DEPARTMENT OF COMMERCE * UNITED STATES OF AMERICA *

Southwest
FISHERIES SCIENCE CENTER

HONOLULU LA JOLLA MONTEREY TIBURON

REPORT OF ACTIVITIES First Quarter 1995

SOUTHWEST FISHERIES SCIENCE CENTER

CENTER ADMINISTRATION- La Jolla, California

This report does not constitute a publication and is for information only. Its contents should not be cited or reproduced.

Editor: Esther Perez
Layout: Roy Allen

The Report of Activities of the Southwest Fisheries Science Center is compiled at La Jolla from material submitted by the Center's staff. To change the delivery address of the Report of Activities, or to cancel your subscription, please notify Esther Perez, at P.O. Box 271, La Jolla, CA 92038-0271. Telephone: (619) 546-7058.

ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

1995 AMLR Predator/Prey Research Completed

On March 4, 1995, the NOAA Ship *Surveyor* returned to the port of Punta Arenas, Chile, completing the U.S. Antarctic Marine Living Resources (AMLR) program's annual investigation of predator/prey interactions in the waters surrounding Elephant Island, South Shetland Islands, Antarctica. The AMLR program, which is managed by the Antarctic Ecosystem Research Group (AERG) at the Southwest Fisheries Science Center (SWFSC) in La Jolla, California, has been conducting predator/prey research in this 15,000-square-mile area of the Southern Ocean for seven consecutive austral summers. The AMLR program provides information needed to formulate U.S. policy on the conservation and international management of resources living in the oceans surrounding Antarctica. The program advises the U.S. delegation to the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), part of the Antarctic treaty system.

The Seal Island field camp was reactivated on November 30, 1994, when the field team arrived via the tourist ship *Explorer*. The team included John Bengtson, Mike Cameron, Lisa Hiruki, John Jansen, and William Meyer, all of the National Marine Mammal Laboratory (NMML), and Fishery Biologist Rennie Holt (SWFSC). After setting up satellite communication and radio systems, and various camp structures, scientific operations were immediately started.

In conjunction with studies on foraging behavior and time spent ashore, 40 female Antarctic fur seals, *Arctocephalus gazella*, were instrumented with radio transmitters in early December. Time-depth recorders (TDRs) were deployed on 18 of the 40 females to provide detailed information on diving behavior. In addition, 10 other female fur seals were instrumented with satellite-linked transponders to provide more information on foraging locations of these animals. Capture and release of the animals during instrumentation proceeded very smoothly.

The first census of chinstrap penguins, *Pygoscelis antarctica*, was also conducted in early December. The census was designed to estimate the number of penguins attempting to breed in ten colonies representing a diversity of nesting habitats at Seal Island. In addition, a census of macaroni penguins, *Eudyptes chrysolophus*, was conducted. As part of a study on penguin demography, efforts were begun to resight penguins which had been banded as chicks over the last seven years.

Thirty-eight adult chinstrap penguins were equipped with radio transmitters; 12 from nests with one member of each nesting pair instrumented and 13 from nests with both members of the pair instrumented. In association with foraging behavior studies, the attendance of each bird to its nest was monitored every 15 minutes. For the offshore tracking study, an additional 27 chinstrap penguins were instrumented with radio transmitters; 21 of these animals also received TDRs. To provide detailed information on chinstrap penguin diving behavior at sea and how that behavior may change with the progression of the breeding season, 34 other chinstrap penguins were equipped with TDRs.

On December 16, Bengtson, Meyer, and Cameron embarked the Japanese research vessel *Kaiyo Maru* to take part in cooperative studies with scientists from the National Institute of Far Seas Fisheries of Japan. The main goals of the study were to track predators (antarctic fur seals and chinstrap penguins) as they left Seal Island on foraging trips and to sample the water column close to tracked animals (both acoustically and with nets) to determine the type and density of prey. Both fur seals and penguins, which had been previously instrumented with radio transmitters, were tracked using an automatic direction finding (ADF) system located on the island. Many of the tracked animals had been previously instrumented with TDRs also. By analyzing acoustic and net tow data, as well as TDR records from tracked animals, a better understanding of the type and density of prey that Seal Island predators typically encounter and how these factors influence their diving behavior can be gained. Meyer returned to Seal Island on December 25, while Bengtson and Cameron returned to Chile via *Kaiyo Maru*.

Preliminary analyses from the December *Kaiyo Maru* studies showed that a tracked chinstrap penguin used an iceberg as a resting platform. The diving profile recovered from the bird's TDR complemented shipboard observations and both indicated that the penguin expended considerable diving effort during forays into the water around the iceberg.

Diet samples were lavaged from five chinstrap penguins during the incubation phase as they returned from foraging trips at sea. The diet composition was dominated by krill, *Euphausia superba*, with evidence of lantern fish found in two of the samples. In addition, scat samples were collected from female fur seals tracked at sea to provide insight into their diet. The krill retrieved from both penguins and fur seals were analyzed by scientists aboard *Kaiyo Maru* as part of an effort to understand how predator prey preference relates to what is seemingly available to them.

The hatching of chinstrap penguins began on December 21, about three days later than last season. The first macaroni penguin chicks were seen on December 24, only one day later than last year. By the beginning of January, hatching of chinstrap penguin chicks was about 75 percent completed at one study colony known as Parking Lot colony. At this time, the field team also noted that due to the increasing number of chicks and their demand for food, parent birds shifted their foraging strategy by increasing the frequency of trips to sea. This change was reflected by a dramatic increase in the number of birds transiting the beach area in front of the field camp.

In the first few days of January, monitoring of fur seal pup growth rates began. One hundred pups were weighed individually, and the procedure was repeated at biweekly intervals throughout the season. After the first weighing, mean weights for both male and female pups were found to be typical as compared to past seasons. Daily censuses at two rookeries on the island and biweekly island-wide censuses showed an increase in the number of subadult fur seal males moving into the Seal Island area.

By mid-January, daily counts of fur seal pups began to decline from a total of 196 to about 150. As in past years, this trend was attributed to predation on pups by leopard seals, *Hydrurga leptonyx*. Eight pups were observed taken by one female leopard seal in North Cove. This female, identified by a tag applied last year, was the same leopard seal observed hunting pups in the 1993/94 season. Although only this tagged female was observed hunting, a second adult leopard seal was observed at the entrance to the cove on two days while she was hunting, and it appeared that the tagged seal released the pups to the other seal before proceeding to capture another pup. This is the first observation of leopard seals feeding together at Seal Island.

