basal split of *Stenocercus* into two clades. One of these clades is restricted to the central Andes except for a few species occurring in the northern Andes in Ecuador and Colombia. The second clade is more widespread and includes species occurring in the northern, central, and southern Andes, as well as species in the Amazon Basin and lowlands in southeastern South America. A dispersal-vicariance analysis (DIVA) suggests that the most recent common ancestor of species of *Stenocercus* occurred in the central Andes.

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Long-term effects of short-term variation: how egg environment changes tadpole phenotype and survival

*Hyla ebraccata* is a neotropical leaf-breeding treefrog with terrestrial eggs and aquatic larvae. Embryonic development takes 3-4 days and depends on rainfall, which varies. Eggs rapidly desiccate, and eventually die, without rain. Clutches laid near the water's surface can also become submerged when large storms fill ponds (25% of clutches observed in 2005, N=100 clutches). *Hyla ebraccata* eggs therefore develop in one of three environments: rained upon, not rained upon, or underwater. We reared split *H. ebraccata* clutches under simulated heavy rain, no rain (but occasionally misted) and submerged underwater. The egg-stage environment affected development, hatching time and hatchling phenotype. Submergence and desiccation both increased embryo mortality 20% and submergence delayed hatching by 17%. Preliminary analyses indicate that hatchlings from submerged eggs were smaller and less developed. In the first three days post-hatching, 33% of hatchlings from submerged eggs died, while mortality in other treatments was negligible. To test the effect of egg-stage environment on larval phenotype and development, hatchlings from each egg treatment were reared until metamorphosis. We removed subsets every 10 days after all tadpoles finished hatching for morphometric analysis and 24h predation trials with libellulid dragonfly nymphs and belostomatid water bugs. Egg environment had a counter-intuitive effect on survival with predators after 10 days; tadpoles from submerged eggs had the highest survival and those from heavy rain had the lowest, regardless of predator. Despite this fitness effect, preliminary

analyses indicate no morphological differences in tadpoles from different egg environments at 10 days. At 20 and 30 days, egg environment no longer affected survival with predators. We previously documented that desiccation dramatically increases predation on *H. ebraccata* eggs. It is now clear that short term abiotic environmental variation affects not only egg survival, but alters hatching timing and has substantial effects on tadpole survival, phenotype and predator-prey interactions.

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Reproductive mode variation in a neotropical treefrog: the leaf-breeding *Hyla ebraccata* lays eggs in water

Many anurans make oviposition site choice decisions in order to avoid competition, parasites, or predation. However, these flexible oviposition strategies remain within the confines of a single reproductive mode (i.e. aquatic or terrestrial oviposition). There are currently no known cases of anurans using multiple reproductive modes. Last summer we discovered that *Hyla ebraccata*, a neotropical treefrog with terrestrial eggs and aquatic tadpoles, lays its eggs in the water at Quarry Pond in Gamboa, Panama. In extensive fieldwork at nearby ponds we have found only terrestrial *H. ebraccata* eggs. This species is abundant and conspicuous throughout Central America, yet its aquatic oviposition has never been described. Aquatic oviposition in *H. ebraccata* represents a reversion to a more primitive reproductive mode and alters the ecological and physiological environment for developing embryos. When *H. ebraccata* embryos develop underwater about 20% die, and the rest hatch later and less developed than terrestrial eggs, probably because of oxygen limitation. This, as well as aquatic egg predation, likely favors terrestrial oviposition. However, risk of desiccation selects against terrestrial oviposition. Terrestrial *H. ebraccata* clutches need rain to survive, although those laid in shade survive 23 hours longer without rain than clutches in sun. Desiccation also increases egg predation rates 6-fold over hydrated clutches. Quarry Pond differs from nearby ponds in that it lacks a forest canopy, so eggs are fully exposed to sun. It also has more abundant floating aquatic vegetation, which may alter selection on eggs in the water. We will present data from oviposition site choice tests and experiments measuring the adaptive value of aquatic versus terrestrial oviposition in ponds where *H. ebraccata* uses each strategy. The variation in oviposition site (between aquatic and terrestrial) documented here is previously unknown in anurans and offers a tremendous opportunity to study the evolution of reproductive modes.

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### Age and growth of four skates commonly caught as by-catch in the southeast Australian fisheries

In Australia, skates (Rajidae) are a common by-catch/by product of both State and Commonwealth trawl and non-trawl fisheries. Three continental shelf species (*Dipturus* sp. A, *D. cerva* and *D. whitleyi*) and one continental slope species (*D. gudgeri*) were examined for annulus deposition in the vertebral centra and caudal thorns. The two largest bodied skates *D. gudgeri* (n=300) and *D. whitleyi* (n=73) showed the most promising band formations in both structures using two different methods: whole and sectioned vertebrae and whole and sectioned caudal thorns. Both *Dipturus* sp. A (n=437) and *D. cerva* (n=180) showed relatively clear annuli in vertebral sections. These were viewed with transmitted light using a dissecting microscope fitted with a ColourView digital camera by Soft Imaging System and processed with AnalySIS software. The periodicity of growth band deposition for *D. gudgeri* was verified using marginal increment analysis and the caudal thorns were used for comparative measures in both *D. gudgeri* and *D. whitleyi*. Estimates for male and female longevity of *D. gudgeri* are 20 and 21 years, respectively. Longevity estimates for male and female *D. whitleyi* are 13 and 18 years, respectively. The two smaller inshore skates have lower longevities. *Dipturus cerva* male and female longevity is estimated at 8 and 9 years, respectively. von Bertalanffy growth model (VBGM) parameters for *D. cerva* males were estimated as  $K = 0.20$  and  $L_{inf} = 73.35$  cm and females  $K = 0.31$  and  $L_{inf} = 73.35$  cm. Male and female longevity for *Dipturus* sp. A is estimated at 11 and 12 years, respectively. The Francis reparameterised VBGM equation was also used for comparison.

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### Dietary habits and overlap in the rajid species in southeastern Australian waters

Dietary information on skates (Rajidae) is vital in determining their ecological role and trophic relationships within their local environment and for creating ecosystem models. In southeastern Australia, seven skate species (*Dipturus* sp. A, *D. sp. B*, *D. cerva*, *D. gudgeri*, *D. lemprieri*, *D. whitleyi* and *Pavoraja nitida*) were collected from commercial and recreational fishermen between 2002 and 2004. The aim of this study

was to determine dietary overlap between the species and to examine the ontogenetic shifts in diet. All stomachs from dissected skate species were excised, contents weighed and preserved. All prey items were then counted, weighed and identified to the lowest possible taxon. Each prey group was assigned an ecological group listing to identify whether a shift in diet from benthic to pelagic prey occurred with ontogeny, size and species. The Index of relative importance was used to characterise diet. Seasonal, sex, trophic levels and geographic variations were also examined. Ontogenetic changes in diet were evident, five species as juveniles fed primarily on caridea (shrimp: *Leptochela sydniensis*), as size and maturity increased the diet progressed to larger prey items of a wider variety of taxa. The smallest skate species *P. nitida* consumed caridea throughout ontogeny. *Dipturus gudgeri* and *D. sp. B* showed the highest percentage of empty stomachs, possibly due to the fishing method, bottom drop-lining. Caridea, brachyura (crabs), cephalopoda and osteichthyes (fish/eels) were of the most importance in the diet of *D. sp. A* and *D. whitleyi* at different stages of ontogeny. *Dipturus lemprieri* preyed primarily on crabs, and the diet of *D. cerva* and *P. nitida* consisted of substantial amounts of *L. sydniensis*. *Dipturus sp. B* fed primarily on crustaceans (spider crabs, goneplacid crabs and squat lobsters). *Dipturus gudgeri* ingested similar prey to *D. sp. B*, although osteichthyes were also a significant part of the diet.

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Morphological changes of the *transversospinalis* muscles in the preloacal region of squamates and implications for the cervico-dorsal boundary in snakes

Although the complete loss of the pectoral girdle obscures the distinction between cervical and trunk regions in snakes, snakes possess cranio-vertebral muscles that differentiate from the rest of the axial musculature in the anterior preloacal region and insert on the skull, indicating the presence of a myologically distinct "neck." In the present study, the morphology of the most medial group of the epaxial musculature, the *m. transversospinalis* group, was investigated in various squamates, with an emphasis on changes in lengths of muscle slips toward the cranio-vertebral boundary. In tetrapodal squamates such as *Varanus* and *Gekko*, lengths of slips of *m. semispinalis* remain almost constant from the anterior dorsal region to the cranio-vertebral boundary, while those of *m. spinalis* begin decreasing anteriorly at around the cervico-dorsal boundary. Similar changes were observed in snakes: while the first 20 slips of *m. semispinalis* do not show much change in length, the *m. spinalis* slips begin shortening in the most anterior preloacal region. For example, such shortening starts with the slips arising from the sixth and eighth preloacal vertebrae in *Ramphotyphlops* and *Anilius*, respectively. Compared to tetrapodal squamates, therefore, the cervico-dorsal boundary in snakes may be located around those levels,

based on this myological characteristic. The neck lengths inferred on this basis are within the range of those based on the posterior extent of *m. transversospinalis capitis* (a cranio-vertebral muscle belonging to the *m. transversospinalis* group), but are much shorter than those based on the subvertebral *m. rectus capitis anterior*, suggesting that patterning of the axial differentiation may be independently regulated in different muscle groups.

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Effects of forestry practices for red-cockaded woodpeckers on space use by gopher tortoises (*Gopherus polyphemus*)

The gopher tortoise (*Gopherus polyphemus*) occurs in the southeastern Coastal Plain and has experienced widespread decline due to habitat loss and other human impacts. Although the species is currently listed as federally threatened in only the western portion of its range, many biologists believe federal protection throughout its range is warranted. The largest remaining populations occur on private lands (e.g., commercial timber lands) and military installations. Proper forest management at these sites will be critical to the success of the species. The goal of our study was to determine the response of gopher tortoises to forestry management practices commonly implemented in the management of red-cockaded woodpeckers (RCWs; *Picoides borealis*). We monitored habitat use of individual tortoises by radio-tracking adult gopher tortoises at four study sites with different ownership and management scenarios: Ft. Gordon (military installation, winter burning), Savannah River Site (federal defense facility, winter burning, translocated population), Tillman Sand Ridge (state wildlife preserve, summer burning), and a private hunting preserve (no management). Fifty-nine tortoises (8-26 tortoises/site) were tracked 2-3 times/week for two years. Canopy cover, tree density, basal area, and herbaceous vegetation categories were used to characterize each study site overall. Similar data were collected at active burrows to compare "tortoise-selected" vs. "typically-available" habitat. Movement patterns, space use, site fidelity, and burrow use patterns of tortoises were compared among the four study sites in the context of observed habitat parameters. Although sites with different management prescriptions varied in habitat characteristics important to both RCWs and gopher tortoises, habitat characteristics at "tortoise-selected" sites (i.e., burrows) were remarkably similar across study sites. Management for RCWs generally support tortoise habitat needs, although the prescriptions may not be identical. Results will be used to develop recommendations for the management of both resident and translocated populations of gopher tortoises.

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Site fidelity, survivorship and growth of juvenile translocated gopher tortoises (*Gopherus polyphemus*)

Until relatively recently, translocation of rare, non-game species has generally been viewed with skepticism, especially for reptiles and amphibians. For gopher tortoises in particular, two of the major concerns that have been raised are that translocation: 1) is not a proven conservation tool for the species, and 2) can undermine land conservation efforts by offering developers an "easy way out." However, continued fragmentation and loss of upland habitat, coupled with an increased focus on rigorous translocation research and post-translocation monitoring, suggest that translocation may become an increasingly important management tool for populations of threatened species. We translocated a population of gopher tortoises (n=106; 35 hatchlings, 33 juveniles, 39 subadults/adults) to the Savannah River Site, Aiken Co., South Carolina in Fall 2001. Radio-telemetry data from this and other studies of translocated tortoises suggest that subadults have greater site fidelity than adults, but the response of juvenile tortoises is largely unknown. We periodically trapped juvenile tortoises during the first five years following translocation, resulting in more than 110 captures-recaptures of 40 juvenile founders and new recruits. Site fidelity, survivorship, and growth data of translocated juvenile tortoises will be presented and compared to the limited data available for natural populations. The feasibility and importance of including juvenile tortoises in translocation projects will be evaluated.

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Productivity comparison of young of the year opaleye (*Girella nigricans*) and their algal food source

Herbivorous fishes have a profound impact on marine plant communities. Opaleye (*Girella nigricans*) are one of the few temperate marine herbivorous fish occupying Southern California waters. Currently, little information regarding the productivity of opaleye is known. This study seeks to compare productivity estimates of opaleye and their algal food source in order to link primary and secondary energy transfer. Opaleye biomass and wet weight will be used to estimate productivity based on Ricker (1946) and Allen (1950) production models. Algae productivity will be estimated by measuring dry weights of algae grown on unglazed terra cotta tiles. Productivity estimates of opaleye will help elucidate the importance of trophic

energy transfer between a primary producer and consumer within Southern California algal communities.

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"Temporary" population structure and its importance for evolution of freshwater fishes: Examples from the American Southwest

Many evolutionary studies of fishes discount population structure that is unstable or "temporary" in time and space as being unimportant for determining genetic diversity in the long term. Examples of temporary population structure include aggregations of spawning adults and spatially or temporally distinct assemblages of larvae and juveniles. We propose that aggregation behaviors may strongly influence genetic diversity in freshwater fishes, even when aggregations are composed of random subsets of the overall population. Genetic effects could be especially pronounced in the larval phase when mortality is high and resources required for recruitment are patchy in time and space. To support our argument, we present genetic and ecological data for two endangered fishes of the American southwest: the Rio Grande silvery minnow, *Hybognathus amarus*; and the razorback sucker, *Xyrauchen texanus*. In both cases, genetic samples were taken at spatially distinct localities over a period of seven years. Aggregations were spatially and genetically distinct each year, but genetic identities of aggregations changed from year to year. In the Rio Grande silvery minnow, we concluded that differential mortality among larval aggregations increased variance in reproductive success among spawners thereby reducing overall genetic diversity in the species. Natural recruitment in the razorback sucker no longer occurs, but genetic diversity of the species is only maintained by collecting larvae from several spatially distinct localities as a source for repatriation into the wild. Taken together, these studies suggest that temporary aggregations can have profound influence on maintenance of genetic diversity in evolutionary time.

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Natural history and habitat use of the Plains Garter Snake (*Thamnophis radix*) in Alberta

Most of what is known about the ecology of northern garter snakes comes from studies of the common garter snake (*Thamnophis sirtalis*). At northern latitudes, these snakes often have a characteristic annual cycle that includes communal overwintering and long-distance migration between hibernacula and summer habitats.

