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Life History Studies of California Chondrichthyans: Determining Essential Biological Information for Effective Management of Bycatch and Emerging Fisheries

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**Keywords:**
chondrichthyans, skates, catsharks, chimaeras, life history, age and growth, reproduction, diet, feeding ecology, bycatch

**Abstract:**
In cooperation with NMFS Northwest Fisheries Science Center and Southwest Fisheries Science Center, Santa Cruz Lab, researchers from the Pacific Shark Research Center/Moss Landing Marine Laboratories have been participating and assisting in groundfish surveys since 2002. Vertebrae for age and growth estimation, reproductive tracts, and/or stomachs for feeding analyses were collected from over 5,000 specimens. Studies on the age and growth of the roughtail (Bathyraja trachura) and sandpaper (Bathyraja kincaidii) skates were completed, with one paper having been published and another having been accepted for publication. Age and growth studies for several other commonly encountered chondrichthyans are continuing. Studies on the reproductive biology of the big (Raja binoculata), California (Raja inornata), longnose (Raja rhina), roughtail, and sandpaper skates, and the white-spotted chimaera (Hydrolagus colliei) were completed and manuscripts are currently being prepared for publication. A study on

the reproductive biology of three deepsea catsharks (Scyliorhinidae) was completed, with two publications currently in press. Dietary studies were completed for four species, the big, California (Raja inornata), longnose, and sandpaper skates, with analyses continuing for several other species. Research results for this project have resulted in two Masters Theses, ten publications, and 18 presentations at seven conferences. This project funded two California Sea Grant trainees both of whom worked on projects that served as their Masters Theses.

**Supporting material:**

2009 paper resulting from project

**CALIFORNIA SEA GRANT PROJECT FINAL REPORT**

# LIFE HISTORY STUDIES OF CALIFORNIA CHONDRICHTHYANS: DETERMINING ESSENTIAL BIOLOGICAL INFORMATION FOR EFFECTIVE MANAGEMENT OF BYCATCH AND EMERGING FISHERIES

**California Sea Grant Project R/F – 199: Final Report**
*National Sea Grant College Program of the U.S. Department of Commerce's National Oceanic and Atmospheric Administration under NOAA Grant no. NA04OAR4170038*

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**29 May 2007**

**SUMMARY:**
In cooperation with NMFS Northwest Fisheries Science Center and Southwest Fisheries Science Center, Santa Cruz Lab, researchers from the Pacific Shark Research Center/Moss Landing Marine Laboratories have been participating and assisting in groundfish surveys since 2002. Vertebrae for age and growth estimation, reproductive tracts, and/or stomachs for feeding analyses were collected from over 5,000 specimens. Studies on the age and growth of the roughtail (*Bathyraja trachura*) and sandpaper (*Bathyraja kincaidii*) skates were completed, with one paper having been published and another having been accepted for publication. Age and growth studies for several other commonly encountered chondrichthyans are continuing. Studies on the reproductive biology of the big (*Raja binoculata*), California (*Raja inornata*), longnose (*Raja rhina*), roughtail, and sandpaper skates, and the white-spotted chimaera (*Hydrolagus colliei*) were completed and manuscripts are currently being prepared for publication. A study on the reproductive biology of three deepsea catsharks (Scyliorhinidae) was completed, with two publications currently *in press*. Dietary studies were completed for four species, the big, California (*Raja inornata*), longnose, and sandpaper skates, with analyses continuing for several other species. Research results for this project have resulted in two Masters Theses, ten publications, and 18 presentations at seven conferences. This project funded two California Sea Grant trainees both of whom worked on projects that served as their Masters Theses.