The *Surveyor* departed from Punta Arenas via the eastern end of the Straits of Magellan on January 11, 1995. The ship arrived at Seal Island on January 14, and fresh food provisions and other supplies were offloaded to the field team on the island. In addition, two additional team members, Peter Boveng (NMML) and William Cobb (SWFSC), were transported to the island. The weather was fair and the resupply was completed without incident. During the visit, ship and field team personnel conducted a census of fur seal breeding sites on several islets in the Seal Island archipelago.

On January 15, the ship traveled to King George Island where the acoustic system was calibrated. Two hull-mounted acoustic transducers were calibrated in the Martel Inlet of Admiralty Bay. Standard spheres were positioned beneath the transducers via downriggers and monofilament line. The beam patterns were mapped, and system gains were determined for each transducer. Following the calibration, an acoustic and net sampling survey for krill was conducted in Admiralty Bay in collaboration with Wayne Trivelpiece (NMML), who was conducting studies on the foraging behavior and reproductive performance of Adelie penguins, *Pygoscelis adeliae*, in the area.

On January 17, the scientific party initiated a large-area survey, consisting of 91 conductivity-temperature-depth (CTD)/rosette and net sampling stations, spaced along approximately 2,037 kilometers (1,100 nautical miles) of acoustic transects. The objectives of the large-area survey were to describe the distribution of krill and other zooplankton, to assess phytoplankton biomass and productivity, and to characterize the physical oceanography in the waters surrounding Elephant Island and the eastern end of King George Island.

During the acoustic transects, krill and other zooplankton were located using an acoustic survey system, comprised of a Simrad EK500 echosounder, two down-looking transceiver/transducer subsystems mounted in the ship's hull (120 kHz and 200 kHz), and two Sun SparcStations for data logging and postprocessing. Operations at each station included (1) measurements of temperature, salinity, oxygen, light transmission, and fluorescence; (2) collection of discrete water samples at standard depths for analysis of chlorophyll-*a* content, absorption spectra, particulate organic carbon and nitrogen content, primary production, ATP and DNA content, size fractionation, floristics, and inorganic nutrient content; and (3) deployment of a 6-ft (1.8 m) Isaacs-Kidd midwater trawl, fitted with a 505-

micron nytex net, to obtain samples of zooplankton and nekton (krill).

A second cooperative predator tracking study was conducted aboard *Kaiyo Maru* January 19-28. The foraging trips of tracked penguins in this study were found to be much shorter in duration (one day or less) to provide for their rapidly growing chicks. In contrast, tracked penguins in the December study made multiday trips while they were brooding their eggs. The shorter foraging trips limited the January birds' maximum foraging range to on-shelf and near-shelf zones. Fur seals, however, continued to make multiday foraging trips on and off the continental shelf in search of prey. During the study, prey in both these areas appeared to be abundant with krill and fish present in net tows conducted aboard *Kaiyo Maru*.

On Seal Island in late January, macaroni penguins completed creching at Parking Lot colony, prompting the field team to conduct a fourth census of the island's macaroni colonies. The creching stage is characterized by chicks being left unattended by both parents for the first time. Leaving chicks in the safety of the colony, both parents from a nest are free to forage simultaneously to meet the increasing food demand of the growing chicks. The importance of the colony becomes apparent as chicks that venture beyond its boundaries are quickly preyed upon by other large birds, including giant petrels, *Macronectes giganteus*. Also by late January, about 25 percent of chinstrap penguins chicks had creched.

In preparation for their first experience feeding at sea, fur seal pups began molting into their juvenile pelage in the last days of January. Also, penguin chicks began their final molt into their juvenile plumage: brilliant, slate-blue backs with white chests and the distinctive thin, black "chinstrap" markings on their chins.

The large-area survey on *Surveyor* was completed on January 29. Following that, a small-area acoustic survey was conducted to the north of Elephant Island from January 29 to February 1. Acoustic data were collected along a 56 by 56 kilometer (30 by 30 nautical mile) grid, and directed net sampling was conducted during dark hours upon krill swarms detected by the acoustic system.

On the morning of February 1, *Surveyor* again visited Seal Island to pick up Peter Boveng and William Meyer. During the visit, fur seal pups were counted on a small islet at the far end of the Seal Island archipelago. Upon departure from the island, a radio transmitter was towed behind *Surveyor* to calibrate the ADF system located on the island. A series of eight net-sampling stations were then conducted in the southeast corner of the study area to obtain specimens of Antarctic silverfish, *Pleuragramma antarcticum*. The ship then crossed the Drake Passage and returned to Punta Arenas on February 5. During the port call, the ship took on supplies and received scientific personnel for Leg II.

The ship departed from Punta Arenas for Leg II on February 8, this time via the Beagle Channel. After crossing the Drake Passage, the ship arrived at Seal Island on February 11. Supplies and mail were dropped off at the field camp during the visit. Immediately following the resupply visit to Seal Island, a small-area acoustic survey was conducted north of Elephant Island. The survey was similar to the one conducted on Leg I to describe the abundance, distribution, and density of krill within the foraging range of krill predators at Seal Island. The survey was completed on February 14.

A large-area survey, a replicate of the one conducted during Leg I, was conducted from February 15-26. Throughout the cruise, continuous measurements of incident visible radiation, spectral ultraviolet radiation, and meteorological parameters were recorded from shipboard sensors. Water temperature, salinity, light beam attenuation, and chlorophyll-*a* fluorescence were recorded from the ship's clean intake water line at a 5-meter depth.

On Seal Island, the fourth fur seal pup weighing session was completed in mid-February. One hundred pups were weighed and sexed at the two rookeries on the island. Also, TDRs were deployed on six chinstrap penguins still feeding chicks during the creche phase. Data on diving behavior during creching will be compared with diving data collected throughout the breeding season to assess potential changes in diving behavior in response to the growing demands of their chicks and changes in prey availability offshore, as indicated by studies aboard *Surveyor*.