Other northern species of garter snakes have not been observed as frequently to engage in the same behaviours, suggesting either that they are understudied or that they use the landscape in different ways and therefore may have different habitat requirements. The western plains garter snake, *Thamnophis radix*, provides an opportunity to test the generality of this 'sirtalis model' of habitat use in garter snakes. The natural history and the habitat use of these snakes were studied at the northern limits of their distribution in central Alberta in 2005. Snakes were captured opportunistically and tracked using telemetry, and data were collected on population structure, food habits and habitat use. Snakes were captured most of the time in fields, even though field comprised only 15% of the available habitat. Snakes were also strongly associated with edge habitat between field and scrub vegetation. Five snakes were radio-tracked to individual holes in the ground for over-wintering sites, and no communal dens were identified. Average distance moved to den site was 600 m from release location. Additional data on the spatial relationships between summer and winter habitats will be collected in 2006 to complete the comparison with the *sirtalis* model.

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Bonnethead shark (*Sphyrna tiburo*) androgen receptor: cDNA cloning and tissue specific expression through the male reproductive cycle

Steroid hormones are essential for proper reproductive development in all vertebrates. Androgens are sex steroids secreted by the gonads that regulate virilization, spermatogenesis, and sexual behavior. These physiological actions require the binding of androgen to a specific receptor protein. Androgen receptors (AR) are ligand-activated transcription factors that bind to a specific nucleotide sequence of DNA and positively or negatively regulate transcription. An understanding of the distribution and levels of expression of the elasmobranch ARs on the cellular and tissue level demonstrates the pattern of responsiveness to the androgenic hormones. In this study, a fragment of the AR gene was cloned and sequenced from the bonnethead shark, *Sphyrna tiburo*, an elasmobranch species with a well-defined annual reproductive cycle. Acquiring this gene sequence facilitated the construction of species-specific AR polymerase chain reaction (PCR) primers and bonnethead AR mRNA probes that were used to screen reproductive tissues for evidence of AR gene expression using reverse transcription (RT)-PCR and in situ hybridization (ISH), respectively. The RT-PCR screens demonstrated AR gene expression in the testes, seminal vesicles, and epididymides of male bonnethead sharks. ISH results localized the AR expression to the interstitial cells of the testes and mature spermatozoa within the seminal vesicles and the testes. Immunocytochemical methods used to detect the AR protein produced comparable results in the shark testes. These findings along with seasonal and ontogenetic differences in AR expression will be discussed. Knowledge of AR receptors in

elasmobranch fishes, being the oldest living animals that possess an archetypical vertebrate pattern of reproductive endocrinology, may provide insight into the evolution of steroid receptors and nuclear receptors as a whole. Further, knowledge of steroid receptor function may enhance our understanding of the mechanisms behind endocrine disrupting chemicals in the environment.

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Twenty-one years of long-term nest monitoring (1985-2005) of the American alligator in Everglades National Park, Florida USA

Systematic Reconnaissance Flights (SRFs) have been used from 1985-2005 to monitor nesting effort and nesting success of the American alligator in Everglades National Park (ENP). In the 1970s, annual alligator nest mortality due to flooding was high (97%) in ENP. This was largely due to unseasonal water discharge into Shark River Slough, a region of abundant alligator nesting. Because Everglades restoration in South Florida will modify the quantity, quality, timing, distribution (QQTd) and flow of water on an ecosystem-wide scale it is vital to understand how alligator nesting effort and success relate to hydrologic conditions. SRFs, have been used as a tool to detect landscape-level changes in alligator nesting in response to hydrologic change. We used harmonic analysis to assess relationships among hydrological variables such as stage, discharge, and rainfall, with abundance, nest success, and flooding of alligator nests. A total of 1,173 nests were counted along 25 variable length line transects from 1985 to 2005. The number of nests varied annually, with 85 % of nests occurring in Shark River Slough (SRS). There was less nesting effort during drier years compared to wetter years. There was a positive linear relationship between mean annual water, total rainfall from January-June, and nesting effort. Nest flooding was related to amplitude of stage and annual periodicity. Years with wet dry seasons and little periodicity had none to little nest flooding. The greatest nest flooding and mortality (86%) recorded since 1985 occurred in 2005, this was due to both, Hurricanes Dennis and Katrina which produced large rainfall events over a short time period. These events raised the water stage precipitously, flooding many nests. Because nest mortality due to flooding is relatively low in other parts of Florida (6-9%) and little periodicity results in low flooding mortality in the Everglades, this suggests that the seasonal amplitude in water levels of Shark Slough were historically more stable and not as great as they are now.

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### Historical biogeographic patterns across multiple Australian freshwater fish groups

Freshwater aquatic systems are different biogeographically to other habitat types due to their different distribution and connectivity patterns. Because obligate freshwater aquatic organisms are only able to move via direct connections between habitats, drainage basins greatly limit opportunities for movement due to their isolated nature. Potential physical connectivity between drainage basins is largely limited to two factors: changes in sea level, which allow drainages to coalesce when sea level falls; and drainage rearrangements, which result in changed catchment boundaries. Three freshwater fish groups, *Craterocephalus*, *Melanotaenia* and *Nannoperca* were chosen for phylogeographic analysis based on their broad ranges, number of species, geographic overlap and to provide maximum coverage of Australia. When phylogenetic patterns for each fish group were combined, there was little congruence in their patterns of divergence across Australia despite a high degree of co-occurrence. Two factors are proposed to explain this result. The first is that dispersal across freshwater biogeographic barriers may be more common than previously thought. This is due to the widespread presence of low drainage divides which may allow fishes to move across catchment boundaries during high rainfall periods without drainage rearrangement. The second is that vicariance in freshwater systems does not appear to be a powerful structuring force. Although vicariant events are occurring on a regular basis, the fish fauna may not be equally affected by these events due to differences in ecology and climate. Over-arching biogeographic hypotheses are inadequate to explain the independent histories of each group. My research adds to the growing body of literature that suggests independent biogeographic patterns are common. Therefore, finding broader explanations for patterns may be the exception rather than the rule.

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### Reproductive biology of *Pterapogon mirifica*, an Australian apogonid with direct development, sexual dichromatism and solitary behavior

*Pterapogon mirifica* is an apogonid restricted to the western coast of Australia. Before this study, nothing was known about any aspect of its natural history, including its reproductive habits. In addition, its taxonomic position is not clear; there seems to be enough evidence to support placing it back into its original genus, i. e., *Quinca*. After years of unsuccessful intents in obtaining live specimens, the author traveled to the North Cape area and collected 10 individuals to conduct reproductive studies. Under

laboratory conditions *Pterapogon mirifica* showed very aggressive behavior towards other co-specifics, which was in accordance with its unexpected solitary behavior seen in the wild. As a result, artificial pair formation was challenging and required ample space. Courtship displays generally followed other apogonids behaviors with side-by-side trembling and the female being the most active. One of the most conspicuous behaviors was the striking dichromatism displayed by males, which were able to change their body coloration from a normal all black to white in a few seconds. Only males incubated the clutch, which consisted of between 90 and 200 eggs. Unlike other apogonids, the eggs were not held together by chorionic filaments, and the size ranged from about 3.2 to 4.3 mm in diameter. The embryos needed 18 days (26-27°C) to complete development, hatched as eleutheroembryos, and remained 4 days within the parent mouth until release as juveniles. Juveniles showed co-specific aggressive and territorial behavior few hours after being released. The embryologic development of *P. mirifica* is presented, and compared to that of *Pterapogon kauderni*, an endemic species from Indonesia. *Pterapogon mirifica* is the third apogonid in which direct development is reported. The presence of this highly unusual reproductive mechanism among coral reef teleosts might be useful to clarify the phylogenetic relationships within Apogonidae, still poorly understood.

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#### **VALVERDE, ROLDAN**

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#### Toward the development of an assay to detect endocrine disruption in reptiles

Thyroid hormones (THs) play an important role in the development of the vertebrate nervous system and are important regulators of the vertebrate metabolism, particularly that of mammalian and avian species. However, it is not clear the physiological and endocrine relevance of these hormones in poikilothermic organisms. Various organochlorines that act as environmental pollutants, such as polychlorinated biphenyls and hexachlorobenzene, are known to alter the normal function of the hypothalamo-pituitary-thyroid (HPT) axis. These synthetic compounds have been shown to induce a decrease in circulating TH and a compensatory increase in TSH production in mammals. Thus, by affecting the physiology of the HPT axis these compounds have the potential to alter developmental and cellular functions in vertebrates. To investigate the impact of these pollutants on the HPT axis of non-homeothermic vertebrates we have cloned the thyrotropin-releasing hormone (TSHb) full length cDNA from the freshwater turtle pituitary. TSH is thought to be one of the main regulators of the reptilian thyroid gland. The cloned TSH cDNA exhibits extensive sequence conservation relative to other vertebrate sequences. The elucidation of the TSH cDNA sequence will allow us to develop a real time PCR assay to evaluate the impact of environmental pollutants on the expression of the POMC gene at a high control level of the reptilian HPT axis. In addition, the clone will help us gain an improved understanding of the physiological role of THs in the turtle.

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Embryonic and hatchling metabolism of smooth softshell turtles (*Apalone mutica*)

Elevated metabolic rates of developing embryos and juvenile offspring are considered a result of the cost of growth. Cost of growth includes synthesis of new tissues and metabolism of remaining yolk. Embryonic metabolic rates also increase as a result of rising maintenance costs as embryos grow in size. Metabolic rates of Smooth Softshell Turtle (*Apalone mutica*) eggs and hatchlings were estimated by measuring CO<sub>2</sub> production via open-flow respirometry. Metabolic rates were measured prior to hatching, at hatching, and once every 10 days over a 30-day period after hatching. Repeated-measures analysis shows that *A. mutica* metabolic rates increased to a maximum at hatching, then decreased below pre-hatch levels approximately 30 days after hatching. All terrestrial and aquatic turtle species studied thus far exhibit pre-hatch peak metabolic rates. However, data presented here shows that *A. mutica* undergoes a different pattern of metabolic expenditure. Causes of taxonomic variation in the timing of peak metabolic expenditure in embryonic and hatchling vertebrates are not well understood. In birds, pre-hatch metabolic peaks occur in precocial species that are able to thermoregulate, walk, and feed themselves immediately after hatching. Post-hatch metabolic peaks occur in altricial species that are not able to thermoregulate until several days or weeks after hatching. In reptiles, a pre-hatch metabolic peak is hypothesized to maximize hatching synchrony in variable nest environments. Pre-hatch metabolic peaks also suggest that growth may slow, or that all yolk reserves may be metabolized prior to hatching. Metabolic peaks occurring at or after hatching are hypothesized to occur in species that incubate eggs in uniform nest environments, continue growth-related organization of tissues after hatching, or retain post-hatch yolk reserves that are metabolized with a cost similar to specific dynamic action (SDA).

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Antipredator adaptations for two color morphs of the Eastern Red-backed Salamander, *Plethodon cinereus*

Populations of Eastern Red-backed Salamanders, *Plethodon cinereus*, exhibit color polymorphism. Two color morphs are common: a striped phase that is characterized by a red dorsal stripe and a lead phase bearing a completely black dorsum. Color polymorphism in *Plethodon* is widespread and may result from genetic drift acting on isolated populations or it may be maintained by selection. A recent hypothesis attributes the maintenance of the polymorphism and the geographic distribution of

the color morphs to selection on correlated characters, namely behavior and physiology. It is unclear, however, if differential predation plays a role in this system. A series of laboratory experiments and a field study were conducted to determine whether striped and lead phase salamanders exhibit different antipredator responses and if the forms are preyed upon differentially. To test the hypothesis that red-striped and lead phase color morphs have different skin secretions, we conducted a tongue flick experiment with a common snake predator, *Thamnophis sirtalis*. Snakes were able to distinguish between salamander treatments compared to controls, but were unable to distinguish between the secretions of the two color morphs of *P. cinereus*. In predation trials, the red-striped morph and lead morph responded differently to *T. sirtalis*. Compared to the lead morph, red-striped individuals spent significantly more time in ATR and tended to remain immobile whereas lead phase individuals were significantly more mobile, spending more time walking and in sustained escape than red-striped individuals. In the field, the proportion of red-striped salamanders with autotomized tails was lower than expected by chance while the number of lead phase salamanders with autotomized tails was higher than expected by chance. The results from this study demonstrate that striped and lead phase individuals of *P. cinereus* respond differently to snake predators; these differences may explain differential rates of predation observed between the two forms.

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### Effects of forest clearcutting on spotted salamander migration and dispersal

For vernal-pool-breeding amphibians, conservation laws in eastern North America may be ineffective because the laws preserve the amphibians' wetland, but not upland habitat; though the amphibians spend most of their lives in uplands surrounding their breeding pools. For one such species, spotted salamander (*Ambystoma maculatum*), inadequate understanding of upland habitat requirements, coupled with nocturnal and subterranean behavior, hinder improvement of conservation plans. Furthermore, though spotted salamander survival may depend on metapopulation maintenance, little is known about its inter-patch dispersal mechanisms. Upland buffer zones around vernal pools have been proposed as a management strategy for these amphibians. However, substantial validation of such buffer zones, in the form of experimental upland habitat disturbances, has yet to occur. Specifically, no studies have examined the immediate effects of clearcutting on spotted salamander migration and dispersal. In this study, we used clearcutting to experimentally manipulate upland buffer widths at eleven vernal pools. We then conducted intensive radio tracking, and mark recapture at pitfall traps, to observe effects of clearcutting on spotted salamander movement. Three pools were used as controls; while four pools had a 30-m buffer and four pools had a 100-m buffer, each encircled by a 100-m clearcut. A total of 40 salamanders (21 in 2004, 19 in 2005; 25 females, 15 males) were tracked for an average of 124 days (range: 6 to 270 days).

Mean maximum migration for females was 120m (range: 1.6 to 405m), and for males was 83m (range: 3.9 to 288m). At the clearcut treatment pools, 20% of females and 29% of males successfully crossed the clearcut; and for about 30% of both sexes, their longest stay at a single location was in the clearcut (range of longest stay in clearcut: 30 to 121 days). Results from this study will be used to improve forestry Best Management Practices.