***Keywords:*** Chondrichthyans, life history, bycatch

**INTRODUCTION:**

Global chondrichthyan (sharks, rays, and chimaeras) populations are currently being fished at their highest levels historically (Bonfil 1994; FAO 1997). Regional evidence of this pattern has been documented on the United States west coast where chondrichthyan landings have been rapidly increasing among groundfish fisheries (Camhi 1999). The increasing exploitation of this group is especially alarming because many aspects of their biology (e.g. long life span, slow growth, low fecundity, and late age at maturity) may severely restrict their ability to sustain fishing pressure or recover from overexploitation (Cailliet 1990; Cailliet and Goldman 2004; Hoenig and Gruber 1990; Holden 1974; Stevens et al. 2000; Walker and Hislop 1998). Closely related species have been reported to respond in dramatically different ways to the same levels of fishing effort, necessitating a detailed understanding of life history traits in order to establish sustainable management practices (Stevens 1999). However, knowledge of such basic life history traits is unavailable for most exploited species. This lack of essential information is of serious concern to management agencies responsible for developing strategies for sustainable fisheries. Although attention has been drawn to targeted species such as the shortfin mako (*Isurus oxyrinchus*) and common thresher (*Alopias vulpinus*) sharks, and to the collapse of historic shark fisheries, such as the California soupfin shark (*Galeorhinus galeus*) fishery (Cailliet et al. 1992), less attention has been focused on those species taken in bycatch fisheries. These chondrichthyan groups include, but are not exclusive to, the catsharks (Scyliorhinidae), skates (Rajiformes) and the poorly known chimaeras (Chimaeriformes).

Sharks and skates, collectively known as elasmobranchs, have long been a significant component of bycatch and discard in eastern North Pacific (ENP) trawl fisheries. In Alaskan waters alone it has been estimated that approximately 48 million pounds of skate bycatch is discarded (Camhi 1999). This number likely underestimates the actual discard amount since bycatch data are not well documented. Despite their abundance in landings throughout the ENP, very little is known of the biology or distribution of these chondrichthyans throughout the region.

In the North Atlantic, fishing pressure has notably impacted the abundance, population structure, and distribution of several elasmobranch species, emphasizing the need for baseline biological information of this poorly known group (Dulvy et al 2000; Frisk et al. 2002; Walker and Hislop 1998). For example, populations of the barn door skate (*Dipturus laevis*) are believed to have declined by more than 95% due to bycatch landings in Canadian and New England groundfish fisheries (Casey and Myers 1998). These declines have prompted the National Marine Fisheries Service (NMFS) Office of Protected Resources to consider listing this species under the Endangered Species Act. The gray skate (*Dipturus batis*) has reportedly been extirpated in regions of the Irish Sea due to bycatch overfishing (Brander 1981). Studies in the North Sea have revealed that skates have quite discrete distributions, and these species may vary widely in their age and length at maturity (Walker and Hislop 1998). Thus, each species will be affected differently by fishing pressure.

Skate fisheries along the California coast have historically been of relatively little economic value (Zorzi and Martin 2001). In 1999, the total economic value ex-vessel was approximately $340,000. However, over the past decade the biomass of commercial skate landings have increased ten-fold from about 228,566 pounds in 1989 to 1,912,695 pounds in 1999. Skate fishery landings in California appear to have increased as targeted shark fisheries have declined due to increased management and regulations (Figure 1). It appears that as shark fisheries have declined skate fisheries have been on the increase. These numbers should be viewed with caution as this increase merely reflects an increase in landings and does not indicate the amount of skate bycatch that is discarded in these groundfish fisheries. It has been estimated that for every ton of chondrichthyans that is landed, an equal amount is discarded (Camhi 1999). Therefore, the true impact on the skate population is uncertain.

Skates are one of the more visible components of bycatch fisheries due to their large size and the fact that they are occasionally landed as supplemental income for the vessel. Other chondrichthyan species, predominantly catsharks and chimaeras, are virtually ignored and are rarely recorded as bycatch even though they may be taken in considerable numbers. Catsharks are generally small, flabby bodied, and their meat is of poor texture. They appear to be taken in considerable numbers in trawl and longline fisheries, but the impact on their populations is virtually unknown. Although chimaeras are commercially fished in Asia, Chile, New Zealand, South Africa and elsewhere, and have even been imported into California, they have never been commercially landed in California (Kato 1992). The white-spotted chimaera (*Hydrolagus colliei*) is commonly taken in trawl nets and on long-lines fishing near the bottom, and may represent a sizeable underutilized resource in California.