Toward the end of February, chinstrap penguin chicks began to fledge. Fledging is a stage when the young penguins become independent of the parents and make their first trips into the water. With the initiation of fledging, the field team scientists turned their attentions toward capturing and weighing the fledglings. Chick weight at fledging provides an index of fledging condition for comparisons between breeding seasons. The team also collected various morphometric measurements from the birds (culmen length, culmen depth, wing chord length).

Following the completion of the large-area survey, the ship transited to Admiralty Bay at King George Island to calibrate the acoustic transducers for a second time. In addition, an abbreviated survey of prey availability in the Admiralty Bay area was conducted. Results of this small survey will be compared with diet samples obtained at a local Adelie penguin colony.

The Seal Island field team spent the last days of the season completing their observations of chinstrap penguin fledglings and the final stages of closing the field camp. On March 2, the ship called at the island to retrieve the entire field team. The ship then transited the Drake Passage to Punta Arenas, bringing to a close the predator/prey research of the 1995 AMLR field season.

Following a port call, *Surveyor* departed Punta Arenas on March 9 for Leg III, bound for the island of South Georgia. Originally, the planned scientific operations called for the ship to operate between the 100- and 350-meter depth contours surrounding South Georgia. Bathymetric mapping surveys, using the ship's Seabeam system, were to be conducted during dark hours. Also, a remotely operated vehicle (ROV), equipped with a video camera, was to be used during daylight hours for benthic surveys to characterize the abundance and distribution of Antarctic crabs.

However, after completing two days of ROV operations, it became apparent that the ROV could not be safely deployed in offshore waters due to limited maneuverability of *Surveyor* and also because the ROV was not powerful enough to keep up with the ship as she drifted. Following this realization, a contingency plan was instituted in which ROV benthic surveys were conducted inside protected bays and anchorages along the northern coast of the island. The scientific objective of the new plan was to describe the different types of benthic species assemblages in the protected waters of South Georgia. Four key physical factors were used in picking dive sites: (a) exposure to offshore wave action and weather, (b) bottom slope, (c) proximity to former whaling stations, and (d) proximity to large glaciers.

During the first week (mid-March), three major dive sites were surveyed using the ROV. The first site in Rosita Harbor revealed a flat, topographically featureless bottom which was dominated by large (up to 1-meter tall) glass sponges. These sponges appeared to be the only habitat available for other benthic epifauna; very few animals, other than the sponges, were found living directly on the substrate of fine silt and clay. The distribution of the sponges was mapped, and data were collected to estimate sponge density.

The second surveyed site was located in Stromness Harbor; this site was similar to Rosita Harbor in all respects, except for the presence of an abandoned whaling station. Although it was expected that debris (whale bones, sunken ships, discarded equipment, etc.) might be found near the station, the ROV survey did not reveal any such items. The same glass sponges found in Rosita Harbor were also found here; however, tube-building polychaetes (marine annelid worms) were found to be the dominant fauna.

An exposed pinnacle at the mouth of Stromness Bay was the third site chosen for ROV operations. This part of Stromness has a significant bottom slope, and the site is considered to be exposed to wave action. The density of benthic epifauna appeared to be much lower than at the first two sites, but species diversity appeared to be higher than at either Rosita or Stromness Harbor.

During the rest of March and in the early part of April, nine more sites were visited along the northern coast of the island. Interestingly, each site's benthic community was unique: at Leith Harbor, ascidians were dominant; at Jason Harbor, tube-building polychaetes with symbiotic isopods; at Fortuna Bay (a site within 500 meters of a large, receding glacier), ophiuroids (brittle stars); at Godthul, tube-building polychaetes; at Gold Harbor (a solid rock bottom exposed to a nearby glacier), no animals; at Drygalski Fjord, polychaetes with calcareous tubes and sponges; at Moltke Harbor, soft corals and ophiuroids; at Cape Crewe, sponges and compound ascidians; and at Right Whale Bay, sparse densities of starfish, large isopods, and unidentified juvenile fish. A triangular dredge was fabricated to collect specimens at each dive site for species identification; dredge specimens served as "ground truth" for the ROV's video data.

Toward the end of Leg III, a hydrographic survey of a submarine canyon on the northern coast of South Georgia was conducted using the Seabeam system. During the 1992 austral winter, a U.S. fishing vessel spent considerable time fishing in this area for Antarctic crabs. The goal of the survey was to create a detailed bathymetric map of the sea floor in an area where crabs are known to occur. This information will be used in research on crab population dynamics in this area. The NOAA Ship *Surveyor* returned to Punta Arenas on April 7, bringing to a close a successful 1995 AMLR field season. (J. Rosenberg, 619-546-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

Environmental Regulations and Technical Efficiency: The Case of Tuna-dolphin Fishing

Government regulations that address environmental problems may affect the technical efficiency of firms in an industry. Technical efficiency is a measure of a firm's ability to produce relative to the best firms in the industry, that is, relative to the industry's "best-practice frontier." New regulations cause firms to alter their use of labor, capital, energy, natural resources, and other factor inputs in the production process. The changes required to comply with regulations often lower technical efficiency. To the extent that firms adapt to new regulations, technical efficiency may return to or exceed pre-regulatory levels. In the long term, environmental regulations may induce firms to invest in research and the development of new, more efficient and "environmentally friendly" production technologies.

The impact of environmental regulations on firms' technical efficiency has been given relatively little consideration. In view of this, Sam Herrick and Dale Squires (SWFSC, Industry Economists) and Kjell Salvanes (Norwegian School of Economics and Business Administration, Bergen-Sandviken, Norway) investigated the impact of the U.S. dolphin-safe policy on technical efficiency in the U.S. eastern tropical Pacific (ETP) purse seine tuna fishery. The data used in this study were records of individual sets from 34 U.S. purse seiners that operated in the ETP during one or more years from 1987 to 1991. The period 1987-1991 was chosen because it includes both the pre- and post-regulatory periods for regulations implementing the U.S. dolphin-safe policy.

Under the U.S. tuna processors' dolphin-safe policy, enacted in April of 1990, U.S. processors stopped buying tuna from suppliers who could not certify that the tuna was "dolphin safe." This decision essentially precluded purchases of any tuna caught using the predominant strategy of fishing on dolphins because some incidental dolphin mortality is unavoidable when engaging in "dolphin fishing." In response to the dolphin-safe policy, U.S. tuna fishermen switched to two alternative purse seine fishing strategies. In one, vessels set their purse seines around schools of tuna which are sighted at the surface, a strategy known as "school fishing." In the other alternative, called "log fishing," the purse seine is set around logs or other floating debris (natural or man-made) to catch tuna often associated with them. All three purse seine fishing strategies involve the same basic gear and operational techniques, and can be conducted during the same fishing trip.