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## **VICTOR, BENJAMIN**

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### The late-stage larvae of Caribbean gobies, eleotrids, and microdesmids: Identification guide and patterns of size and age at settlement

The late-stage larvae of most of the shallow-water genera of Caribbean gobioids are identified from collections in Panama. Most species occur in nearshore waters only at their specific settlement sizes and many specimens have begun transition in body form and markings. The range of settlement size within species is notably narrow; typically plus or minus one or two millimeters. The size and age at settlement vary greatly between species, encompassing much of the range exhibited by all reef fishes. Size at settlement for goby species ranges from around 5 mm SL in *Bathygobius curacao* to almost 30 mm SL for *Sicydium (antillarum)*, with most species settling around 6-10 mm SL. Pelagic larval durations for different gobioid species range from about two weeks to many months. I found notable variation in melanophore patterns within larval types as well as a remarkable range of morphologies and markings in larvae undergoing transition, making identifications from conventional keys and literature difficult. The number of photographs required to describe accurately this variation necessitates a web-based guide I have prepared at [www.coralreeffish.com](http://www.coralreeffish.com). In general, the transition from larval melanophore patterns to juvenile markings begins in a subset of individuals while larvae are still pelagic and continues into the first few days after settlement, thus providing an invaluable missing link for larval identifications. Morphological changes in transitional larvae include marked changes in eye shape, head morphology, and the acquisition of complex patterns of head neuromasts. Most larvae were identified to species by meristics or transitional missing links, however for several genera with numerous similar species (*Lythrypnus spp.*, *Sicydium spp.*, and the cleaner gobies *Elacatinus spp.*), DNA sequence analysis studies are underway or planned.

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Actual status of NOM-029-PESC-2004

In 1997 initiated the workshops of the Technical Group to elaborate the NOM-029 project about the shark fishery regulation in Mexico. After several meetings, in January 12, 2000 this project was published for its public consultation. Nevertheless, due to diverse observations, the final version was not published. Subsequently, in July 12, 2002 was published practically the same version for its public consultation. The main objective of NOM-029 was regulate the shark fishery, but this version did not regulate the fishing areas, neither establish prohibitions, neither regulate the types of hooks and nets, neither establish limits to the incidental catches and neither limit the fishing effort. So, in base to a NOM-029 workshop called by three Commissions of the Senate, one of the Representatives Camera and the government of the state of Baja California Sur, the entrance in vigor of the NOM-029 was abrogated. From then a review process began by the Technical Group, there were carried out diverse workshops about the impact of the fishery on marine mammals and turtles, fishing gears, legislative aspects and shark population status. With the results of these workshops a new NOM-029 project was elaborated and sent to competent Mexican government instances. Nevertheless this project was rejected by pressure of the industrial fishery sector, since the project regulated the type and number of hooks and established prohibition areas for the big boats. It is urgent to regulate the shark fishery in Mexico, since their populations have diminished hardly affecting the fisheries in both oceans.

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**VOGEL, LAURA S.**

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Displacement of a toad species, *Bufo fowleri*, via larval competition with the invasive *B. nebulifer*

Fowler's toad (*Bufo fowleri*) was historically abundant and widespread in various habitats, including urban and agricultural areas, in southern Louisiana. Coincident with intense anthropogenic disturbance, the abundance of the Coastal Plain toad (*B. nebulifer*) has increased significantly in degraded habitats. Subsequently, *B. fowleri* is found only in forested areas near permanent water bodies that are not preferred breeding habitat of *B. nebulifer*. I hypothesized that larval competition with *B. nebulifer*, a species that breeds in extremely ephemeral habitat commonly found in disturbed areas, contributed to *B. fowleri*'s decline. I raised tadpoles in intra- and interspecific competition in artificial ponds under simulated permanent and temporary breeding habitat conditions. Six ponds contained a total of 140 *B. nebulifer* tadpoles per pond, six ponds contained a total of 140 *B. fowleri* tadpoles per pond, and six ponds contained 70 of both tadpole species, totaling 140 tadpoles.

Competition with *B. nebulifer* tadpoles, but not pond drying, resulted in a decrease in body size measures and a lower rate of survival to metamorphosis for *B. fowleri* tadpoles. *B. nebulifer* tadpoles were slightly larger in drying than in permanent ponds, and were larger and had a higher rate of survival to metamorphosis in interspecific tanks than in intraspecific tanks, indicating that it is easier for *B. nebulifer* to outcompete congenetics than conspecifics. At ephemeral breeding sites often found in disturbed habitat, *B. fowleri* tadpoles may be unable to compete for food resources with *B. nebulifer* tadpoles that are likely to be adapted to actively forage and swiftly metamorphose at a larger size. The Coastal Plain toad's superior competitive ability in temporary breeding sites may have resulted in ecological displacement and a decline of regionally sympatric populations of Fowler's toad in degraded landscapes.

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### Impact of directional hybridization between two toad species (Genus: *Bufo*) on the decline of a parental species

Habitat disturbance leading to the breakdown of ecological barriers between sympatric species has resulted in hybridization between numerous plant and animal species, and often contributed to the decline or extinction of one or both parental species. Toads of the genus *Bufo* are known to hybridize where species ranges overlap, although differing habitat requirements generally function as an effective barrier to gene exchange. Despite strong postzygotic selection against it, hybridization occurs between two normally ecologically isolated species, *B. nebulifer* and *B. fowleri*, as a result of anthropogenic habitat alteration. This hybridization is potentially resulting in a decline of the rarer species, *B. fowleri*. Hybrids can be morphologically cryptic; therefore, molecular methods were used to identify them. Single nucleotide polymorphisms (SNPs) are a recent technique utilized to identify hybrids that cannot be conclusively identified by morphological characteristics alone. Twelve species-specific SNPs from a 330 base pair fragment in a nuclear intron of the Rhodopsin gene were used to identify each species, and hybrids were identified based on heterozygosity at these sites. Eighty-one individuals from eight mixed breeding populations were directly sequenced and three male hybrids of *B. nebulifer* and *B. fowleri* were identified. The mating of a *B. nebulifer* male and a *B. fowleri* female produced two of the hybrids. The reciprocal cross, widely thought to be inviable, resulted in the other hybrid. Although hybrids represent a relatively low segment of the sample population, directional hybridization of male *B. nebulifer* with female *B. fowleri*, as demonstrated by previous research, may be a historical factor in the decline of *B. fowleri*. Furthermore, infertile male hybrids have been shown to preferentially mate with *B. fowleri* females, potentially causing a devastating loss of reproductive effort in females of that species.

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Satellite transmitters are tracking *Podocnemis expansa* to their non-nesting habitat in the Rio Trombetas, Brazil

*Podocnemis expansa* is listed as NR conservation dependent by the IUCN because of the continued effort Brazil has made towards the conservation of this species at the nesting beaches. This has worked in many areas where the nesting populations have increased or at least remained stable. This is not the case in the Trombetas River where populations have crashed from 8000 in 1976, to 850 in 1989, to less than 200 in 2003. IBAMA has requested that this population be listed as Critically Endangered because of the recent rapid decline. During 1989-1996 we were able to show through the use of VHF transmitters that the turtles nesting in the Trombetas Reserve leave the reserve after the nesting season, but we were not able to determine where they went. In November 2005 we attached both VHF and satellite transmitters to 10 post nesting females to determine where they migrate after the nesting season and to discover if the ships used in transporting bauxite may be frightening the turtles away from the river. In addition to this we want to find out where the turtles actually go when they leave the river and how long they remain in other habitats. The project is a success we are documenting the movements and microhabitat use by 9 of the tagged females. After 4 months the turtles are all still within the reserve, some have migrated 65 km downstream, others have taken up residence in the large lakes. Some have been found foraging in 1.5 m of water with temperatures of 43 C. Habitat use and home ranges as well as migration rates and distances will be presented. The limitations of satellite transmitters for tracking freshwater turtles will be discussed.

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The effect of toe-clipping on two species of treefrogs in Florida

Accurately estimating vital rates of populations is critical for management and conservation of amphibians. Estimation of survival requires unique marks for individuals, but efficient, low-cost marking methods for small treefrogs are limited to toe clipping. In the Everglades of southern Florida we marked green treefrogs (*Hyla cinerea*) and squirrel treefrogs (*Hyla squirella*) in unique toe-clip patterns of 2, 3, or 4 toes. Subsequently, we performed survival analyses on capture-recapture data using

Cormack-Jolly-Seber open population models to estimate both apparent survival and recapture probability. Our objective was to determine if there was an effect of the number of toes removed on survival of individuals. There was a significant toe-clip group effect for green treefrogs. Individuals with 4 toes removed had a 7.2% lower average monthly survival compared to those with 2 toes removed, but there was no significant difference in survival between green treefrogs with 2 and 3 toes removed. Power analysis indicated that there was a 95.6% probability of detecting the 7.2% decrease in survival with the sample size of this study (n=1296), and 98.4% probability of detecting an average monthly decrease in survival of 10% per toe. No significant toe-clip effect was found for squirrel treefrogs. Power analysis indicated that it would require a four-fold increase in our sample size of squirrel treefrogs to detect a 5% decrease in average monthly survival per toe removed with a probability of 97.8%, but the sample size of the study (n=712) was adequate to detect a 10% decrease per toe. Other studies have found effects of 4-11% decrease in return rate per toe removed. Studies that use return rates to estimate survival assume that recapture rates are constant, but the best model of recapture probability for both species in this study allowed recapture probability to vary with time. We caution against an approach based on return rates alone.

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Is the Desert Tortoise of the Mojave Desert a keystone species in an old-growth ecosystem?

The concepts of keystone species and old-growth ecosystems have been widely used in the past few decades, so much so that a clear understanding of them has faded away. However, the management implications for both concepts are tremendous, thus an understanding of definitions is necessary. Keystone species are ones that play dominant roles in an ecosystem and affect many other organisms; they can be predators, herbivores, or habitat modifiers. However, the title *keystone species* in most cases does not apply to all members throughout the species range but rather its functional role in a particular community assemblage. Examples of keystone species include the ochre sea star, sea otters, beavers, and gopher tortoises. We will present a case study of the gopher tortoise as a keystone species and compare it to results from our research on desert tortoises. Old-growth is a definition that was developed for forested systems and as such is not traditionally applied to desert ecosystems. However, key features are present in all definitions of old-growth that can be applied to desert ecosystems. These include: large long-lived species, the tendency for dominant species to have complex crown structures, mixed aged stands, sensitivity to fire, and minimal signs of human disturbance. They also tend to provide habitat for plants and animal species that either do not occur in younger stands, or occur less abundantly. We will make a comparison of these old-growth features to creosote

bush scrub. We will then present data from a study on microhabitat selection by the desert tortoise to show that they are highly selective of habitat, selecting large shrubs, primarily large creosote bush. Results from this research, although preliminary and from a localized area, support the statement that in the Mojave Desert the desert tortoise is a keystone species in an old-growth ecosystem.

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Habitat specificity and home-range size as attributes of species vulnerability to extinction: A case study using sympatric rattlesnakes

Ecologically similar, closely related, sympatric species can be used to test the role of ecological attributes in determining species vulnerability. Large home-range size and habitat specificity are two commonly cited ecological attributes that are believed to contribute to species vulnerability. The eastern diamondback rattlesnake (*Crotalus adamanteus*) is a declining species that occurs sympatrically with the more abundant canebrake rattlesnake (*C. horridus*) in a portion of the southeastern Coastal Plain, USA. In this study, ecological similarities of the two species were used as experimental controls to test the role of home-range size and habitat specificity in the imperilment of the eastern diamondback rattlesnake. Analysis of variance was used to investigate differences in home-range size between the two species, and home range selection was modeled as habitat use versus availability with a case control sampling design using logistic regression. We failed to detect differences in home-range size between the two species; therefore, we could not identify home-range size as an attribute contributing to the imperilment of eastern diamondback rattlesnakes. However, eastern diamondback rattlesnakes selected pine savannas to a degree that suggests that the species is a habitat specialist. Of the two factors affecting species vulnerability, habitat specificity to the imperiled longleaf pine ecosystem may be a significant contributor to the decline of the eastern diamondback rattlesnake.

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Phenotypic distribution of *Nerodia erythrogaster* in extreme southern Illinois, western Kentucky, and adjacent western Tennessee (USA)

To investigate anecdotal range distributions for *Nerodia erythrogaster*, 130 adult specimens from southern Illinois, western Kentucky, and adjacent western Tennessee were scored for ventral color and dorsal pigment invasion onto the ventral scales. Analysis of these characters suggests that true *Nerodia erythrogaster flavigaster* populations do not occur in Kentucky and may be absent from Tennessee as well. The region is instead dominated by morphs intermediate between *Nerodia*

*erythrogaster flavigaster* and *Nerodia erythrogaster neglecta*. Furthermore, the range of *Nerodia erythrogaster neglecta* should be extended along the Ohio and Cumberland Rivers.

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Effects of parturition and feeding on thermal preference of Atlantic stingray, *Dasyatis sabina* (Lesueur)

Temperature is the most important and least well documented environmental entity affecting reproduction and feeding of elasmobranch fishes, but it is unclear to what extent these fish may exploit behavioral thermoregulation to optimize metabolic processes. Laboratory thermal preference determinations are important for understanding behavioral processes because they provide the vital quantitative link between environment, physiology, and adaptive behavior. Temperature preference data were collected on Atlantic stingrays, *Dasyatis sabina* (Lesueur), to assess the fish's ability to behaviorally optimize feeding and reproduction. Trials were run in a temperature preference chamber comprised of a small vertical thermal gradient suspended in a layer of oil. Groups of 10 and 15 pregnant female Atlantic stingrays exhibited significantly higher preferred median temperatures (26.2 and 26.1°C, respectively) than non-pregnant females (25.3°C) (one-way ANOVA on ranked data;  $F_{(2,77)} = 7.1$ ;  $df=29$ ;  $P=0.038$ ). Median preferred temperatures in unfed stingrays of both genders ranged from 24.5 to 31.0 °C, whereas, fed fish preferred temperatures between 23.5 to 27.5 °C. Unfed stingrays preferred a median temperature of 24.5 °C; however, after feeding fish preferred significantly warmer water temperatures of 25.7 °C (Wilcoxon one-tailed, matched-pairs, signed ranked analysis;  $P<0.088$ ). While overall differences were subtle, small preference adjustments can have important physiological consequences. For example, the 1°C increase pregnant females over non-pregnant fish would reduce gestation time by as much as two weeks. Likewise, by moving to cooler water after feeding, stingrays may increase nutrient uptake efficiency by reducing evacuation rates. Our data indicated that movement and distribution of Atlantic stingrays are dictated, in part, by temperature effects on physiology.

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### Relationship between anuran species richness and the composition of bottomland hardwood forests

Development of conservation strategies for pond-breeding amphibians relies on a fundamental understanding of the habitat and landscape-scale characteristics associated with populations. As part of USGS's Amphibian Research and Monitoring Initiative (ARMI), we monitored 40 roadside sites in the Atchafalaya Basin, Louisiana, for calling anurans and quantified the overstory vegetation adjacent to 19 of those sites. A total of 12 species of anurans varied in occupying from 26-100% of the sites. Stepwise multiple regression indicated that values of tree dominance have a significant positive relationship with overall anuran species richness. Hydroperiod has a strong influence on site occupancy by amphibians, and is also known to influence dominance in communities of overstory trees in floodplain areas. This relationship between hydroperiod and dominance explains, in part, the observed relationship between overstory dominance and anuran species richness. We suggest that estimates of dominance in the overstory vegetation may be a good surrogate for hydroperiod in situations in which direct measurement is not feasible. Our data suggest that heterogenous, mixed-species forests with low dominance promote the highest species richness of anuran amphibians. Thus, species' dominance is an important habitat variable to consider in designing management plans for amphibian populations.