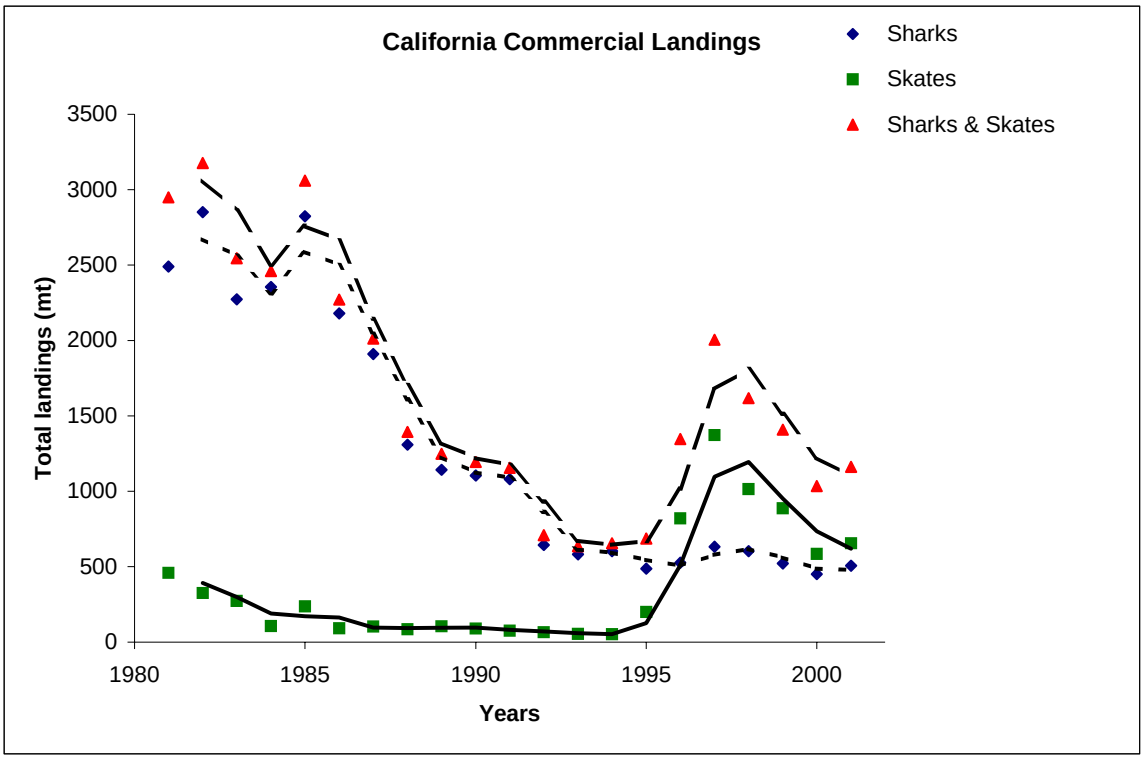


Figure 1. The California commercial landings of sharks, skates, and sharks and skates combined from 1980-2001.

Renewed local interest in directed fisheries for skates in particular, emphasizes the urgent need for life history studies of chondrichthyans taken as bycatch in California waters. Therefore, in an effort to fill this gap in knowledge, the Pacific Shark Research Center (PSRC) at Moss Landing Marine Laboratories (MLML) have been collaborating, since 2002, with the National Marine Fisheries Service Santa Cruz Laboratory (NMFS SCL), Santa Cruz, California and Northwest Fisheries Science Center (NMFS NWFSC), Newport, Oregon, to study chondrichthyans obtained from their ongoing shelf and slope groundfish survey efforts along the California coast. Successful completion of these directed life history investigations will provide west coast managers with essential information necessary to curtail or avoid potential chondrichthyan population declines as have been reported from the Atlantic.

**BACKGROUND:**

In 2002, Congress approved funding for a National Shark Research Consortium (NSRC) to augment NMFS information on the biology of chondrichthyans with the goal of better managing this important, but often overlooked group of fishes. The NSRC has four member institutions, of which three (Mote Marine Laboratory's Center for Shark Research; the Florida Program for Shark Research at the Florida Museum of Natural History, University of Florida; and the Virginia Institute of Marine Science Shark Research Program) are located on the east coast of the United States. The PSRC at MLML is the sole west coast representative of the NSRC.