A fishing vessel's technical efficiency is a measure of its ability to produce relative to the best-practice frontier in the fishery. The best-practice frontier is the maximum output (tuna production) possible from a given set of factor inputs (fuel, labor, etc.) and production technology (radar, purse seine, etc.). Technical efficiency for an individual vessel is basically measured as the difference between its output and the corresponding output at the best-practice frontier. If a vessel is not technically efficient, then it is likely that its production can be increased through better use of the existing technology (for example, changes in the way nets are deployed).

The best-practice frontier used in this study was assumed to include a random component in order to capture the positive and negative effects of factors, such as weather, that are beyond the control of vessel operators. The more technically efficient vessels are, the closer they will be to the best-practice frontier, and the smaller will be the difference between their production and the best practice frontier.

The best-practice frontier for purse seine operators was estimated using regression analysis. An index of yellowfin and skipjack catch was regressed on the following factor inputs: (1) short tons of holding capacity, a measure of capital stock; (2) effort, the number of hours spent searching for tuna between sets; (3) sea surface temperature, to reflect variation in the availability of tuna and fluctuations in the ocean environment over time; (4) a variable indicating whether or not helicopters were used for locating tuna and herding dolphins; (5) variables for the type of set (dolphin, school or log); and (6) a variable for the year in which the set took place.

The regression results indicated that, for the purse seine fishery as a whole, observed output was significantly less than the best practice frontier due to technical inefficiency rather than random factors, such as weather, beyond vessel operators' control. These findings suggest that there is scope for expanding production and raising technical efficiency in the U.S. fleet as a whole by improving fishing techniques.

The impact of the dolphin-safe policy on the U.S. ETP tuna fishery was assessed by investigating changes in technical efficiency for the three different purse seine fishing strategies before and after the policy was enacted. Scientists found that prior to the dolphin-safe policy, year-to-year differences in technical efficiency were nonexistent or minimal, and following the onset of the dolphin-safe policy, year-to-year differences in technical efficiency increased significantly.

Researchers hypothesized that the technical efficiency of vessels fishing continuously during 1987-1991 might be unaffected by dolphin-safe policies because of better fishing skills. In contrast, vessels that entered and exited the fishery might have been less efficient and affected by dolphin-safe policies because these vessels would have less opportunity to hone their fishing skills.

For the fleet as a whole, and for vessels that did not fish continuously, researchers found that technical efficiency decreased slightly after the dolphin-safe policies were implemented. Declines were small, probably because vessels were already using dolphin-safe fishing strategies. For vessels that fished continuously, there were no declines in technical efficiency and evidence for a small increase in technical efficiency for dolphin sets. These results suggest that vessels fishing continuously may have anticipated the dolphin-safe standard in 1989-90 and began to make adjustments before the policy was implemented.

The study's main result was that changes in technical efficiency after the introduction of the dolphin-safe policy were small. This result is consistent with studies of other industries that indicate environmental regulations (for instance, pollution controls) generally have had only modest effects on firm productivity. It may be that firms adapt to regulations unless environmental regulations require firms to substantially alter production practices or investments. If industry is forewarned about impending environmental regulations, as in the case of dolphin-safe fishing, adjustments can often be made to diminish the impact of regulations on technical efficiency and hence costs to the industry. (S. Herrick, 619-546-7111)

MARINE MAMMAL DIVISION

La Jolla, California

Comparison of California Sea Lion Pups Counted on the Ground to Pups Counted from Aerial Photographs

The Coastal Marine Mammal Program (CMMP) conducts annual counts of California sea lion pups at the end of their breeding season in July of each year. The counts are used as an index of the population, which are then used to estimate population growth rates and size of the population in the United States. The annual census is commonly conducted by biologists on the ground who walk near the sea lions. In 1987, the CMMP began using large-format aerial photography to conduct these censuses in order to reduce the amount of disturbance that is sometimes caused during a ground census and to make it easier to count large groups of pups that are encountered at San Miguel and San Nicolas Islands. An important question was "how do the counts from each method compare?"

Studies were conducted at San Nicolas Island in 1992-1994 to compare counts of pups by biologists on the ground to counts obtained from 126-mm format aerial color photographs. The surveys were conducted within a few days of each other. In 1992 and 1994, three biologists divided the island among themselves to obtain one ground census each year. In 1993, two biologists conducted ground surveys of the entire rookery one week apart to obtain four total ground censuses. In conjunction with these ground surveys, two photographic surveys were conducted in 1992 and 1994, and three were conducted in 1993.

At San Nicolas Island, California sea lions are found along approximately 16 km of coastline on the southern side of the island. This segment of the island was divided into 64 (unequal) areas that depicted rock or sand substrate, or mixtures of both. Pups were counted in 33 areas in 1992, 39 in 1993, and 37 in 1994. Paired samples *t*-test analyses were made of pup counts at these areas to evaluate the precision of each method. This analysis tests whether mean sample differences between pairs of readings are significantly different from zero and calculates the standard deviation difference. The results of this analysis indicated that counts obtained from aerial photographic censuses are more precise (standard deviation difference = 45.073) than counts obtained from ground censuses (standard deviation difference = 89.629). People counting on the ground have difficulty counting large groups (tend to count more than are present) and undercount in most areas, especially areas that are not completely visible to them (Fig. 1).

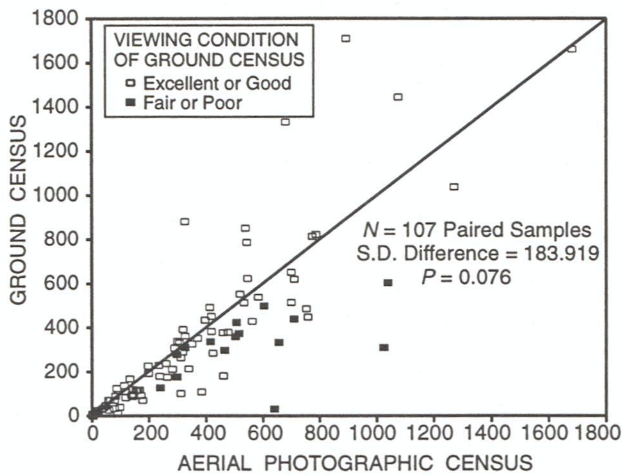


Figure 1. Comparison of counts of California sea lion pups that were made from aerial photographs and by biologists on the ground at the same areas of the rookery located at San Nicolas Island, 1992-1994. The line represents 1:1 (the counts would fall on the line if they were identical).