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### The role of individual variability on consumption rates of captive juvenile winter flounder, *Pseudopleuronectes americanus*

Details about the feeding of an organism may be critical to understanding its growth and survival. Although important, individual variation in consumption rates is often overlooked. We studied consumption rate in laboratory-reared juvenile winter flounder, *Pseudopleuronectes americanus*, by conducting a series of input-output trials using a range of sizes of recently settled winter flounder (7 to 30 mm TL). Individual winter flounder were introduced into a 14-cm diameter arena, offered a known number of *Artemia* nauplii (2.5 per ml), and allowed to feed for 2 hr. The number of live *Artemia* remaining after 2 hr were preserved and counted. The number of *Artemia*

consumed by the flounder increased linearly with flounder body size, especially in smaller juveniles ( $R^2 = 0.3$  for flounder  $< 16$  mm TL). Above 16 mm TL, no significant relationship was found between the number of *Artemia* consumed and flounder size. We evaluated the intra-individual component of variability in number of *Artemia* consumed by running two trials on the same individuals over multiple days and found repeatability to be very high ( $R^2 = 0.8$ ). We also repeated the 2-hr trials on a subset of individuals after 14 and 28 days. Repeatability remained high throughout these trials. Thus, variability in the number of *Artemia* consumed was partly due to flounder size for recently settled fish but the major portion of the variation was due to individual differences other than body size. Moreover, individual consumption rates were directly related to growth rate in the short term. Although the source(s) of differences in consumption rates among individuals is unknown, and the environmental conditions in these trials did not vary, the high level of intra-individual repeatability means that individual fish feed at a consistent rate, and that these rates are predictive of growth and perhaps survival.

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**Population responses of wood frog (*Rana sylvatica*) tadpoles to overwintered bullfrog (*R. catesbeiana*) tadpoles**

In temperate latitudes, the larval stage of bullfrogs typically lasts two years to complete metamorphosis. As such, ephemeral ponds in these latitudes are not suitable breeding sites for bullfrogs. Other amphibian species having shorter larval periods might breed successfully in both permanent and ephemeral ponds. Larvae in ephemeral ponds, therefore, experience a different community structure than those larvae of the same species in permanent ponds where bullfrogs might also be present. We examined the population responses of sympatric wood frogs tadpoles to native overwintered bullfrog tadpoles. The presence of an overwintered bullfrog tadpole had a negative effect on the growth of wood frog tadpoles allotopic (naïve) to bullfrogs, whereas the presence of bullfrogs had no effect on growth of syntopic (experienced) wood frog tadpoles. There were also differential behavioral responses of the wood frog populations to overwintered bullfrog tadpole visual and chemical cues. Only allotopic wood frog tadpoles decreased activity levels and increased use of refugia in the presence of overwintered bullfrog tadpoles. These observations indicate that overwintered bullfrog tadpoles might exert a selective pressure on other sympatric amphibians, and that bullfrog establishment within its native range might have negative consequences on larval dynamics of other amphibian species.

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### Passive acoustic evaluation of red tide effects on sand seatrout spawning

Sand seatrout, *Cynoscion arenarius*, is an estuarine sciaenid with a protracted summer spawning season generally beginning in March and ending in late October. Mature male sand seatrout generate courtship calls in the crepuscular and evening periods during the spawning season. Underwater microphones, or hydrophones, can be used to detect these courtship calls and locate spawning sites. During the 2004 and 2005 sand seatrout spawning seasons a mobile hydrophone survey was conducted in Tampa Bay to assess the frequency and location of sand seatrout spawning aggregations. Sampling stations were selected in the lower and middle portions of Tampa Bay using a stratified random sampling design with sampling occurring between April-October in both 2004 and 2005. During 2004, 610 stations were sampled with sand seatrout spawning occurring at 44% of stations. Aggregations were consistently detected during the 2004 season with no significant monthly variation. Aggregation detection drastically declined in 2005 to only 28% of stations (n=624) containing aggregations. Monthly detection of aggregations varied significantly during the 2005 spawning season with a pronounced decline after June. The annual variation in spawning between 2004 and 2005 as well as the monthly variations observed in 2005 are likely attributable to a large and persistent red tide bloom (*Karenia brevis*) that inhabited the Tampa Bay area. Although the bloom began in spring 2005, middle and lower Tampa Bay experienced elevated cell counts as well as massive fish mortalities starting in late June and continuing throughout the summer, paralleling the decline in sand seatrout spawning. Typically, red tide effects on finfish are limited to observing and counting mortalities. However, this two year study comparing a normal spawning season to a season where spawning habitat health has been compromised demonstrates how passive acoustics may be used as an additional tool to evaluate red tide impacts on a fishery.

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### **WALTON, ELIZABETH M.**

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### Using remote sensing and geographic information science to predict habitat for the Bog Turtle, (*Glyptemys muhlenbergii*)

The southern population of the bog turtle, (*Glyptemys muhlenbergii*), was listed with the US Fish and Wildlife Service as "threatened due to similarity of appearance" in 1997. Status surveys are on-going for the southern population, yet the current methodology for locating new populations is labor intensive and fiscally exhaustive. Remote sensing offers the opportunity to use known parameters to discover additional habitats that are similar in biological composition and environmental

conditions. Using multispectral bands, a "fingerprint" of the exact biological and environmental assemblages can be used to find other habitat areas that have the same fingerprint. Furthermore, remotely sensed imagery and associated data can be read and interpreted in the convenience of an office, reserving field investigation time and financial resources for sites that have a high predictive success rate. The purpose of this paper was to determine whether publicly available data, in the form of satellite imagery and digital aerial photographs, could be analyzed to identify additional or potential bog turtle wetland habitat sites. A subset of a Landsat 7 ETM+ image and digital color infrared aerial photographs were used for a portion of Ashe County, North Carolina where the wetlands occurred. The results of this study indicate that publicly available data may not be suitable for detecting small, isolated wetlands across the landscape due to heterogeneous landscape features, low spatial resolution of the images, and inherent poor quality of some of the images. However, in some areas the digital imagery was of high quality, high spectral/temporal resolution, making it possible to define spectral signatures for these wetlands. These GISc technologies can be calibrated for specific criteria and used for other turtle species, thereby enhancing conservation resources, reducing investigative field search efforts and affording turtle species the protection required to assist in their future survival.

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### Salamanders in forest-floor food webs: Plethodontid salamanders exert strong influence on invertebrate species composition

Terrestrial salamanders are hypothesized to play an important role in the regulation of forest-floor invertebrate communities of temperate North America, but few studies have quantified these effects experimentally. We investigated the role of the red-backed salamander, *Plethodon cinereus*, within forest-floor food webs using field experiments with both open-plot and enclosure designs. The objectives of this work were to characterize the importance of salamanders for shaping species composition of forest-floor communities, and to identify the principal taxa and trophic channels influenced by salamanders. During a long-term field experiment in open-plots, salamanders have been associated with significant reductions in density (>30%) of major mesofaunal taxa, e.g., Collembola and Acari, in comparison to habitat patches unoccupied by salamanders, and the magnitude of mesofaunal suppression increased with salamander density within plots. However, the strength of salamander effects is greatest during periods with high leaf-litter thickness and favorable salamander foraging conditions. Salamanders have had no effect on the density of macrofauna, e.g., spiders, centipedes, beetles, ants, etc. A short-term study within field enclosures also indicated that salamanders suppressed mesofauna, but not macrofauna, and that the negative effect of salamander predation on mesofauna was greater than the effect of large competitors, i.e., isopods, of mesofaunal detritivores. These results suggest that *P. cinereus* exerts top-down effects principally

through mesofaunal trophic channels, and that the strength of these effects can be similar to or greater than that of other forces shaping mesofaunal communities (e.g., competition).

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### Patterning of the abdominal viscera in Polypteriformes

Highly elongate body forms have evolved multiple times independently within Actinopterygii. Axial elongation in ray-finned fishes occurs via the addition of abdominal vertebrae, the addition of caudal vertebrae, or through a lengthening of the vertebral centra. *Erpetoichthys calabaricus*, a member of Polypteriformes, has twice as many abdominal vertebrae as its sister genus, *Polypterus*. Most work on anterior-posterior patterning has focused on the vertebral column. In this study, we examined anterior-posterior patterning of the viscera in *Polypterus senegalensis*, *Polypterus palmas*, and *Erpetoichthys calabaricus*. We recorded the anterior and posterior positions of individual visceral organs relative to both percent total length and vertebral number to determine whether the organs were relatively longer and covered more segments, or whether the organs were patterned differently in *Polypterus* and *Erpetoichthys*. In addition, we examined whether there were differences between males and females within the same species. We found that abdominal elongation involves both lengthening of some organs, as well as changes in the segmental positions of others. The results of this study provide a basic understanding of the anterior-posterior patterning of the viscera in Polypteriformes, and how changes occur when the number of abdominal segments is increased. In the future this work will be extended to investigate the visceral topography of other abdominally-elongate lineages of vertebrates.

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### Prey selection in early life stages of *Semotilus Atromaculatus* (Creek Chub) in a small Ohio stream

In most ecosystems fish species switch their diet as they undergo development from larval to juvenile stages. During the course of development the ability to ingest a larger prey item could be due to morphological changes, such as the gape size, ossification of cranial elements, fin development or greater functionality of the sensory system. Past studies of feeding behavior have focused on European cyprinids, while North American cyprinids have not been studied extensively. In this study, feeding behavior of larvae through early juvenile stages of *Semotilus*

*atromaculatus* was examined. Fish were collected from Doan Brook, an urbanized stream located in Cuyahoga County, Ohio. Doan Brook has a very limited food base consisting largely of chironomids. The gut contents of 132 specimens were analyzed and prey items measured. Chironomids appeared in the gut of early larvae and continued to be the main food source with increased size. It appears that fish around 9.7mm standard length switch to significantly larger sizes of chironomids. Another switch to even larger sizes of chironomids appeared around 14.8mm standard length. Using ANOVA, there was a significant difference in size of the largest chironomids ingested among fish of different sizes. The degree of cranial ossification and fin development were further examined using 25 cleared and double stained specimens to determine if, in fact, there exists a correlation between these factors and shift in prey item size. Ossification is nearly complete in key cranial bones, the maxilla, premaxilla, dentary, pharyngeal arch, and opercle, near 9.7mm standard length, the size where fish are able to utilize larger prey. Fin development appears to correlate to some degree with the switch in prey item size. The results suggest that ossification of cranial elements along with fin development plays an important role in prey capture of larval fish.

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**Decline in yellow stingray (*Urobatus jamaicensis*) in the Florida Keys National Marine Sanctuary, USA**

The 'common' elasmobranch species *Urobatus jamaicensis* (yellow stingray) has undergone a steady decline in the Florida Keys National Marine Sanctuary (FKNMS), USA. The yellow stingray is one of the smallest and most common elasmobranch species in the Caribbean. It is considered a good tropical fish for personal/commercial aquariums and is often used for scientific experiments. Currently, no permit is required for extracting *U. jamaicensis*, and only sold extractions are reported. This study analyzed temporal trends and environmental preferences of the yellow stingray in the FKNMS as recorded by trained volunteer divers using the Roving Diver Technique. Data were obtained from Reef Environmental Education Foundation (REEF) Fish Survey Project. Experienced divers in the FKNMS were interviewed about their impression of the yellow stingray to determine if the decline was detected. Included in this study were 10 different habitat types, depths from 0-37 m, and surface temperatures from 15-35°C. A generalized linear model on presence-absence data with a binomial distribution and logit link was used to estimate the change in *U. jamaicensis* by year. Habitat type, depth, site, average temperature, and Julian date were included in the model to standardize the data. A total of 15639 surveys conducted at 388 sites throughout the FKNMS were used. *U. jamaicensis* was seen on 2502 dives in FKNMS (16%). The decline in sighting frequency has occurred in all habitat types, depths, sites, and

regions of the FKNMS. *U. jamaicensis* sightings declined from 32.1% SF (425 sightings in 1326 surveys) in 1994 to 8.5% SF (93 sightings in 1093 surveys) in 2005, averaging <18% decline per year. Preliminary analysis indicates that the decline in yellow stingrays is consistent in other areas of the Caribbean. The decline has gone virtually unnoticed. This study highlights the importance and use of trained volunteer divers for monitoring elasmobranchs.

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Timing of vibration-cued hatching in red-eyed treefrogs: How much information is enough to assess predation risk?

The arboreal eggs of red-eyed treefrogs, *Agalychnis callidryas*, hatch rapidly and up to 30% early in attacks by egg-eating snakes and wasps. They escape by falling into the water, where they face new predators; thus when to hatch is a behavioral decision balancing two risks. Physical disturbance of the clutch plays a key role in predator-induced hatching and, in playback experiments, vibrational cues from snakes are sufficient to induce hatching. However, egg clutches are also subject to vibrations from benign sources. Embryos should not, and do not, hatch in response to all vibrational disturbances. Embryos use both frequency characteristics and temporal pattern (duration and spacing) of vibrations in their hatching decision. Assessing temporal pattern requires a period of sampling and, since neither benign natural disturbances nor predator attacks are stereotyped signals, several cycles may be necessary to distinguish between them. We used playback experiments to examine the time course of hatching in response to synthetic vibration stimuli that elicited similar overall levels of hatching and were matched for duty cycle, but varied in cycle length (1.1-11 sec). The mean onset of hatching varied from 25 to 75 sec into the playback across stimuli. Embryos started hatching sooner, and the peak of hatching was earlier, in response to stimuli with shorter cycles. However, embryos sampled fewer cycles of long-cycle stimuli before initiating hatching, compared with short-cycle stimuli (range 7-23 cycles). Information, and thus certainty about the level of risk, should accumulate with cycles of the vibrational pattern. In contrast actual risk, or the cost of gathering information, accrues as eggs are consumed over time. The variation in the amount of information required to initiate hatching in response to different patterns of disturbance may reflect a trade-off between the value of additional information and the cost of information acquisition.