To determine what scientific information is currently available for ENP chondrichthyans, PSRC personnel developed a life history data matrix (LHDM) incorporating the 105 species known to inhabit the waters between Cabo San Lucas, Mexico, and the eastern Bering Sea. The LHDM was compiled using all pertinent literature to analyze what is known and, more importantly, what is not known about the life histories, distributions, and population dynamics of these cartilaginous fishes. The format of this database allows those interested to quickly access species-specific information including: diet, fecundity, genetic variance, growth rates, intrinsic rates of population increase, longevity, mortality estimates, movement patterns, nursery areas, parasites, size-at-birth and maximum size, taxonomy, reproductive cycles, and other biological parameters. Life history aspects for which there is no available ENP information is clearly noted in the matrix and will help to guide PSRC and NMFS personnel toward research projects that will address these gaps in knowledge. The completed ENP chondrichthyan LHDM is available to fisheries management agencies and the general public through the PSRC website (http://psrc.mlml.calstate.edu). The LHDM is considered to be a dynamic product and will be periodically updated as new information becomes available.

**PROJECT GOALS:**

The apparent decline of some once common North Atlantic skate species highlights the urgent concern for management of chondrichthyans taken as bycatch in groundfish fisheries. In the ENP virtually no life history information exists for most of the common skate species that occur along the California coast. Additionally, of the approximately 22 batoids known from California waters, only five species, two of which are skates, are officially recognized in the California Department of Fish and Game's (CDFG) taxonomic categories for landings statistics. Most federal and state fisheries management agencies lack any detailed species-specific records of chondrichthyan landings. This lack of life history data is of serious concern since many of these species are taken in large numbers and the impact fisheries have on these populations cannot be assessed. In an effort to address the critical need for biological information necessary for formulating effective management strategies, this study integrated multiple life history studies.

The objectives of this project are contained in four main components and applied to the most commonly observed species. These four components include; 1) age and growth, 2) reproductive biology, 3) diet and feeding ecology and 4) tag and recapture. The objectives of the first component were to determine age and growth estimates for those chondrichthyans that are commonly caught as bycatch in California groundfish fisheries. Using techniques reviewed by Cailliet and Goldman (2004), we examined vertebrae, and other structures such as caudal thorns on skates, to determine whether they would serve as reliable ageing structures. If the use of caudal thorns, and dorsal fin spines, were to prove successful this potentially would provide a non-lethal ageing method for those species.

Knowledge of the reproductive biology of most ENP chondrichthyans is either unknown or extremely limited, but is necessary for effective management (Ebert 2003). The objective of this second component was to examine, analyze, and determine the reproductive parameters for each of the various species encountered during this study.

Determination of the size at maturity, seasonal cycles (if they exist), and fecundity of those commonly caught species is of crucial importance for management purposes.

The third component, diet and feeding ecology is of central importance in determining predator-prey relationships to better understand the trophodynamics and community structure of the demersal chondrichthyan assemblages. Since chondrichthyan fishes typically occupy high trophic levels, it is especially important to determine their diets and feeding ecology in order to elucidate any top-down effects on the ecosystems they inhabit (Cortes 1999; Shears and Babcock 2002). Additionally, trophic differences are often the main limiting factor affecting the distribution and abundance of marine fish species (Ross 1986). Through determination of temporal, spatial, inter-gender, and ontogenetic differences in diets, the degree of dietary overlap among and within co-occurring chondrichthyan species can be assessed and the resource requirements and feeding relationships of this assemblage can be better understood.

Tagging studies, the fourth component, involves the capture, marking, and release of study species. Subsequent recapture of tagged individuals by commercial and recreational fishermen or scientific surveys will provide information on abundance, movement patterns, growth, fishing intensity, and mortality rates (Casey et al. 1988; Kohler and Turner 2001). This information is extremely valuable to fisheries managers who incorporate these details to assess population status and the rate at which animals are being removed from the population in order to set harvest levels.

**METHODS:**

Chondrichthyans were collected from fishery independent surveys conducted by the NMFS SCL and NMFS NWFSC. The NMFS SCL began conducting monthly groundfish trawl and longline surveys off the central California coast in November 2001. Trawls are conducted over soft bottom substrate while long-line surveys are carried out on rocky reefs. NMFS SCL has been providing chondrichthyan samples to PSRC/MLML from these ongoing groundfish surveys. In addition, researchers from PSRC/MLML have been assisting and obtaining samples from NMFS NWFSC groundfish surveys conducted along the entire California shelf and slope, and down to 1,200 m deep. These samples have provided a rare opportunity to advance life history studies on numerous chondrichthyan species that are commonly taken as bycatch in groundfish fisheries. Those specimens that were retained from each cruise were identified, sexed, measured to the nearest centimeter, and weighed to the nearest 0.1 kg. The maturity status of those individuals examined was classified as an adult, adolescent, or juvenile.