The total count of pups obtained by each method can be quite close (as in 1994), or very different (as in 1992; Fig. 2). In 1993, when multiple counts were made, the coefficient of variation (CV) for aerial photographic surveys was 0.040 and for ground surveys it was 0.067 (indicating greater precision in aerial photographic surveys).

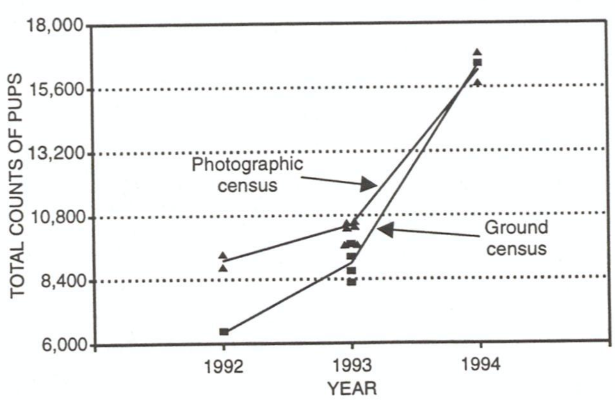


Figure 2. Total counts of pups at San Nicolas Island obtained from aerial photographic census and from ground census, with a line (through the mean when available) to demonstrate the general trend that would be observed by counts obtained from each method.

The results of this study imply that counts obtained from aerial surveys are more accurate than ground surveys. The trend depicted from aerial photographic surveys (and the population growth rate that would be calculated from it) would be more comparable to that of the population than would be interpreted from ground surveys (Fig. 2). (M. Lowry, 619-546-7174)

HONOLULU LABORATORY

Honolulu, Hawaii

PROTECTED SPECIES INVESTIGATION

Hawaiian Monk Seal Recovery Team Meets in Honolulu

The Hawaiian Monk Seal (*Monachus schauinslandi*) Recovery Team met at the Honolulu Laboratory December 6-7, 1994. Staff of the Marine Mammal Research Program (MMRP) presented data collected through the summer of 1994 on (1) status and trends in the populations at the species' major breeding sites and (2) the progress of the pup rehabilitation project and recent efforts to mitigate the mobbing problem at Laysan Island. Much discussion at the meeting was focused on (1) the continuing decline in abundance of seals at French Frigate Shoals and the proposed expansion of the pup rehabilitation project, (2) evaluation of the 1992 reintroduction of seals to Midway and further Midway population rebuilding efforts, (3) the absence of annual population assessment data from each of the five major breeding locations (Lisianski Island, Laysan Island, Pearl and Hermes Reef, French Frigate Shoals, and Kure Atoll) and Midway, (4) the need to perform mobbing-related monitoring of the Laysan Island population to assess the effects of the male removal that occurred in 1994, and (5) the critical need for more funding for the recovery program.

Minutes of the Recovery Team meeting containing the Team's recommendations for future recovery actions were forwarded to the Southwest Regional Director on February 24, 1995. In addition to the serious funding issue, important highlights of the recommendations included the need for annual population assessments at all sites, an evaluation of the methods used to estimate survival and abundance, development of island-specific population models, expansion of the pup rehabilitation capability with reintroduction of seals to Kure in 1995 and to Midway in 1996, and monitoring Laysan seals and establishing criteria for evaluating the effects of the male removal on female injuries and deaths. In addition, the Team decided to draft a proposed amendment to the Hawaiian monk seal recovery plan that would delineate the Team's research and recovery recommendations for the period 1996-98. A final version of this document will be completed later this year. (W. Gilmartin, 808-943-1239)

STOCK ASSESSMENT INVESTIGATION

International Symposium on Pacific Swordfish

Honolulu Laboratory scientists participated in the International Symposium on Pacific Swordfish held in Ensenada, Baja California, Mexico, December 11-14, 1994. The symposium was organized by the Centro de Investigación Científica y Educación Superior de Ensenada and the Southwest Fisheries Science Center. Funding was provided by the Mexican Swordfish Fishery Section of the National Fishing Industry Chamber (CANAINPES in Spanish), the Third World Academy of Sciences, and Northwest Marine Technology, Inc.

With growing market demand for swordfish, fisheries in the Pacific (including the Hawaii-based fishery and those off the west coast of the United States, Mexico, and Chile) have expanded significantly in recent years. The purpose of the symposium was to update information on the expanding Pacific swordfish fisheries, exchange knowledge of swordfish trends and swordfish biology, and stimulate international cooperation in swordfish research. Swordfish research programs in the Atlantic and Pacific Oceans were also represented. Scientists from Australia, Chile, and Japan attended in addition to those from Mexico and the United States.

Three papers were presented by Honolulu Laboratory fishery biologists and another by researchers associated with the NOAA/University of Hawaii Joint Institute for Marine and Atmospheric Research (JIMAR). Fishery Biologist Robert Skillman presented a paper entitled "Central Pacific swordfish status report" in which he described the recent development of the Hawaii longline fishery for swordfish and world landings, reviewed swordfish biology and population dynamics in the Pacific and Atlantic oceans, and described Honolulu Laboratory fishery monitoring and research strategies. Fishery Biologist Russell Ito presented the paper "The Hawaii longline fishery for swordfish" coauthored with Fishery Biologists Robert Dollar and Kurt Kawamoto. This paper profiled the Hawaii-based domestic longline fishery describing the gear and fishing practices, landings and revenue, participants, and the product and its distribution. Fishery Biologist James Uchiyama's paper, "Ageing of North Pacific swordfish using hard parts," was coauthored with Skillman and Jeffrey Sampaga, biological laboratory technician. The paper described progress on developing techniques for determining the age of swordfish from fin spines, otoliths, and vertebrae and establishing relationships between size measurements for these tissues and whole animal measures. A provisional growth model was also presented. Gerard DiNardo of JIMAR presented the paper "Spatio-temporal dynamics of broadbill swordfish (*Xiphias gladius*) landings in the Hawaii-based North Pacific pelagic longline fishery." The paper, coauthored with fellow JIMAR investigator William Kwok, characterized the spatial and temporal dynamics of swordfish landings in the Hawaii-based domestic longline fishery and developed preliminary length-based metrics of fishery performance.