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### Habitat use and reproduction of the Desert Massasauga Rattlesnake in Colorado

The Massasauga Rattlesnake is a diminutive species with a distribution in the United States which largely tracks the retreat of Pleistocene glaciation and the spread of grasslands. It is found in a variety of habitats, including arid grasslands in Colorado. We have monitored several metapopulations of Desert Massasaugas (*Sistrurus catenatus edwardsii*) in Colorado over the last ten years and have conducted radiotelemetry on one population in SE Colorado. Massasaugas were most active between 14 and 30 C, with an average ambient temperature during activity of 22 C. In the spring, snakes make long distance movements (up to 2 km) from the hibernaculum (shortgrass, compacted clay soils) to summer foraging areas (mixed grass/sandsage, sand hills). Summer activity is characterized by short distance movements, and snakes are most often observed at the base of sandsage in ambush or resting coils. Snakes showed a seasonally-dependent shift from primarily crepuscular/diurnal to nocturnal movement patterns. Massasaugas in Colorado gave birth to five-seven young in late August, and reproduction appears to be biennial. Observations on three radioed gravid females suggested that Desert Massasaugas show maternal attendance until the first neonatal shed. Snakes returned to the hibernaculum area in October and appear to hibernate individually in rodent burrows; however, the immediate region is utilized by several other species of snakes, particularly Prairie Rattlesnakes (*Crotalus viridis viridis*), and we believe this area is exceptionally important as a winter refuge for numerous snake species. Population size of *S. c. edwardsii* in Colorado appears to be quite large based on total number of captures and low recapture rates. At present, the main metapopulations occur far from developing regions in the state, and they appear to be stable. However, due to habitat loss and fragmentation resulting from agricultural expansion and urbanization, these populations will become increasingly threatened in the future.

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### A re-examination of diversity patterns of South American herpetofaunas using multivariate statistical approaches

We studied patterns of species richness and composition of the herpetofauna at 67 sites representing seven biogeographic regions in South America: Amazonia, Atlantic Forest, Caatinga, Cerrado, Chaco, Guayana, and the Llanos. We acquired the most data for frogs and snakes, so we used those taxa to make comparisons between

taxonomic groups and across regions. Alpha diversity of frogs was highest in Amazonia, followed by Guayana and the Atlantic Forest. Snake richness was highest in Guayana, and slightly lower in the Cerrado and Amazon. Across all sites, alpha diversity of frogs and snakes was correlated, but this was not the case within any of the biogeographic regions. Analysis of species composition revealed that most of the biogeographic regions included were faunistically distinct, but snake species composition did not differ between Chaco and Cerrado or Amazonia and Guayana. Compositional dissimilarity among regions was greater for frogs than for snakes, a pattern likely attributable to the observation that snakes occupy a greater fraction of available sites than frogs. The correlation between compositional similarity and geographic distance (a metric of beta diversity) was stronger for frogs than for snakes, though it is not clear if this represents biological reality or sampling bias. Species composition was least correlated with distance in Atlantic Forest, indicating particularly high levels of beta diversity in that region. We modeled species richness as a function of five variables: annual rainfall, distance of a site from the geographic center of the region, latitude, longitude, and the ratio of amphibians : reptiles ( a metric of the community saturation of the two groups). In order of importance, richness of amphibians was best predicted by longitude, distance from center of the region, rainfall, and the amphibian: reptile ratio. For snakes, richness was predicted by the amphibian: reptile ratio and rainfall.

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### Species richness and composition of amphibians and reptiles on isolated tabletop mountains of the Guayana Shield

Tepuis are isolated tabletop mountains of the Guayana Shield in northern South America. Here we investigate patterns of species richness and composition of the herpetofauna of Pantepui (the informal biogeographic province representing tepui summits) from the perspective of island biogeography. We describe the relationship between species richness, area, and five measures of isolation (elevation, summit-slope ratio, nearest neighbor distance, distance to nearest larger tepui, and straight-line distance from the Andes), as well as patterns of faunal nestedness. Because the Pantepui biota is characterized by high levels of endemism, we also describe associations between endemism, area and isolation. We present results from across Pantepui and within eastern, northern, western, and southern subdistricts. Elevation and area were the two variables that best explained species richness of both reptiles and amphibians across Pantepui. Nestedness was significant for amphibians but not reptiles in Pantepui, and amphibian nestedness was best explained by distance from the Andes and elevation. There was a decrease in nestedness from east to west, resulting from an increase in endemism along the same gradient. This increase in endemism was very closely associated with an increase in summit-slope ratios along the same geographic gradient. Thus, high levels of endemism in the western

subdistrict are ascribed to the fact that western tepuis are characterized by relatively steep slopes and sheer cliffs that effectively isolate them from the lowlands and other tepuis, providing a fertile ground for evolution of endemic taxa.

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**Optimal foraging behavior and diet overlap in two ambush predators in southeastern Arizona: *Sceloporus jarrovi* and *Sceloporus virgatus***

Optimal foraging theory states that given a diverse selection in prey choice, predators will minimize energy capturing prey to maximize energy intake over time. Whether or not to consume a particular prey item is also affected by the abundance of prey with greater nutritional value. Thus, an optimally foraging predator must be capable of determining nutritional value of its various prey, as well as their relative abundances. Both *Sceloporus jarrovi* and *Sceloporus virgatus* are sit-and-wait insectivorous lizards common to southeastern Arizona. In order to ascertain prey choice and the level of optimality exhibited in these two species, I observed the predatory behaviors of two age classes of *S. jarrovi* (adult and neonate) and adult *S. virgatus*, while sampling for insect abundance. In addition, I sampled stomach contents of the same lizard groups to determine total diet composition. Average profitability per lizard diet was highest for *S. jarrovi* adults, followed by *S. virgatus* adults and *S. jarrovi* neonates. Stomach contents showed that the dominant food item for all these lizard groups were the Hymenopteran ants; though their profitability is low, the ants are readily available in high quantities in the environment. Those items that were most profitable (Odonata, Orthoptera, and Lepidopteran adults and larvae) made up 5 percent or less of the diet, likely due to their decreased availability. These data indicate that although the adults of the two species are foraging more profitably than the neonates, all lizards are primarily feeding on those prey items that are readily available, because the more profitable items are rare; this is consistent with optimal foraging theory. There was also high diet overlap between the three lizard groups, indicating that competition for food may not be a factor, due either to an adequate prey base or low lizard population densities.

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**Reproductive biology of an invasive species, the Brown Tree Snake (*Boiga irregularis*)**

The brown tree snake (*Boiga irregularis*) was accidentally brought to the island of Guam and quickly became established throughout the island. This introduction has resulted in the loss of many native species and has had a large economic impact on the island. Of particular concern is that the snakes will also become established in

other locations, especially Hawaii. Although this population has been monitored and managed for over twenty years, the reproductive cycle of brown tree snakes on Guam has yet to be described. Preliminary data suggest that males with mature sperm can be found all year on Guam, but the proportion of males that are undergoing active spermiation varies seasonally. Previous research has found that few snakes of reproductive size (reproductively competent) are actually reproductively active. Most individuals have very low levels of plasma sex steroids and snakes from Guam also have higher levels of the stress hormone corticosterone than those from the native range or in captivity. Brown tree snakes on Guam also have a significantly lower body composition index (the residual from the linear regression of mass on snout-vent length) than captive brown tree snakes or those from Australia. It is possible that reproductively competent adult snakes are unable to find enough food to maintain body condition, so the majority of them are not reproductively active during any given season. We manipulated the diet of captive snakes on Guam to explore the effects of food intake on sex steroid and corticosterone production, with the hypothesis that the *high food* group would show an increase in sex steroids and a decrease in corticosterone when compared to the *low food* group. A better understanding of the reproductive cycle and constraints of this species will aid in management efforts on Guam.

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### Behavioral evidence for magnetoreception in the red-sided garter snake

Long-distance migrations between seasonal habitats and successful return following displacement have been considered evidence that snakes are able to navigate over long distances. However, the means by which they navigate have been little explored. Some studies have found evidence for celestial cues (position of the sun or polarized light) while others point to visual cues (landmark recognition) as mechanisms of navigation. Sea turtles and alligators orient using the earth's magnetic field, but as far as we know this has never been tested in snakes. To examine whether garter snakes respond to magnetic cues, we collected male red-sided garter snakes (*Thamnophis sirtalis parietalis*) from the Interlake region of Manitoba, Canada, in May 2005 and transported them southwest to Corvallis, Oregon to create a long distance displacement. We then video-recorded baseline directional preferences of these snakes in a circular arena. The snakes were later retested with either a small, strong magnet or an equivalent-mass brass weight attached to the head. The mean angle of dispersal of the control (brass weight) group did not differ significantly from that of the baseline (no weight or magnet) group, while the mean angle of the magnet group was significantly different from the baseline mean angle. These results imply that *T.s.parietalis* can detect magnetic fields and therefore may use them in their long-distance migrations back to den sites in the fall; future research will involve similar experiments conducted in the field.

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Diet of the Northern Pacific Rattlesnake (*Crotalus oreganus oreganus*) within the Yakima River Canyon of Washington State

I investigated the diet of a population of the Northern Pacific Rattlesnake (*Crotalus oreganus oreganus*) in Washington state. A total of 122 prey items was identified from 420 snakes collected as either dead-on-road (DOR) or alive-on-road (AOR) from May through October 2003-2005. Snakes were measured, weighed and placed into three size classes; <30 cm, 30-60 cm, and >60 cm. The stomachs and intestinal tracts of DOR snakes (n = 384) were examined for prey items and fecal material. The stomachs of all AOR snakes (n = 36) were palpated to collect any prey items, which were identified to the lowest taxonomic level, weighed and preserved. Small mammals (e.g. deer mice (*Peromyscus maniculatus*) Great Basin pocket mice (*Perognathus parvus*) and voles (*Microtus* spp.)) were the most frequent prey item in the diet (74 %) followed by lizards (20 %) and birds (6%). Predator-prey mass ratios ranged from 0.02-0.94. Larger snakes did not necessarily ingest larger prey items, but do have a more diverse diet. Diet was independent of sex, but not size class. Snakes contained multiple prey items (2-6) from April to June, but rarely later in the season. In addition, we compare our data with other populations of *C. o. oreganus* in the Pacific Northwest.

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**\*WEAVER, ROBERT E.; DARDA, DAVID M.**

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Comparative ecology of the Ring-neck snake (*Diadophis punctatus*) and Sharp-tailed snake (*Contia tenuis*) in Washington State

We investigated the ecology of two secretive species of Pacific Northwest snakes, the Ring-neck (*Diadophis punctatus*) and the Sharp-tailed Snake (*Contia tenuis*). A total of 135 snakes were collected from April-October 2002-2005 from three counties (Kittitas, Klickitat, and Yakima). Forty-five specimens of *D. punctatus* were collected within Oregon white oak (*Quercus garryana*) savannah, and along riparian zones in the shrub steppe zone, an area characterized by big sage (*Artemisia tridentata*) and rabbitbrush (*Chrysothalmus* spp.) shrubs. Specimens were active from 1200-1500 h in April and May, and September, at air temperatures of 18-23°C. Extensive surveying was conducted at night, with no specimens observed. Prey items of adults included Western Skinks (*Eumeces skiltonianus*) and small Gartersnakes (*Thamnophis* spp.). Limited data indicates the diet of juveniles and hatchlings are earthworms and insect larvae. Reproductive data showed female *D. punctatus* to have enlarged follicles or ova from May to June, with hatchling specimens collected in August and September. Eighty specimens of *C. tenuis* were collected from March-October. Unlike *D. punctatus*, specimens were collected during the day (0900-1600 h) and at night (2000-

0300 h), and at a wider range of air temperatures (10-32°C). Anecdotal reports indicate that *C. tenuis* is active on the surface after rain fall. However, during this study several specimens were collected on the surface during the hottest, driest times of the year. Like *D. punctatus*, specimens of *C. tenuis* were collected within the shrub-steppe zone, but also within dense coniferous forests, and many areas of human disturbance (agricultural, residential, and commercial areas). Female *C. tenuis* with enlarged follicles or ova were collected from April-July, with hatchlings collected Sept-Oct. Unfortunately no prey items were collected from specimens *C. tenuis*. Our study shows *C. tenuis* to more abundant and widespread. However, *D. punctatus* is less abundant, and restricted in terms of distribution and habitat preference.

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**WELLS, R.J. DAVID**

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**Habitat use and the effects of trawling on fish and invertebrate communities on the northern Gulf of Mexico continental shelf**

Habitat disturbance from trawling is a major threat to marine biodiversity that destroys critical biogenic and sedimentary habitat structure for benthic species. The Gulf of Mexico trawl fishery targets shrimp in soft-sediment habitat that is assumed to be of low structural and species diversity; however, trawling is not confined solely to soft-sediments, but rather to a suite of different habitat types. The goals of this study were both to characterize habitat use patterns of fish and invertebrate communities and to assess the effects of trawling on these communities and their associated habitats over sand, shell-rubble, and natural hard bottom reef substrates. Quarterly trawl surveys were conducted over a two year period to quantify fish and invertebrate habitat use patterns in conjunction with concomitant remote operated vehicle (ROV) transects used to quantify habitat characteristics. Results of the habitat characteristics and their influence on the biotic community will be discussed. Fish and invertebrate communities showed distinct differences among habitat types and with respect to trawling exposure. The total number of species and the total number of individuals were highest over non-trawled sand habitat; however, both evenness and diversity were highest on non-trawled shell-rubble habitat. Length-frequency distributions on the most influential fish species characterizing the communities indicated a truncated size distribution over trawled habitats when compared to similar non-trawled habitat type. This study demonstrated habitat-specific differences in the community structure and highlighted the anthropogenic impacts that trawling has on the biological community and the associated habitat.

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### The Status of *Etheostoma osburni* (Candy Darter) in West Virginia

*Etheostoma osburni* is endemic to the upper Kanawha River system of West Virginia and Virginia. It inhabits cool to warm waters of small streams to medium sized rivers in the Ridge and Valley Province of Virginia and West Virginia, and the Appalachian Plateau of West Virginia. Due to extirpations and/or low numbers at certain sites and a lack of recent data, conservation documents have listed this fish as a species of concern in both states and consequently, at the federal level. In 1991, a survey to determine the abundance of candy darters at historic locations in the Monongahela National Forest suggested that West Virginia's population was declining. In response to this limited survey and the federal designation, the West Virginia Division of Natural Resources initiated a survey in 1993 to evaluate the status of the candy darter throughout its entire range in the state. To date, approximately 40 of 50 historic candy darter sites (i.e., localities established prior to 1980) have been visited, including many sites during 2005. This new information reveals that, although this species is probably declining or has been extirpated from certain waters within its West Virginia range, several excellent sites still exist. Reasons for population declines are presented and new threats are identified, including hybridization with the introduced variegate darter.