Age determination and validation studies were undertaken to obtain essential information on the growth rates and longevity of selected species. Chondrichthyan vertebrae have proven to be useful structures for estimating the age and growth rates of these fishes. In addition, the suitability of skate caudal thorns as an ageing structure was investigated as a means for providing a non-lethal ageing technique for this group (Cailliet 1990; Cailliet and Goldman 2004; Gallagher and Nolan 1999). A minimum of eight vertebral centra were excised from a region posterior to the cranium between the $5^{th}$ and $20^{th}$ vertebral elements. Caudal thorns were removed from the anterior caudal region of skates. Multiple techniques were implemented to enhance banding patterns for age determination. Confirmation of the periodicity of growth increment deposition for all size classes was attempted using marginal increment and centrum edge analyses. Age-at-

size estimates based upon microscopic examination of vertebrae and other calcified structures were fit to appropriate growth models (including von Bertalanffy, Gompertz, and logistic) to describe population and individual growth characteristics for each species and sex.

PSRC researchers in collaboration with the NMFS SCL collected and examined the reproductive tracts of chondrichthyans taken during monthly research cruises in central California. Egg cases or embryos, when present, were examined, removed, and preserved. Temporal variation in gonad and liver weights were assessed in relation to size, sex, and reproductive condition. The number of ovarian eggs, uterine eggs, and oviducal gland width were plotted against total length and season to determine the maturity and the reproductive cycle. Detailed information on fecundity, reproductive cycles, and size-at-first, -50%, and 100%, and maturity was assessed for those species in which sufficient data were collected.

To determine diet and feeding ecology of California chondrichthyans, stomach content samples were collected from NMFS SCL groundfish surveys and NWFSC slope surveys. The foregut of each specimen examined was excised and stored frozen. Upon examination, prey items were identified to lowest possible taxon, enumerated, and weighed to the nearest 0.01 g. Single indices such as percent number (%N), percent weight (%W), and percent frequency of occurrence (%FO) were calculated (Hyslop 1980) and used as inputs for compound indices, such as the Index of Relative Importance (%IRI) and Geometric Index of Importance (%GII) (Pinkas et al. 1971; Cortes 1997; Assis 1996). Cumulative species curves were constructed to determine if sample sizes are large enough to adequately characterize the diet of each species (Hurturbia 1973; Ferry and Cailliet 1996). The feeding habits and dietary overlap of those central California chondrichthyans studied were examined in relation to depth, size, sex, habitat, and season to determine whether any dietary differences related to these factors exist. Power analyses were conducted prior to dietary comparisons to ensure adequate sample size (Ferry and Cailliet 1996). Indices (e.g.; Morisita's and Horn's) and multivariate statistics (e.g. multidimensional scaling, correspondence analyses) were used for comparison of dietary overlap (Krebs 1999; Platell et al. 1998). Once the diet has been characterized for each species, inter-specific dietary comparisons will elucidate the possibility of resource partitioning among this demersal elasmobranch assemblage. Completion of these studies will allow researchers to document feeding relationships, assess future changes in these relationships, and predict possible trophic cascades due to removal of these apex predators.

In cooperation with NMFS personnel, PSRC researchers began tagging chondrichthyans during monthly fishery-independent research surveys in central California. Skate and shark species were captured with long-line and trawl gear, measured, and marked using a coded, plastic identification tag inserted into the dorsal musculature. An injection of the antibiotic oxytetracycline (OTC) was given to selected captured skates in the dosage of 25mg/kg (Holden and Vince 1973; Smith 1984; Simpfendorfer 2000).