Several other papers were presented by staff of the La Jolla Laboratory, SWFSC. (R. Skillman, 808-943-1257)

ECOSYSTEM AND ENVIRONMENT INVESTIGATION

Trans-Pacific Migration of Northern Bluefin Tuna Studied

Jeffrey Polovina, chief of the Ecosystem and Environment Investigation, Honolulu Laboratory, has been studying the dynamics of the trans-Pacific migration for the northern bluefin, *Thunnus thynnus*. In recent years, the Hawaii longline fishery has reported occasional catches of juvenile bluefin as the bluefin migrate from the western to the eastern Pacific. Since the mid-1970s, bluefin catches off Mexico and California have been declining; a recent review of the northern bluefin stock by Inter-American Tropical Tuna Commission scientist William Bayliff has suggested that a reason for the decline in eastern Pacific catches may be related to a decline in the proportion of fish migrating from the western Pacific to the eastern Pacific. Polovina has found a coherent relationship between the proportion of Pacific bluefin catch coming from the western Pacific and the abundance of a bluefin prey, the Japanese sardine, *Sardinops melanosticta*. During 1960-75, when sardines were scarce, western Pacific catches accounted for about 50 percent of the North Pacific catches, while during the 1950s and 1980s, when sardines were abundant, 80 percent of the North Pacific catches came from the western Pacific. The age composition of the western Pacific catch shows a 50 percent increase in ages 2-5 bluefin (the ages of fish usually caught in the eastern Pacific) when sardines are abundant off Japan. Thus, researchers hypothesized that the proportion of bluefin tuna which migrate from western to eastern Pacific vary with the abundance of sardines off Japan. When Japanese sardines are abundant, fewer bluefin migrate to the eastern Pacific. If the abundance of sardines off Japan continues to decline, this hypothesis forecasts an increase in catches of bluefin in Hawaii and the eastern Pacific. (J. Polovina, 808-943-1218)

FISHERY MANAGEMENT AND PERFORMANCE INVESTIGATION

Hawaii Commercial Catch Landings Down for 1994

Preliminary estimates of Hawaii's total commercial fishery landings for 1994 (Table 1) indicate that landings were 12.6 million kg (27.7 million pounds) valued at $62.4 million, down 3.7 million kg (8 million pounds) from 1993's record 16.2 million kg (35.7 million pounds)—the highest historical landings for Hawaii. These are preliminary figures; final figures may be revised due to additional information being involved in the estimation procedures.

Table 1. Hawaii commercial fishery data summarized, 1994. Figures are preliminary estimates—combination of National Marine Fisheries Service (N) and Hawaii Division of Aquatic Resources (H) data (first estimates, February 13, 1995). MHI = main Hawaiian Islands; NWHI = Northwestern Hawaiian Islands.

	kg (lb) caught (1,000s)	Revenue ($1,000s)
Longline (N)	8,721 (19,210)	44,800
Troll-hand pelagics (H)	2,315 (5,100)	9,600
Aku boat (H)	454 (1,000)	1,500
MHI bottomfish (H)	227 (500)	1,600
NWHI bottomfish (H)	209 (460)	1,400
NWHI lobster (N)	73 (160)	850
Other	590 (1,300)	2,600
Total	12,589 (27,730)	62,430

The data were compiled using 10 months of Hawaii Division of Aquatic Resources (HDAR) commercial catch reports (extrapolated to 12 months) and replacing HDAR longline and Northwestern Hawaiian Islands (NWHI) landings with NMFS estimates based on Federal logbooks and shoreside monitoring.

The primary cause of the decline in 1994 was a drop of 2.5 million kg (5.5 million pounds) in swordfish landings. Associated longline bycatch was also down because many swordfish longliners left Hawaii during the year for fisheries in other regions.

The exact reason for this exodus is not known, but several causes have been discussed. These include the following:

1. The high cost of commercial fishing in Hawaii (due to the cost of fuel, supplies, and repairs);
2. The time spent by some owners and captains in transit to and from the mainland United States;
3. Requirements for keeping permits active in other fisheries (such as the Atlantic swordfish fishery);
4. New fishing opportunities (such as in the South Pacific); and
5. Reduced availability for swordfish in the North Pacific (due to weather, oceanographic conditions, prey abundance, or declining stocks).

None of these possible causes are known to actually explain the situation; it is both a situation scientists at the Honolulu Laboratory are studying carefully now and a central focus for a joint NMFS-University of Hawaii 5-year research project.

Total longline landings were down over 3.2 million kg (7 million pounds) but still comprise 70 percent of total commercial catch in Hawaii. Longline landings peaked in 1993 at 12 million kg (26.5 million pounds); in 1994 they were 8.7 million kg (19.2 million pounds) and in 1990 they were just 5.90 million kg (13 million pounds). Hawaii has become a major source of swordfish for the U.S. market, with most swordfish from Hawaii exported to the east coast.

The impact on Hawaii fishing businesses is probably limited to those directly supplying the longline vessels and those transhipping swordfish to the mainland United States. However, more longline vessels may now target tuna, which are more important to the local market. Tuna prices are not likely to increase because of this change in the fishery.

Aku (skipjack tuna) boat landings continued their long decline in 1994. However, gains were seen in most other Hawaii fisheries, including NWHI bottomfish and lobster and main Hawaiian Islands tunas and bottomfish.

Final estimates of Hawaii landings will not be available until mid-year when complete HDAR commercial catch reports are available. (S. Pooley, 808-943-1216)

The 1994 Hawaii-based Longline Fleet

The 1994 Hawaii-based longline fishery was the largest and most prominent domestic commercial fishery in Hawaii. Preliminary longline landings for the year are estimated at 8.72 million kg (19.2 million pounds) and $44.9 million in 1994 (Pooley, unpublished report). There were many changes in the Hawaii-based longline fishery during 1994; the following is a summary of those changes:

The Western Pacific Fishery Management Council (Council) moratorium on longline vessels, in place since April 1991, has been replaced with a limited entry program. This program allows permits to be freely transferred and vessels to be upgraded to a length limit. The maximum number of Federal limited entry permits for the Hawaii-based longline fishery is 168 vessels.