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### Movement, behavior and habitat of juvenile white sharks in the eastern Pacific

Six juvenile white sharks ranging in age-class from 1 to 3 years were tagged in the Southern California Bight using pop-up satellite archival tags. Young-of-the-year white sharks in the Eastern Pacific occupy a larger nursery area than suggested in

previous studies, spanning California Current waters of Southern California and Baja California, Mexico. Young-of-the-year sharks preferred surface mixed layer waters of 16-20C but made frequent movements through the thermocline, and showed a strong diel pattern in behavior. Three-year-old sharks used a larger geographic, vertical and thermal habitat, making movements to greater depths and cooler temperatures, and one individual moving into cooler waters north of Point Conception. This ontogenetic thermal niche expansion suggests that young-of-the-year sharks are thermally limited in their habitat. Juvenile white sharks are captured as bycatch in both US and Mexican waters, suggesting that management of fishing mortality should be of increased concern.

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**WERMAN, STEVEN D.**

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Venom evolution in *Bothrops* and related Neotropical pitvipers

In the last decade great strides have been made in resolving the phylogenetic relationships of New World pitvipers based on DNA sequence analysis of various mitochondrial and nuclear genes. While the relationships of some problematic taxa remain unclear the general picture of pitviper phylogeny is now robust. Parallel to this effort has been rapid progress in the molecular characterization of important venom components related to their structure, function and evolution. The connection between species phylogeny and the evolution of venom components has not been fully explored. This paper examines the phylogenetic patterning of important differences in venom components of bothropoid pitvipers (*Atropoides*, *Bothrops*, *Lachesis*, etc.) as compared to other New World forms (*Crotalus*, *Sistrurus*, *Agkistrodon*). Primary consideration is given to secretory phospholipases (sPLA<sub>2</sub>), their role in neurotoxicity and myotoxicity, and to metalloproteinases that are the primary mediators of hemorrhage and coagulopathy.

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Recent growth and renovations within The Auburn University Museum fish collection

The Auburn University Museum fish collection comprises 44,167 catalogued lots of fishes representing 3288 species in 235 families. Since 1998, collection personnel have catalogued over 16,000 including a large backlog of fishes from the southeastern United States and recent accessions that include materials from expeditions to Bangladesh, Guyana, Indonesia, Peru, and Venezuela. In 2004, the fish collection expanded into new space to accommodate future growth needs.

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**WESTNEAT, MARK W.**

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Labroid phylogeny and the search for perciform relatives using outgroup jackknifing

The question of relationships among the labroid fishes (cichlids, damselfishes, surfperches and wrasses) has been the subject of intensive research by morphologists for many years. A primary focus of this research has been the pharyngeal region, which yields a number of characters suggesting their close relationship. Recently, molecular data have questioned this close alliance, suggesting that cichlids, pomacentrids, and embiotocids are closely related but that labrids are rooted to a different part of the perciform tree. Neither morphology nor DNA has yet provided a clear answer to the question of what other perciform fish families might be close relatives to labroid families. Key questions remain: Are labroids one clade or more? What non-labroid families are close relatives to these families? In this context, we assembled a dataset consisting of DNA sequences from mitochondrial and nuclear genes from over 120 perciform taxa including all major labroid clades to test hypotheses of labroid relationships. Six genes and about 4KB were analyzed using outgroup jackknifing, in which alternative sets of outgroups were used to assess support for labroid clades. The molecular evidence strongly supports the sister-pair of embiotocids and pomacentrids, with cichlids a close relative but often with other families inserted. The labrids are more closely allied with more basal percoid lineages, with the Gerreidae a possible sister-group to the Labridae. Phylogenetic hypotheses splitting labroid fishes into two or more clades do not require many extra steps when considering morphological character data, but do require reinterpretation of both structural and functional hypotheses of pharyngeal jaw evolution in fishes.

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Primordial germ cell determination in fish

In sexually reproducing organisms germ cells are indispensable for continuation of the genealogical lineage. In classical model organisms such as nematodes, fruit flies, and frogs, primordial germ cells (PGCs) are determined by maternal molecules sequestered in specific regions of the oocyte and embryo. In salamanders and mammals, PGCs are not predetermined, and they must be induced later in development. Our review of PGC determination in fish indicates that, as in amphibians, both mechanisms are present. In zebrafish (*Danio rerio*), experimental evidence demonstrates that PGCs are specified by maternal determinants. Germ plasm in embryos can be tracked by the expression of vasa RNA and dazl RNA, both

of which are localized in the oocyte and early embryo. Localized vasa expression has been found in the blastula stage in a basal teleost, the butterfly fish (*Pantodon buchholzi*), as well as several other teleost fish: the carp (*Cyprinus carpio*), the tetra (*Hyphessobryon ecuadoriensis*), and Fegrades danio (*Danio feegradei*). The pattern resembled that seen in zebrafish at a similar stage. In contrast, our preliminary evidence indicates that vasa RNA and dazl RNA are uniformly distributed in the cytoplasm of oocytes from sturgeon (*Acipenser fulvescens*), a primitive actinopterygian fish. In lungfish (*Protopterus annectans*), a sarcopterygian fish, vasa RNA is also not localized in oocytes. Vasa RNA localization is not seen in early embryos of three teleost fish: the medaka (*Oryzias latipes*), the trout (*Oncorhynchus mykiss*), and the rainbow fish (*Melanotaenia fluviatilis*). These results suggest that even among teleosts, both mechanisms of germ cell determination occur. The evolution of the mechanism for germ cell determination and its affect on potential developmental constraints to morphological change will be discussed.

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### Organization and variation in the Least Brook lamprey control region

The lamprey mitochondrial control region is unique among vertebrates in that it is composed of two distinct regions separated by t-RNAs. Here we describe the structure of the control region in the Least Brook (*Lampetra aepyptera* - LBL) and American Brook lampreys (*L. appendix* - ABL). Several of the conserved regions typically seen in vertebrate sequences are not apparent in the lamprey sequence. All lampreys examined possess multiple copies of a 39-base repeat. Whereas the Sea lamprey (*Petromyzon*) and the European River lamprey (*L. fluviatilis*) have 3 copies, populations of LBL can have 4 or 5 copies. Typically the last copy is imperfect or is only a fragment of a normal repeat. However certain populations of LBL have the first two copies imperfect. When the number of repeats is superimposed on a phylogeny, we observed cases of a change in repeat number within a clade. The repeats are capable of forming secondary structures of variable stability. The second part of the control region is preceded by the Thr and Glu t-RNA genes. It consists of a short (12 bp) conserved region followed by multiple copies of a second repeat sequence of 25-29 bp. A consensus repeat sequence is apparent in some LBL populations but not all. These repeats can also form secondary structures. Poly-T and poly-A sequences were common and prevented accurate sequencing of the entire region. A 13 bp unique region is found at the end of the repeats. The LBL control region appears to be a very dynamic region.

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### Biology meets engineering: biomechanics and two-dimensional finite element analysis of carcharhinid teeth

Applying engineering techniques to biological studies can reveal functional insights into evolution undiscovered by traditional methods. The goal of this study was therefore to explore the evolution of selachian teeth in a biomechanical context. To determine the loads experienced by shark teeth during puncture and unidirectional draw, teeth from nine carcharhinid species were tested with a MTS MiniBionix II universal testing system. Puncture forces were determined by driving teeth into three teleosts of varying scale thickness at 400 mm/s. For unidirectional draw, teeth were embedded in the prey item and drawn in parallel at 400 mm/s. Force and pressure at initial penetration and maximum force and pressure were determined from both sets of experiments. Stress and strain distributions in the teeth were then computed via two-dimensional finite element (FE) analysis, using the measured maximum forces and mechanical properties of mammalian teeth. FE models of various carcharhinid tooth morphologies were created from the coordinates of tooth outlines from digital images. Tooth models were fixed at the base and point loaded at the tip for puncture and on the lateral cutting edges for unidirectional draw. Initial results indicate minimal strain in the teeth under either loading. During puncture, stress is concentrated primarily at the tooth tip for all morphologies. However, teeth with narrow triangular cusps, like those of *Carcharhinus limbatus*, have smaller regions of stress concentration overall than those with broad, curved cusps like *C. leucas*, in which a region of high stress extends along the lateral cutting edge. A stress concentration often occurs at a corner of the tooth base during unidirectional draw. High stress occurs along the cusp-base interface for narrow triangular cusps, and where the lateral cutting edge meets the base for broad, curved cusps. Overlapping bases and flexible attachment of teeth may alleviate these stresses in live sharks.

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### Faunal declines across 35 years at La Selva, Costa Rica: More trouble in paradise?

Amphibian declines are a critical issue in conservation ecology, and enigmatic declines in pristine habitats have evoked particular alarm. However, lack of long-term data makes it difficult to assess the status of most populations. We reviewed published and unpublished reports of density of forest-floor amphibians and reptiles at La Selva Biological Station, a large, relatively pristine, lowland wet forest in northeastern Costa Rica. Total density of all amphibians declined an order of magnitude between 1970 and 2005 in primary forest, but total density increased in adjacent abandoned cacao plantations undergoing succession. Unexpectedly, reptile populations show trends identical to those for amphibians. All species of amphibians and reptiles declined significantly in primary forest, while one third of species present in cacao increased in density. Community-wide declines of such intensity and duration likely indicate an external driver of density rather than natural fluctuations. A parsimonious explanation for the patterns reported here cannot be provided by major processes currently implicated in amphibian declines. Habitat modification and fragmentation are not likely explanations because La Selva is a large protected reserve. Pesticide drift cannot explain increase in total density in successional plantations. Emerging diseases can neither explain declines among reptiles nor population increases in cacao. We suggest that trends for La Selva are best explained by changes in dynamics of forest-floor leaf litter, a major determinant of abundance for this assemblage. Recent changes in climate at La Selva may accelerate decomposition of leaf litter in both habitat types, yet increasing litterfall with forest succession may explain increases in density in cacao. This study indicates that our understanding of faunal declines is still incomplete, suggests that habitat protection alone may be insufficient for the preservation of biodiversity, and demonstrates the value of long-term datasets for assessing status of populations.

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Isolation and partial sequence analysis of *lhx9* in the red-eared slider turtle, *Trachemys scripta*

Many reptiles, including the red-eared slider turtle (*Trachemys scripta*), possess a temperature-dependent sex determination (TSD) mechanism where the temperature at which the developing embryos are incubated dictates the eventual gonadal sex of the animal. A cascade of regulatory genes controlling sex determination has been identified in some mammals and reptiles. Some orthologous genes of this cascade show a high degree of homology among mammals, reptiles, and birds. One such gene, *Lhx9*, controls the proliferation of gonadal cells in mice and its absence drastically reduces the expression of other genes in the male developmental pathway. In addition, *in vitro* studies using mouse models have shown that *Lhx9* binds to and activates SF-1 (steroidogenic factor 1), a central gene regulating the expression of

steroidogenic enzymes in the bipotential gonad. We studied *Lhx9* and its role in TSD in the red-eared slider turtle. Using degenerate oligonucleotide primers, we PCR-amplified then sequenced a 342 bp fragment of exon 3 from red-eared slider turtle genomic DNA. DNA sequence alignment of this fragment revealed 92.7% and 84.5% identity with its ortholog from chicken and mouse, respectively. This high degree of sequence homology among the three species indicates that *Lhx9* of the red-eared slider turtle may have a similar function in the sex determination pathway as in mouse with its influence on SF-1. We are currently characterizing the expression patterns of *Lhx9* during embryogenesis in the red-eared slider turtle to reveal its role in TSD.

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**Combining satellite, bathymetry, and sediment data to refine ecological niche models and predictions of species occurrences**

Our research group has previously demonstrated that statistically robust ecological niche predictions can be used to predict the occurrences of marine fishes using station-based and MODIS satellite data in concert with bathymetry. In this study we combine MODIS, sediment, and bathymetry coverages to further refine the ability of genetic algorithms to predict species occurrences and contrast the results with previous studies.

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**Retention of coded-wire tags in the green anole, *anolis carolinensis***

Our goal was to assess the feasibility of using coded-wire tags (CWT) to batch mark anolis lizards. The green anole *Anolis carolinensis* was selected for this study because of its local abundance. The objectives were to compare the growth and survival rates of, coded wire tagged, toe clipped, and control lizards, as well as to determine the long-term retention rate of CWT in anolis lizards. Each lizard was sexed, weighed, and the snout-vent and snout-tail lengths were measured. Lizards (N=63) were randomly assigned to one of three replicates of each treatment (seven lizards per replicate). Lizards were maintained outdoors in sheltered 38 liter glass aquaria and were fed and watered once a day. Data were analyzed using analysis of co-variance

(ANCOVA) to account for size variation among individuals and to compare pre- and post- growth. From 25 July to 25 August of 2005, retention of coded-wire tags was 100%. Six percent mortality occurred in the toe clipped and control treatments. There were no significant differences in growth rates across all treatments. Control and toe clipped lizards were released after the survival and growth comparison among treatments. Coded wire tagged lizards were transferred to 91x61x91cm cages for assessment of long-term CWT retention. Lizard were moved indoors and were maintained at  $24.7 \pm 2.0^\circ \text{C}$  once outdoor temperatures dropped below  $20^\circ \text{C}$ . No mortalities occurred and long-term tag retention over seven months was 95%. CWT can be used successfully to batch mark anolis lizards. Based on the results of this study, CWT have been used to mark brown anoles *A. sagrei*, a species native to the Caribbean that can now be found in Southeastern Louisiana, for estimations of population size using mark recapture techniques. Additionally, this method of tagging will be used to document over-wintering of the brown anole in Southeast Louisiana.

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**Coevolution of deadly toxins and predator resistance: Behavioral rejection of toxic newt prey by garter snakes**

Deadly toxins and resistance to them are an evolutionary enigma. Selection for increased resistance does not occur if predators do not survive encounters with toxic prey. Similarly, deadly toxins are of no advantage to individual prey if they die delivering the toxins. For individual selection to drive the coevolutionary arms race between resistant predators and lethal prey, the survivorship of individual predators must covary with their resistance. The extreme toxicity of the rough skinned newt (*Taricha granulosa*) appears to have coevolved with resistance in its predator, the common garter snake (*Thamnophis sirtalis*), yet the mechanism by which individual selection can operate has been unclear in this and other lethal prey-predator systems. We show that individual snakes assess their own resistance relative to newt toxicity and reject prey too toxic to consume. Rejected newts all survived attacks and attempted ingestion by snakes that sometimes lasted over 50 min. Behavioral moderation of toxin exposure by snakes provides the association between individual resistance and fitness necessary for coevolution of lethal toxins and resistance to occur.