**GOALS ACCOMPLISHED:**

***Age and growth:*** Age determination and validation studies are continuing to fill critical gaps in the life history of poorly studied species. Studies completed and currently being written up for publication includes the sandpaper (*Bathyraja kincaidii*), roughtail (*Bathyraja trachura*), California (*Raja inornata*) and longnose (*Raja rhina*) skates. Age estimates have been, or are currently being, calculated for all of the aforementioned species with ages at 50% maturity estimated for the sandpaper skate at 6.8 years for females and 7.3 years for males, roughtail skates at 9 years for females and 10 years for males, California skate at 8 years for females and 7 years for males, and longnose skates at 16 for females and 14 for males. The sandpaper skate and roughtail skate age and growth studies were completed as Masters Theses. Results from the roughtail skate study were presented at an international symposium on the "*Biology of Skates*" and was published as part of a special issue that resulted from this symposium. A manuscript on the sandpaper skate age and growth has been accepted for publication while the California skate study is presently being written up for publication. A collaborative effort between PSRC personnel and researchers at Oregon State University has resulted in the completion of a Masters Thesis on the age and growth of the longnose skate. Additional age and growth studies on other ENP chondrichthyans, including the starry skate (*Raja stellulata*) and white-spot chimaera, are continuing.

The growth characteristics of the California skate are being determined using three ageing structures and seven different growth models. The suitability of neural arches and caudal thorns as alternative ageing structures was examined. Neural arches appear to be poorly calcified and lack patterns that could be consistently interpreted for age estimation. Our analysis suggests that caudal thorns of this species grow at differential rates or are replaced and therefore also do not appear to be a suitable ageing structure for this species. Caudal thorns are continuing to be prepared and examined for other skates for potential use as a non-lethal means to age skates.

***Reproduction:*** Investigations of the reproductive biology based on 304 California, 1,179 longnose, 589 roughtail, and 296 sandpaper skates have been completed. Two studies, one each on the roughtail and sandpaper skates, were completed as Masters Theses, with manuscripts from each study currently in preparation. Reproductive studies of the big, California, and longnose skates are complete and are currently being written up by PSRC staff. A study on the reproductive biology and distribution of three ENP deepsea catsharks, brown (*Aprisuturus brunnerus*), longnose (*Apristurus kampae*), and filetail (*Parmaturus xaniurus*) catsharks was completed as a Masters Thesis with two papers, both *in press*, having resulted from that study thus far. Key findings include total length at first, 50% and 100% maturity were determined for males and females of all three catshark species. Results show that at higher latitudes, brown and filetail catsharks reached sexual maturity at larger sizes. Brown and filetail catsharks reproduce year-round, based on the temporal occurrence of gravid females and the lack of seasonal variation in gonadosomatic (GSI) and hepatosomatic indices (HSI) for both males and females. Gravid longnose catshark females were found from July through December. The egg case of the longnose catshark has been described and its morphology compared to the egg cases of the brown, filetail and other *Apristurus* species. Additional studies on

the reproductive biology of other ENP chondrichthyans, including the starry skate and white-spot chimaera, are continuing.

***Diet and Feeding Ecology:*** Dietary analyses of sandpaper, big, California, and longnose skate feeding ecology have been completed with three papers having been published thus far. The sandpaper and longnose skate studies were presented at an international symposium on the "*Biology of Skates*" that was held in conjunction with the annual American Elasmobranch Society meetings in July 2006; both papers were published in a special issue on skates resulting from this symposium. Dietary analysis of big and California skates has been completed with manuscripts for both species currently in preparation. Both the sandpaper and longnose skate studies were completed as Masters Theses. Key findings from the approximately 493 sandpaper skates that were examined included shrimps, euphausids, and mysids being the primary prey items, followed by polychaetes, teleosts (*Sebastes* spp.), and cephalopods. Prey items from approximately 618 longnose skate stomachs were examined and identified. The main prey items appear to be teleosts, crangonid shrimps, and euphausiids. Dietary analysis of 205 big and 287 California skates has been completed. The big skate feeds primarily on demersal teleosts, crustaceans, and cephalopods, whereas the California skate feeds mainly on benthic shrimp, crabs, and demersal teleosts.