The NMFS mandatory observer program began in February of 1994. The focus of this program, administered by the Southwest Region, is on the interaction of longline gear with sea turtles. A recent workshop held at the Honolulu Laboratory examined methods to improve the survivability of turtles taken incidentally in the longline fishery.

Vessel Activity

There were 125 longline vessels operating out of Hawaii in 1994 (Table 2). Although this is a slight increase in the number of vessels, many vessels left Hawaii during the year. Most of the vessels leaving originally came from the east coast or areas of the U.S. Gulf of Mexico. Reasons mentioned for leaving Hawaii included the high cost of operations and maintenance, poor swordfish catch rates, anticipation of better fishing elsewhere, and a desire to keep longline permits active in other parts of the country. In the fourth quarter of 1994, there were 14 fewer vessels than there were during the same period in 1993.

Table 2. Hawaii-based longline fleet operations, 1991-94. Summaries are based on date of landing. Activity and catch are a result of trips summarized in the concluding year.

Category	1991	1992	1993	1994
Vessels	140	123	122	125
Trips	1,664	1,260	1,192	1,107
Total number of days fished	12,656	11,501	12,283	11,042
Average days fished per trip	7.6	9.1	10.3	10.0
Total number of hooks set (millions)	12.4	11.7	13.0	12.2
Hooks set inside EEZ	8.0	5.5	6.8	7.8
Hooks set outside EEZ	4.3	6.1	6.2	4.2

Hawaii-based longliners completed 1,107 trips in 1994 (Table 2). The number of trips has declined since 1991 because of fewer vessels fishing as well as increased length of trips. The total number of days fished in 1994 decreased to the lowest level since the logbook collection program began in 1991. The average number of days fished per trip peaked in 1993 and decreased slightly in 1994. In 1994 there were 12.2 million hooks set; hooks set inside the Exclusive Economic Zone (EEZ) increased by about 1 million while hooks set outside the EEZ decreased by 2 million. Hooks set reached the lowest level in 1992 and peaked in 1993.

Catch and Landings

Bigeye tuna became the largest component of the landings by weight in 1994 (Table 3). Although bigeye tuna landings decreased slightly in 1994, the decrease was not as dramatic as landings for swordfish which decreased by 46 percent. Even though swordfish landings decreased substantially, swordfish still managed to rank second in composition. All other species of billfish, with the exception of spearfish, also decreased in 1994. Mahimahi increased 30 percent and retained its third place composition ranking. Albacore, the fourth largest component of the landings, increased 21 percent, while yellowfin tuna decreased slightly. Shark landings remained about the same. Very few sharks are returned whole; most of the sharks are finned.

Table 3. Landings (in numbers) by the Hawaii-based longline fleet, 1993-94.

Species	1993	1994
Billfish		
Swordfish	76,000	43,100
Striped marlin	16,200	11,300
Blue marlin	4,800	4,700
Spearfish	3,500	4,000
Other billfish	1,900	1,200
Tunas		
Bigeye tuna	53,000	48,700
Albacore	21,900	26,600
Yellowfin tuna	15,000	13,700
Other tunas	5,300	6,900
Sharks		
Blue shark	14,200	14,500
Mako shark	1,000	800
Thresher shark	300	400
Other sharks	1,100	1,000
Other Pelagic Management Unit Species (PMUS)		
Mahimahi	24,500	32,000
Moonfish	4,500	5,100
Ono	4,300	2,500
Miscellaneous PMUS	---	1,200
Miscellaneous (non-PMUS)	7,200	6,700

Table 4. Catch-per-unit-effort (fish per 1,000 hooks) of the Hawaii-based longline fleet, 1993-94.

Species	1993	1994
Billfish		
Swordfish	6.11	3.61
Striped marlin	1.40	0.94
Blue marlin	0.39	0.39
Spearfish	0.28	0.33
Other billfish	0.15	0.10
Tunas		
Bigeye tuna	4.21	4.01
Albacore	2.34	2.59
Yellowfin tuna	1.23	1.13
Other tunas	0.41	0.58
Sharks		
Blue shark	11.53	9.18
Mako shark	0.10	0.09
Thresher shark	0.07	0.12
Other sharks	0.17	0.16
Other Pelagic Management Unit Species (PMUS)		
Mahimahi	2.00	2.75
Ono	0.34	0.21
Moonfish	0.35	0.42
Miscellaneous PMUS	-	0.11
Miscellaneous (non-PMUS)	0.96	0.58

Catch-Per-Unit-Effort

Catch-per-unit-effort (CPUE) is measured by the number of fish caught per 1,000 hooks set. Swordfish CPUE declined by 41 percent in 1994, influencing some swordfish longliners to switch target species during the latter part of the year. Even though there was a concurrent rapid rise in bigeye tuna CPUE during the fall season, there were only slight changes in CPUE for all tuna species. Striped marlin CPUE decreased by 33 percent. Blue shark CPUE remained highest of all shark species although it dropped 20 percent in 1994. Mahimahi CPUE rose 38 percent in 1994, the highest of all other pelagic management unit species (PMUS). Other miscellaneous PMUS have much lower CPUE by comparison. (R. Ito, 808-943-1213)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

Monterey Bay Area Sport-caught Rockfish

The Monterey Bay and surrounding areas have been important recreational fishing sites for a century. Relatively little is known, however, about how these fisheries have changed over time. Using data collected by California Department of Fish and Game under three Federally funded programs, Fishery Biologist Jan Mason has described changes in the commercial passenger fishing vessel (CPFV) and skiff fisheries from 1959 to 1986. The database developed includes 437,000 fish identified by species from 22 of the 28 years.

During 1960, this area produced 30 percent of the northern and central California total ocean sport fishing from only 9 percent of the coastline. Fishing effort from CPFVs more than doubled in this area from 1960 to 1982, but since then, effort has fluctuated and catch per day has declined. Fishing from small skiffs has increased approximately fourfold since 1960. Both the CPFV and skiff fisheries catch various species of rockfish, *Sebastes* species, in the Monterey Bay region. Rockfish comprised 90 percent of the CPFV catch and 50 percent of the skiff catch. Other shallow water sand bottom fishes, Pacific sanddabs in Monterey and white croakers in Santa Cruz, were also important in the skiff fisheries.