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The Relationship Between El Niño/Southern Oscillation Events and Growth of Juvenile White Seabass (*Atractoscion nobilis*)

Since 1995, the Nearshore Marine Fish Research Program (NMFRP) at CSUN has been under contract with the California Department of Fish and Game and the Ocean Resources Enhancement and Hatchery Program to sample and determine the spatial and size distributions, seasonality, and abundance of white seabass (*Atractoscion nobilis*) in the shallow, nearshore waters of Southern California. One hundred sagittal otoliths were aged from each sampling year between 1997 and 2004. The hatch year of each fish was back calculated using the age at catch and the catch year. Growth rates are determined by using the means of standard length at age for each hatch year. Linear regression equations for each set of hatch year data provide a general growth rate for the first few years of life. The large time span of this study includes several El Niño/Southern Oscillation (ENSO) events of varying strengths, all of which caused noticeable changes in the sea surface temperature in the Southern California Bight. This study relates the growth rate of juvenile white seabass and the changes in the local ocean temperatures due to ENSO conditions.

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A progress report on a Barstovian (Middle Miocene) herpetofauna from Fort Polk military installation, Louisiana, USA

The Miocene herpetofauna from west-central Louisiana is important in the field of paleoherpetology, as there is nothing else known of Miocene Gulf Coast herpetofaunas between east Texas and the Florida panhandle. In twelve years of work by LSU paleontologists, dissolving rock, deflocculating clay, and picking microvertebrates under a microscope, 9175.9 kilograms of sediment have been processed from six Miocene-aged (13.5 million years old) fossil-bearing sites on the Fort Polk, Louisiana military base. Stonehenge, the most prolific site, has yielded 315 identifiable herpetological postcranial elements in 3050.91 kilograms of screen-washed sediments or 0.103 elements per kilogram. The next most prolific site is TVOR, which has 0.024 herpetological elements per kilogram of sediment. Thus far, colubrid and viperid snakes have been recovered, including *Thamnophis* sp., *Elaphe* sp., and a species of *Texasophis*. Ranid and bufonid anurans have been identified using ilial characters, and 68 salamander vertebrae have been separated from bulk collections for study. One of the salamander vertebrae compares favorably to the Barstovian *Batrachosauroides dissimulans* from Florida and Georgia. A lizard dentary,

belonging to *Eumeces* sp., exhibits bulbous tooth crowns that are unlike any modern species of *Eumeces* living in Louisiana today and might represent a new species. Finally, the presence of numerous crocodylian teeth, trionychid carapace fragments, natricine snake vertebrae, and ranid frog ilia at the Fort Polk sites suggest permanent freshwater sources near the areas in which the animals lived.

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**Influence of the Casiquiare connection on biogeography of Neotropical fishes: Inferences from *Cichla* mitochondria**

Previous molecular phylogeographic studies of South American fishes emphasized closer relationships among taxa and lineages from the Amazonas basin and coastal Guyanan drainages to the exclusion of the portions of the Orinoco basin. Despite this pattern, a significant direct connection between the Amazonas and Orinoco basins currently occurs through the Casiquiare river, a tributary of the Amazonas that captures a portion of the headwaters of the Orinoco and provides a potential corridor for movement of fishes between the basins. Rather, this incongruence between biological pattern and contemporary hydrography probably implicates a major role for the complex evolution of South American hydrography through geological time in taxonomic diversification and prehistoric demographics of South American fishes. Four of eight putative species of *Cichla* show distributions in both the Orinoco and Amazonas drainages, but these overlapping distributions were arrived upon from different biogeographic backgrounds and in different temporal contexts. Mitochondrial control region data from individuals throughout the range of each species were collected to examine the geographic structure of genetic diversity. Analyses revealed that each species differs in the structure of genetic diversity across this barrier. For all species, analyses show definite geospatial correlation, i.e., haplotypes from particular localities and geographical areas are often members of the same genetic clades. However, each species showed non-monophyly among haplotype groups from either basin, conflicting with null hypotheses that the Casiquiare prohibits dispersal between basins. *Cichla monoculus* exhibited a pattern of recent range expansion from the Amazonas to the Orinoco, while *C. temensis* showed an older pattern of stochastic lineage sorting (genetic drift) among localities in the Orinoco and Amazonas. *Cichla orinocensis* showed a pattern of introgression with *C. monoculus* suggesting ancient colonization of the Amazonas from the Orinoco, and *C. intermedia* showed recent co-ancestry in the Casiquiare and Orinoco but population fragmentation within the Orinoco.

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**\*WILLSON, JOHN D.; WINNE, CHRISTOPHER T.**

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### Evaluation of trap response in two aquatic snake species using mark recapture and an experimental release study

We use data from one year of intensive systematic mark-recapture sampling (2325 captures of 888 individuals) of two aquatic snake species (*Seminatrix pygaea* and *Nerodia fasciata*) using aquatic funnel traps to evaluate factors that influence snake capture rates. Specifically, we examine inter and intraspecific differences in capture probability, including heterogeneity in individual capture probability, behavioral ("trap-happy" or "trap-shy") responses, and time effects. Additionally, we use an experimental release study to examine the potential role of escape from traps in generating the capture patterns we observed. Mark-recapture analyses using program CAPTURE yielded strong support for heterogeneity in capture probability for *N. fasciata* and, to a lesser extent, for *S. pygaea*. There was generally weak support for behavioral or time-dependent response for either species. Despite the intensity of our sampling regime, average individual capture probability was low, but was similar between species (0.04 - 0.15 per night). Within *S. pygaea*, males displayed fairly constant capture probability across the year. Females displayed lower capture probability in the summer, most likely corresponding to reduced activity during pregnancy. Young *N. fasciata*, born mid-summer, had substantially lower individual capture probability than adults. Experimental releases of 196 snakes demonstrated that *S. pygaea* escape from traps far more frequently than *N. fasciata*, even accounting for body size. In both species, smaller snakes escape more frequently. We found a strong effect of capture history on propensity to escape in *N. fasciata*, but not in *S. pygaea*. This correlation between number of previous captures and propensity to escape may partially explain the heterogeneity in capture probability we observed for *N. fasciata*. Our results demonstrate that indices of relative abundance may be biased in multiple ways and must be used with caution when making inferences about snake populations.

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### Reconsidering Chirixalus (Anura: Rhacophoridae): A phylogenetic analysis

We re-examine the status of the genus *Chirixalus* within the larger context of the family Rhacophoridae. Although morphological characters support the monophyly of the genus, molecular work (Wilkinson et al 2002) recovered a polyphyletic *Chirixalus*. Increased taxon sampling within the genus in combination with additional molecular markers provided a more robust estimate of phylogenetic

relationships. Data were analyzed using maximum parsimony, maximum likelihood and Bayesian Inference.

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### Comparison of dietary and isotope-based food web structure of four Central American coastal streams

Food web structure of two coastal streams in Corcovado National Park (Pacific Costa Rica) and two coastal streams in Tortuguero National Park (Caribbean Costa Rica) were examined via analysis of fish stomach contents. Stream drainages in both regions drain tropical rainforest landscapes. This analysis, performed in 1983 and 1985, revealed details of predator-prey interactions and structure involving upper food web elements. The same sites were surveyed again in 2004 to assess food web structure via analysis of stable isotopes in tissues of fishes, macroinvertebrates and plants. Stable isotope analysis (SIA) provides integrated estimates of assimilated production sources but usually is a poor predictor of pairwise trophic interactions. Analysis of nitrogen isotope ratios provides an independent method for assessment of vertical consumer trophic positions. Coefficients of determination for trophic positions based on dietary versus those based on SIA ranged from 0.25 (Corcovado stream) to 0.54 (Tortuguero stream). Phytoplankton is extremely sparse in these systems, and most fishes and macroinvertebrates had carbon isotope ratios that were considerably heavier than local benthic algae. Variable fractions of carbon from terrestrial vegetation, and to a lesser extent from aquatic plants in Tortuguero streams, probably were assimilated by consumers in all four streams. Approximately half the consumers in all four streams had carbon ratios that were heavier than any of the local production sources examined. This pattern seems to be associated with species that migrate from coastal waters or feed on migratory species, and highlights the importance of trophic links between ecosystems in coastal zones for understanding food web dynamics.

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### Rapid recovery of an aquatic snake community following prolonged drought

Coping with climatic variation and associated fluctuations in resource levels is one of the greatest challenges to organisms in many ecosystems. Extreme drought, in particular, is among the most powerful selective forces and has been implicated in the evolution of numerous species, character traits, and life-history attributes. For aquatic organisms inhabiting isolated wetlands specifically, droughts pose one of the most obvious challenges to population stability and persistence. We have monitored the aquatic snake community at a large (10-ha), isolated freshwater wetland (Ellenton Bay) since it began to refill after a 2.5-year drought that occurred from August 2000 to February 2003. *Seminatrix pygaea* survive droughts by aestivating within the dried wetland and exhibit similar relative abundance in pre- and post-drought years, whereas sympatric semi-aquatic natricines that do not aestivate (*Nerodia fasciata* and *N. floridana*) experience precipitous declines or local extinction during the drought. Here, we document patterns of population recovery for *S. pygaea*, *N. fasciata*, and the wetland snake community as a whole in the 3.5 years since the wetland was last dry. In particular, we demonstrate that *N. fasciata* rapidly repopulated Ellenton Bay, returning to pre-drought abundance levels within three years. *Seminatrix pygaea* increased in abundance and achieved record body sizes and levels of reproduction during the post-drought period. Overwhelmingly, the rapid recovery of the snake community appears to be driven by changes in amphibian prey abundances, which have increased substantially since the refilling of the wetland in 2003. Our results are analogous to “supranormal” breeding events of wetland birds following recovery from extreme drought and highlight important interspecific differences in population recovery.

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### The diversity and evolution of the gobiid genus *Trimma*

The Indo-West Pacific marine gobiid genus *Trimma* contains about 46 described species, and perhaps as many again that are currently undescribed. The number of the latter increases every time collections are made below 50 m, so it is currently impossible to estimate the total number of species that make up the genus. However, a number of possible phylogenetic lineages, evidenced by presently untested putative apomorphies, are apparent. I will discuss some of this diversity and some of the lineages, and speculate on the ecological importance of a few of the more abundant species in terms of reef energetics.

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Multi-year comparison of male reproductive biology of the brown treesnake  
(*Boiga irregularis*)

The brown treesnake (*Boiga irregularis*) is an introduced species on Guam which has caused the extinction or extirpation of several species of lizards and birds. Moore et al. (2005, *Biological Conservation* 121:91-98) suggested that reproduction in this species is reduced because of elevated stress hormones caused by limited food availability. The purpose of this study is to compare the reproductive anatomy of male brown treesnakes on Guam over several years (1985, 1995 and 1999) to determine if the size at maturity and development of the testis and sexual segment of the kidney varied between years. These measurements were compared to a sample of brown treesnakes collected from the native range of this species. Reproductive adults on Guam were present in all years examined. The snout-vent length (SVL) at which snakes were reproductive was similar between years. Mean seminiferous tubule and sexual segment of the kidney (SSK) diameters were not significantly different between years. However, the number of SSK tubules hypertrophied per snake varied greatly. In general, snakes from the native range matured at a smaller SVL and had many more hypertrophied SSK tubules per kidney than did the populations on Guam.

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Shovelnose Sturgeons (Scaphirhynchinae): Known knowns, known unknowns, and the unknown unknowables based on genetic analysis

The shovelnose sturgeons of the subfamily Scaphirhynchinae are an important and imperiled component of the large river fauna in North America. *Scaphirhynchus* is composed of three species: *S. albus*, *S. platorynchus*, and *S. suttkusi*. Both the pallid sturgeon (*S. albus*) and the Alabama sturgeon (*S. suttkusi*) are listed as endangered under the US Endangered Species Act. Whether you agree or disagree with the political perspective that led to the paraphrased title of this talk, there is an ineloquent wisdom in it that is directly applicable to North American shovelnose sturgeons and may be comprehensible to decision makers in the U.S. Fish and Wildlife Service. The former is justified by the extensive genetic data we have assembled on these species and a wisdom borne out of our understanding of the limitations of these data. The latter is supported by the fact that policy makers at the USFWS seem very capable of finding a comfortable interpretation in any set of data no matter how clear or how garbled the message. I will present DNA sequence data and microsatellite data on over 200 North American shovelnose sturgeons representing the above three species and attempt to explain what is known, what is

unknown and what is unknowable (but generally assumed to be known) based on a rather large set of genetic data.

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Body size relationships among several species of salamanders in the genus *Desmognathus* (Caudata: Plethodontidae)

Allometric or scaling relationships have been revealed across 27 orders of magnitude in body size, from the smallest genetic constituents to the largest mammals and plants. These relationships have been documented among species, populations, and sexes. Isometry, the converse of allometry, is a relationship in which body mass (or another body size measure, such as length) increases proportionally as body size increases. In the dusky salamander genus *Desmognathus*, it has been hypothesized that these salamanders increase proportionally in body size from the smallest to the largest salamanders. The purpose of this study was to further investigate the isometric relationships among the entire span of body sizes in desmognathine salamanders. Body size relationships were constructed for eight desmognathine species. Ten body measurements were taken for approximately 1300 sexually mature specimens with equal numbers of males and females. Sex was determined by visual inspection of dissected individuals or by the presence of sexually dimorphic characteristics (e.g., mental gland present such as in mature *Desmognathus wrighti*). Preliminary results suggest that both males ( $b=0.96$ ;  $r^2=0.944$ ) and females ( $b=1.00$ ;  $r^2=0.953$ ) exhibit an isometric relationship of log total length (TL) when regressed on log snout-vent length (SVL). Further investigation into the body size relationships within this genus will be conducted to determine if other measurements exhibit similar trends.

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Effects of a wetlands drawdown on an aquatic snake

Wetlands drawdowns are a commonly practiced method used to improve habitat conditions for waterfowl populations. While this practice has been successful for waterfowl management, little is known about its effects on other wetland species. This is of considerable management importance because preserving biodiversity is a high priority for management agencies. Our study focused on how drawdowns affect the northern water snake, *Nerodia sipedon*, at the Patuxent National Wildlife Refuge in Maryland during 2005-2006. We used modified minnow traps to capture water snakes in six man-made impoundments with varying intervals since the last drawdown. We predicted that snake capture rates would be higher in impoundments

that had had more time to recover from the last drawdown. Preliminary data indicate that this prediction was not verified and that other factors determine water snake abundance. Data being collected in 2006 will be used to better determine these factors.

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Transient anatomical features of *Scyliorhinus torazame* embryos

*Scyliorhinus torazame* is an oviparous elasmobranch and its embryos require 214±26 days to complete development at 14-16°C. During this time the embryo and egg case continually adapt to each other. There are four respiratory slits in the egg case, two dorsal and two ventral. The respiratory slits are sealed with solid jelly until 103±6 days at 14-16°C after oviposition. In common with other oviparous elasmobranchs, the tail is used to move water through the egg case via the respiratory slits. The tail has transient anatomical features specialized for development within the egg case. Primary scales found in two rows at the dorsal and ventral margin of both sides of the caudal fin erupt and increase surface area for water movement. The tip of the caudal fin is an extension of the notochord and forms a scoop for water transfer through the egg case by active pumping of the tail. Embryos have been observed to project this tail extension through the hatching terminus of the egg case in the months preceding hatching. The cup-like extension and caudal scales can be observed in embryos after eclosion but are gradually resorbed during the following months. Another specialized embryonic structure to develop during incubation is primary scales found in 2 dorsolateral rows along the trunk. These scales erupt before hatching and may be used to aid in escape from the egg case during eclosion. Ordinary placoid scales do not erupt until after hatching.