***Tagging:*** Approximately 100 elasmobranchs were tagged and released. To date no individuals have been recaptured.

**BENEFITS:**

Results from this study to date has contributed much needed basic and applied research on, and public understanding of, sharks and their relatives. Of the 43 chondrichthyan species known to occur in California waters, life history information prior to this project was available for fewer than 15 species. This lack of essential knowledge for many common chondrichthyan species is of immense concern to fishery agencies responsible for developing management plans for this group of fishes. Thus, the primary beneficiaries of this project are the NMFS and CDFG. Without the cooperation of MLML and PSRC, chondrichthyans taken on NMFS surveys would be identified, measured, and discarded without any further biological data being collected. Although the NMFS and CDFG consider life history information on chondrichthyans to be of critical importance, a lack of expertise and limited resources has constrained its ability to collect these species and develop necessary life history studies. Results of these directed research projects to date have provided critical life history information that is essential for developing sustainable fisheries management strategies for sharks, skates, and chimaeras in California waters.

**SUMMARY OF PUBLICATIONS AND CONFERENCES:**

Research results for this project, as of 29 May 2007, have resulted in ten publications and 18 presentations at seven conferences.

***Publications (as of 29 May 2007):***

Bizzarro, J.J., Robinson, H.J., Rinewalt, C.S., & Ebert, D.A. 2007. Comparative feeding ecology of four sympatric skate species (*Bathyraja* and *Raja* spp.) off central California, U.S.A. Environmental Biology of Fishes, DOI 10.1007/s10641-007-9241-6

Davis, C.D., Cailliet, G.M., & Ebert, D.A. 2007. Age and growth of the roughtail skate, *Bathyraja trachura* (Gilbert, 1892), from the eastern North Pacific. Environmental Biology of Fishes. DOI 10.1007/s10641-007-9224-7

Ebert, D.A. & Bizzarro, J.J. 2007. Standardized diet composition and trophic levels in skates. Environmental Biology of Fishes. DOI 10.1007/s10641-007-9227-4

Ebert, D.A. & C.D. Davis. 2007. Description of skate egg cases (Chondrichthyes: Rajiformes: Rajoidei) from the eastern North Pacific. Zootaxa, 1393: 1-18.

Ebert, D.A. & Sulikowski, J.A. *In press*. Biology of skates. (eds.) Environmental Biology of Fishes.

Flammang, B.E., Ebert, D.A., & Cailliet, G.M. 2007. Reproductive biology of deep-sea catsharks (Chondrichthyes: Scyliorhinidae) of the eastern North Pacific. Environmental Biology of Fishes. DOI 10.1007/s10641-006-9162-9

Flammang, B.E., Ebert, D.A., & Cailliet, G.M. *In press*. Egg cases of the genus *Apristurus* (Chondrichthyes: Scyliorhinidae): phylogenetic and ecological implications. Zoology

Perez, C.R., Cailliet, G.M., & Ebert, D.A. *Accepted*. Age and growth of the sandpaper skate, *Bathyraja kincaidii* (Garman, 1908) off central California, USA. Submitted to Marine and Freshwater Research

Rinewalt, C.S., Ebert, D.A., & Cailliet, G.M. 2007. Food habits of the sandpaper skate, *Bathyraja kincaidii* (Garman, 1908) off central California: seasonal variation in diet linked to oceanographic conditions. Environmental Biology of Fishes. DOI 10.1007/s10641-007-9218-5

Robinson, H.J., Cailliet, G.M, &. Ebert, D.A. 2007. Dietary analysis of the longnose skate, *Raja rhina* (Jordan and Gilbert, 1880), in California waters. Environmental Biology of Fishes. DOI 10.1007/s10641-007-9222-9

***Presentations (as of 29 May 2007)*:**

Bizzarro, J.J., Robinson, H., Rinewalt, C.S., and Ebert, D.A. (2006) Resource partitioning among four central California, U.S.A. skate species. *American Elasmobranch Society*

Bizzarro, J.J., Robinson, H., Rinewalt, C.S., and Ebert, D.A. (2006) Resource partitioning among four central California, U.S.A. skate species. *CalCOFI*

Bizzarro, J.J., Smith, W.D., Ebert, D.A., and Cailliet, G.M. (2005) Life history of the California shark (*Raja inornata*). *American Fisheries Society meetings*

Davis, C., Cailliet, G.M., and Ebert, D.A. (2006) Age and growth of *Bathyraja trachura* (Gilbert, 1892) from the eastern North Pacific. *American Elasmobranch Society*

Davis, C., Cailliet, G.M., and Ebert, D.A. (2006) Age and growth of *Bathyraja trachura* (Gilbert, 1892) from the eastern North Pacific. *Western Groundfish Conference*

Ebert, D.A. and Bizzarro, J.J. (2006) Standardized diet composition and trophic levels in skates. *American Elasmobranch Society*

Ebert, D.A. and Bizzarro, J.J. (2006) Standardized diet composition and trophic levels in skates. *CalCOFI*

Ebert, D.A., Cailliet, G.M., Barnett, L.A.K., Rinewalt, C.S., Smith, W.D., Bizzarro, J.J. (2006) Life history studies of California chondrichthyans: determining essential biological information for effective management of bycatch. *Western Groundfish Conference*

Ebert, D.A., Smith, W.D., Bizzarro, J.J., and Cailliet, G.M. (2005) Skate research in the eastern North Pacific. *American Fisheries Society meetings*

Flammang, B.E., Ebert, D.A., and Cailliet, G.M. (2005) Distribution and reproductive biology of deep-sea scyliorhinids of the eastern North Pacific. *7th Indo Pacific Fish Conference*

Rinewalt, C.S., Ebert, D.A., and Cailliet, G.M. (2006) Diet and ecomorphology of the sandpaper skate, *Bathyraja kincaidii* (Garman 1908): implications for feeding and reproduction. *American Elasmobranch Society*

Rinewalt, C.S., L.A. Ferry-Grahman, D.A. Ebert, and G.M. Cailliet (2007) The importance of intra-specific differences in the tooth and jaw morphology of the sandpaper skate, *Bathyraja kincaidii*: food or mates? *American Elasmobranch Society*

Robinson, H., Cailliet, G.M., and Ebert, D.A. (2006) Food habits of the longnose skate, *Raja rhina* (Jordan and Gilbert, 1880), in central California waters. *Western Groundfish Conference*

Robinson, H., Ebert, D.A., and Cailliet, G.M. (2006) Dietary analysis of the longnose skate, *Raja rhina* (Jordan and Gilbert, 1880), in central California waters. *American Elasmobranch Society*

Robinson, H., Ebert, D.A., and Cailliet, G.M. (2005) Food habits of the longnose skate, *Raja rhina* (Jordan and Gilbert, 1880), in central California waters. *American Elasmobranch Society*

Robinson, H., Ebert, D.A., and Cailliet, G.M. (2005) Food habits of the longnose skate, *Raja rhina* (Jordan and Gilbert, 1880), in central California waters. *Western Society of Naturalists*

Smith, W.D., Bizzarro, J.J., Cailliet, G.M., and Ebert, D.A. (2006) Life history of the California skate (*Raja inornata*). *Western Groundfish Conference*

Smith, W.D., Perez, C.R., and Ebert, D.A. (2005) Growth of the California skate, *Raja inornata*: assessment of multiple ageing structures and somatic growth models. *American Elasmobranch Society*

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Rinewalt, C.S. 2007. Diet and ecomorphology of the sandpaper skate, *Bathyraja kincaidii* (Garman, 1908): implications for feeding and reproduction. Masters of Science thesis, Moss Landing Marine Laboratories, CSU Monterey Bay.

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**SYMPOSIUM:**

Ebert, D.A. & Sulikowski, J.A. co-organizers: International Symposium on the "Biology of Skates" held in conjunction with the 22nd annual meeting of the American Elasmobranch Society meetings, 13-14 July 2006.

**MEDIA COVERAGE:**

Santa Cruz Sentinel newspaper story 27 April 2005

California Sea Grant Science article 13 April 2007:

"Researchers Develop a Key for Identifying Skates from Their Egg Cases" (http://www.csgc.ucsd.edu/STORIES/SkateEggCases.html)

**COOPERATING ORGANIZATIONS:**

NOAA Fisheries, Northwest Fisheries Science Center, Newport, OR

NOAA Fisheries, Southwest Fisheries Science Center, Santa Cruz, CA

**TRAINEES:**

Christopher S. Rinewalt, California State University Monterey Bay, completed M.S. May 2007

Lewis A.K. Barnett, California State University Monterey Bay, M.S. December 2007

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