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**YAMAGUCHI, ATSUKO**

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Reproductive biology of Longheaded Eagle Ray, *Aetobatus flagellum*, in Ariake Bay, Kyushu, Japan

The Longheaded Eagle Ray, *Aetobatus flagellum*, has recently increased significantly in number abruptly in Ariake Bay. The eagle ray is a seasonal visitor to Ariake Bay, increasing in number from April, and peaking during the summer. It is assumed that the eagle ray feeds on bivalves and so, to prevent predation on bivalves by eagle rays, a predator control program aimed at reducing the ray population has been in

place since 2001. When the program was started, there was no biological information about eagle ray, therefore we clarified to examine their occurrence, age, growth and food in Ariake Bay to obtain data on the ecology of the eagle ray and provide basic information on their potential impact on bivalve stocks. In this study we studied reproductive biology of eagle ray. The size at sexual maturity is 800 mm DW for males and 900 mm DW for females. The histological examination of testis and the seasonal variation of GSI showed the mating occurred during August and October. The fertilized eggs were found from August until next May, and in June the smallest embryos were found in their uterus. The fertilization and parturition were occurred in August because the largest embryos were found in August (average size: 350mm DW), therefore the gestation period was approximately 12 month but the growth of embryos was rapid for 3 month. The fecundity was relatively low that ranged from 1 to 6 embryos. Low fecundity and slower maturity suggested that the predator control program is possible to reduce ray population size. The estuaries are used for their reproduction and nursery ground. The existence of large estuaries is one of the reasons with the recent rising water temperature why they increased in Ariake Bay.

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#### A cross-age study on the alternative conceptions in amphibians and reptiles

This study examined the alternative conceptions of reptiles and amphibians of students and the extent to which these conceptions remain intact through the elementary (grades 4 and 6), junior, and senior high school years. We administered multiple-choice and free-response instruments to a total of 513 students and interviewed at least 20 students at each educational level to get an in-depth view of their original conceptions. Then, we developed and administered a two-tier, multiple choice, diagnostic instrument to assess various levels of the understanding of students on amphibians and reptiles (N=1267). The results showed that most students were able to classify snakes as reptiles, whereas fewer than 30% of the students across different ages classified sea turtles as reptiles; the remaining 70% classified sea turtles as amphibians. More students were able to correctly classify frogs as amphibians than toads. In most instances, students correctly classified 'prototypical' representatives of the two animal classes more readily than less exemplary representatives, a finding that supports previous research. Interestingly, the alternative views of sea turtles as amphibians remained intact throughout the school years. Interview data indicated that students classified sea turtles as amphibians largely because sea turtles are able to live in terrestrial and aquatic habitats. Semantically, 'amphi-' means living on land and in water. When asked to distinguish between reptiles and amphibians and to classify several species into those two groups, a wide range of alternative conceptions emerged and the origin of those alternative conceptions are discussed. Similar results were obtained when we applied a two-tier, multiple-choice, diagnostic instrument to assess the understanding of students on amphibians and reptiles.

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Comparative brain morphology in elasmobranchs: From structure to function

There is widespread variation in both brain size and complexity across the elasmobranch phylogeny. The relative brain weight of a species is dependent upon the relative enlargement or regression of individual brain structures, some of which can be identified with different sensory modalities and behaviors. The hypothesis that there is an environmental correlation with structural hypertrophy (AES abstract, 2005) was further tested by adding 18 species to the data set. The total database of 46 species from 25 families strengthens the environmental correlations amongst several families of Chondrichthyans. The data show large variations in relative brain weight and complexity between species that do not follow a simple phylogenetic pattern, as the relative development of the five major brain areas are similar in species that occupy similar habitats. Agile, pelagic species, such as *Prionace glauca* and *Sphyrna zygaena*, have enlarged telencephalons and highly foliated cerebella. Reef-associated benthopelagics have enlarged telencephalons, similar to the pelagic species, but show average cerebellar foliation while bathyal and demersal benthopelagic sharks, such as *Squalus acanthias* and *Dalatias licha*, have enlarged mesencephalon and medulla. Benthic species, such as *Orectolobus ornatus* and *Cephaloscyllium isabella*, have small, smooth cerebella and small telencephalons, though the demersal benthics have enlarged mesencephalons while the reef-associated benthic species have recessed this structure. In batoids, the species that had the highest levels of cerebellar foliation had the most complex batoid wing skeletal structure, adding weight to the hypothesis that there is a cerebellar correlation with fin dexterity. More detailed data will be presented on the cerebellum and the cerebellar like structures and the structure-function relationship of these brain areas. Functional implications of a comparative analysis of these brain structures will be discussed.

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Lessons from five years of promoting international collaborations in amphibian decline research

In 2002, 21 scientists formed the Research and Analysis Network on Neotropical Amphibians (RANA) to accelerate research on population declines and extinctions by providing more fluid communication among researchers, promoting multi-site syntheses, and developing and disseminating data on the population status of Neotropical species. RANA promotes communication among members via annual meetings and symposia, a listserve, and a website. To create a transparent structure, members adopted a charter and elected a five-member board. RANA has succeeded

in many of its goals by forming alliances with like-minded groups for specific projects and building trust among collaborators. Coordination with the IUCN and Conservation International led to the completion of the Global Amphibian Assessment, a major resource now available to scientists. Collaboration with an amphibian disease research group based at Arizona State University led to a successful graduate course on techniques for decline research. Research inspired in part by RANA has led to several groundbreaking publications which have narrowed substantially the list of possible causes of declines in Neotropical amphibians. Lessons learned include the importance of choosing collaborators carefully, forming alliances, speaking in a common language, understanding priorities of collaborators, and building trust via face to face meetings. RANA has successfully grown to over 100 members from 60 academic institutions in 21 countries. Nevertheless, maintaining the network requires constant work to maintain cohesion and create new opportunities for fruitful collaboration.

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#### Rapid colonization of neonate lemon sharks by monogeneans

Sharks are commonly infected by monogeneans (Monogenea); however, few data exist regarding how soon after birth neonates become infected. Fifty juvenile lemon sharks, *Negaprion brevirostris*, captured about Bimini, Bahamas were examined for the presence or absence of monogeneans. Thirty-two percent of the sharks were infected by *Dermophthirius nigrelli*. Twenty-five of these sharks were neonates estimated to be less than 8-10 weeks old and some of these were as young as 3-4 weeks old. Twenty four percent of the neonates were infected by *D. nigrelli*, with the youngest sharks estimated to be 3-4 weeks old. These results indicate that lemon sharks can be infected by *D. nigrelli* soon after birth. This may have important husbandry implications when neonate sharks are selectively acquired for aquarium operations with the assumption that they will not yet be infected by monogeneans. This study was partially supported by an Undergraduate Research, Scholarship and Creative Activity Scholar award to J. Young from Middle Tennessee State University.

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### The fish communities of socotra archipelago: implications for conservation management

Between 1998 and 2002 coastal fish communities of Socotra Archipelago were studied with the objective of assessing patterns of diversity and abundance, community composition, trophic structure and ichthyogeographic affinities. Results were compared with those from other oceanic islands and adjacent coastal areas, and used for an evaluation of existing concepts of marine conservation management and monitoring. The Socotra Archipelago hosts diverse, varied and ichthyogeographically unique inshore fish communities. The structure of the dominant community types, as inferred from multivariate and trophic analysis, is comparable with typical “reef fish” assemblages of the Western Indian Ocean, despite the fact that the Archipelago has hardly any biogenic coral reefs. The numbers of chaetodontid, acanthurid and pseudochromid species exceed those known from the entire Red Sea. Fish diversity and abundance is positively correlated with coral species diversity and the presence of typical mixed benthic communities, which are variably composed of hard and soft corals, macroalgae and sponges. A harsh monsoon regime results in coastal ecosystems varying in space and time, giving rise to a great variety of ecological niches and thus supporting fishes from many different ‘walks of life’. Methods of monitoring and managing tropical marine communities typically focus on rather uniform reef habitats with high cover of scleractinian corals and the presence of so-called “reef-associated” fish species, based on the postulate that these are dominating factors in determining coastal diversity in the tropics. Results from Socotra suggest that habitat availability and connectivity, biotope variability, and linkages among biogeographic units are equally important factors for the establishment of diverse coastal fish communities. Consequently, monitoring and conservation management standards currently applied in the Indian Ocean region need to be adjusted, i.e. giving more consideration to non-reefal benthic communities and to dynamic and varied ecosystems, reflecting more accurately patterns of population dynamics, connectivity and biogeography.

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### Temperature sensitivity of the round stingray, *Urobatis halleri*

The round stingray, *Urobatis halleri*, is a common nearshore elasmobranch found in bays and estuaries ranging from southern California to Panama. Round stingrays have been observed to aggregate in great numbers in shallow areas where sea floor water temperatures range from 11° to 21° C within a single tidal cycle. Because rays do not leave these areas during these periods of tidally-induced thermal change, they

must be physiologically tolerant to these temperatures. The temperature sensitivity ( $Q_{10}$ ) of round stingrays was measured using static respirometry. Oxygen consumption rates were measured of rays exposed to two water temperatures of 16° and 21° C over 6 hr periods and their mass specific metabolic rates were determined at each temperature. Rays were found to have a  $Q_{10}$  of 2.4, indicating that they are comparatively tolerant to changes in water temperature within their thermal preferenda. This high thermal tolerance enables rays to occupy shallow areas where water temperature fluctuates considerably over the course of a day without significant metabolic consequences.

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Habitat attributes influence ontogenetic diet shifts of gizzard shad (*Dorosoma cepedianum*) in a large floodplain river

Gizzard shad (*Dorosoma cepedianum*) are recognized as an important trophic link in many aquatic food webs because of their ability to link detritus carbon sources with higher trophic levels (e.g. piscivorous fishes). Most research on the feeding ecology of gizzard shad concerns populations stocked in reservoirs whereas populations in more dynamic habitats (river-floodplain systems) have been neglected. Here we examine ontogenetic diet shifts in gizzard shad inhabiting oxbow and channel habitats of the Brazos River, Texas. Using stable isotopes of nitrogen and stomach contents we found that oxbow populations show an increase in the consumption and assimilation of primary consumers (zooplankton) during ontogeny resulting in elevated trophic positions despite high diet overlap values calculated using volumetric proportions of stomach contents. Differences in  $^{15}\text{N}$  values indicate that shad greater than 200 mm standard length have a trophic position approximately one level higher than shad less than 200 mm. Populations in the river channel maintain similar trophic positions during ontogeny indicative of detritivory. These results challenge previous models of ontogenetic diet shifts in gizzard shad and similar to other dietary studies using multiple methodologies, suggest that material assimilated may not be proportional to the volume of material consumed.

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**Application of IUCN Red List Criteria in the Status Review for the Okaloosa Darter**

The Red List Categories and Criteria (IUCN 2001) provide a widely-accepted system for classifying species at high risk of global extinction based on quantitative population and range data. The Okaloosa darter was listed as a species endangered throughout its range in 1973 with a revision to the recovery plan approved in 1998. The USFWS has annually updated the status in the USFWS Threatened and Endangered Species System (TESS) database. However, USFWS has not revised the listing, designated critical habitat, or prepared formal 5-year status reviews since the 1973 listing. As part of the first formal status review for the Okaloosa darter, we applied available population monitoring and range data to Red List criteria and assess the relative risk of extinction for the species apart from any consideration of ongoing conservation measures or threats to its continued existence. Based on our evaluation, the Okaloosa darter did not fully meet any of the five criteria for the threatened status categories under the IUCN Red List system. We found that the classification of the darter as Endangered EN B1+2c by Gimenez Dixon (1996) is not presently warranted. The population satisfied only one and not two of the three qualifiers necessary in addition to a small area of occupancy under criterion B. Criteria for small population size, restricted population size, and probability of extinction were not met. Interpreted most conservatively, the Red List classification for the Okaloosa darter would be Vulnerable VU: B2ab(ii), however we feel that the classification Near Threatened (NT) is a more appropriate designation given the nature of the most plausible threats under criterion B2a.

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**Conservation implications of taxonomically revising Panamanian Golden Frogs**

Ongoing studies of mitochondrial DNA (mtDNA) indicate that what was thought to

be a single species of golden frog (*Atelopus zeteki*) in Panama is actually two genetically distinct lineages largely indistinguishable in appearance. In the western half of the golden frog's range, animals exhibiting the golden ground coloration might be a color variant of the more wide-ranging *Atelopus varius*, a species typically possessing black ground coloration with pattern accents of yellow and sometimes red. Nuclear genetic studies are underway to supplement the mtDNA phylogeny in clarifying the pattern of historical and recent genetic exchangeability among extant populations. In conjunction with the molecular data, our ongoing morphological, ecological, and demographic analyses suggest that the Panamanian golden frogs and their kin (the *A. varius-zeteki* clade) can be divided into five distinct, geographically isolated forms. These discoveries engender profound implications for the conservation of this already imperiled group of frogs.

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Genetic variation of the frog *Eleutherodactylus ranoides*, Santa Rosa National Park: Preliminary results

Many amphibian populations have been severely threatened by habitat destruction. In addition, several amphibian populations are threatened by other mysterious causes even in unaltered habitats. Species that inhabit riparian habitats seem to be most affected. The *Eleutherodactylus rugulosus* species group is one of the examples. Several populations of these species have apparently disappeared throughout their distribution. Habitat fragmentation can produce a decrease in the genetic variation in populations affected, increasing the risk of suffering genetic drift. We wish to determine if this effect has occurred to native populations in Costa Rica. We worked at Santa Rosa National Park, Guanacaste province, Costa Rica, during the dry season of 2006. We visited several streams on Naranjo Beach and Santa Elena Peninsula. Frogs were located by visual encounter surveys. We measured each frog with a calliper and determined sex and age. Weight was measured with scale. Geographical location was determined by GPS for each individual. In each stream we collected at least 20 DNA samples by buccal swab and 10 by toe-clipping. DNA concentration obtained by each method was compared. To obtain allelic composition we used 3 loci of microsatellite designed for the species *Eleutherodactylus augusti*. In addition, in each stream we measured the air and water temperatures and pH. Based on our findings we will propose a management scheme that would ensure the medium- and long-term conservation of this species.

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