Rockfish are a diverse group, occupying many different habitats from tide pools to depths of 500 m. Many species are demersal while others are parademersal and some are pelagic. Some species are solitary and some are aggregating. Of the 57 rockfish species found along the California coast, at least 20 species are represented in these two fisheries in the Monterey Bay area. Aggregating species, such as blue rockfish, yellowtail rockfish, chilipepper rockfish and bocaccio rockfish, are often targeted because of their higher concentrations, but other solitary species are often caught at the same time.

There has been a change over time in areas fished by CPFVs. When the first survey began in 1959, CPFVs operated close to port and fished primarily in shallow water for aggregating blue rockfish. A decline in abundance of blue rockfish near Santa Cruz soon prompted skippers to travel farther in search of fish. Some boats went to Año Nuevo Point, 35 km to the north, where they continued to catch blue rockfish and other shallow species for the next 10 years; other boats stayed closer to port but went to deeper fishing sites (50 m) where they caught yellowtail rockfish.

Changes in the areas fished during the 1960s by Monterey CPFVs were less dramatic. The Monterey Peninsula and the coastline to the south contain large areas of rocky outcroppings suitable for blue rockfish. CPFVs gradually traveled farther from port and continued to catch blue rockfish, which composed one-third to one-half of their catch. Skiffs are more limited in range, generally fishing within 10 km of the port of Monterey, and they experienced declines in blue rockfish abundance. Pacific sanddabs increased to half the skiff catch and blue rockfish dropped to one-tenth the catch.

There are no data between surveys from 1973 to 1976. But from 1977 to 1986, CPFVs fished in even deeper water (100 m) in Santa Cruz and Monterey, reflected in a higher proportion of deep water, red rockfish caught, especially chilipepper rockfish. The initial tactic used by CPFVs—traveling farther from port when fish were scarce—appears to have been replaced by deeper water fishing within 18 km of port.

The declining abundance of blue rockfish in the Santa Cruz area in the early 1960s caused concern to anglers and fishery biologists. In the longer time series now available, the decline is not continuous; the abundance of blue rockfish fluctuates. Pulses of increased blue rockfish abundance in the fisheries occur three or four years after a strong recruitment event. In some periods, increased blue rockfish abundance occurs at about the same time in both Santa Cruz and Monterey (1970 and 1982), but in other periods (1963) it is more localized. Variation in blue rockfish recruitment in both time and space has also been documented by the rockfish recruitment project of NMFS Tiburon Laboratory.

Certain life history characteristics of rockfish make them especially vulnerable to heavy fishing pressure. These include residential behavior, high variability of recruitment success, long lives, and late sexual maturity. Heavily fished areas near port are not restocked by adults from other areas because of residential behavior, and these local populations have declined. CPFVs have adapted by shifting to new areas as catch declines; however, fuel costs and travel time become prohibitive over long distances.

Rockfish do not reach sexual maturity for several years and may produce large numbers of recruits only once in several reproductive seasons. Increased fishing pressure, especially from skiffs, results in the harvest of new recruits of blue rockfish within three to five years, and half of them may be harvested before they reach first sexual maturity. A decreased population of spawners may have delayed recovery of the blue rockfish in Santa Cruz during the 1960s.

The multispecies nature of the fishery, the difficulty for anglers of identifying rockfish to species, and the decreased survival of released fish from depth due to expansion of the swim bladder makes size limits for individual species impractical. Management so far has consisted of a bag limit on combined rockfish species. One strategy being investigated by California Department of Fish and Game is the development of marine reserves closed to both commercial and sport harvest. These reserves could protect local populations of spawning adults and provide pelagic rockfish larvae to a wider section of coastline. (J. Mason, 408-648-9028)

Recent Trends in the Spatial Structure of Wind Forcing and SST in the California Current System

In eastern boundary current (EBC) systems, the physical environment is rarely uniform in time. In addition to seasonal and higher frequency variations, El Niño/Southern Oscillation (ENSO) and other perturbations produce profound anomalies in the atmosphere and ocean on climate (interannual to century) time scales. EBCs can also be separated into several discrete geographical regions, dominated by different physical processes, and presumably different biological structure. It is expected that time-space physical variability will impact EBC ecosystems and may lead to swings in plankton and fish abundance, biomass, and distribution. Thus, rather than treat EBCs as spatially homogeneous systems, or use seasonally averaged data to describe their climatology, it is crucial to describe their primary scales of spatial and temporal variability and discern the dynamics responsible for such variance to better understand how EBC ecosystems might be impacted by climate change.

Oceanographer Frank Schwing and Operations Research Analyst Roy Mendelssohn are currently attempting to describe the temporal and spatial variability of the California Current System (CCS), a major EBC system, to provide a foundation from which to evaluate the effect of climate variability in the environment on fisheries—in the recent past, at present, and for the future. The primary database being analyzed is the Comprehensive Ocean-Atmosphere Data Set (COADS). Monthly averages of poleward wind stress and sea surface temperatures (SST) were derived for two-degree squares over the region 22°-48° N, approximating the extent of the California Current. The time period of analysis is 1946-90. A non-parametric and non-linear trend is estimated for the monthly averaged time series, and separated from seasonal and other higher frequency variance, using a state-space model solved by using a combination of the Kalman filter and maximum likelihood method. Schwing and Mendelssohn are currently preparing a series of manuscripts that describe this method and some of the results. Figures 1 and 2 represent the CCS COADS poleward wind stress and SST trends, respectively, derived with this model.

The CCS wind field separates into three distinct regions; 22°-32° N (southern), 32°-40° N (central), and 40°-48° N (northern). Wind stress in the southern region became increasingly equatorward (negative) over time in a relatively monotonic pattern. The central region displayed the strongest equatorward stress in CCS. Stress also became increasingly equatorward, but exhibited much more interannual variation compared to the southern region. The center of this region (38°-40° N) featured the greatest negative tendency, shifting from the series of weakest to strongest stress. In contrast to areas south of 44° N, the northern region featured a mean poleward stress that became increasingly poleward over time. In a transition area between the central and

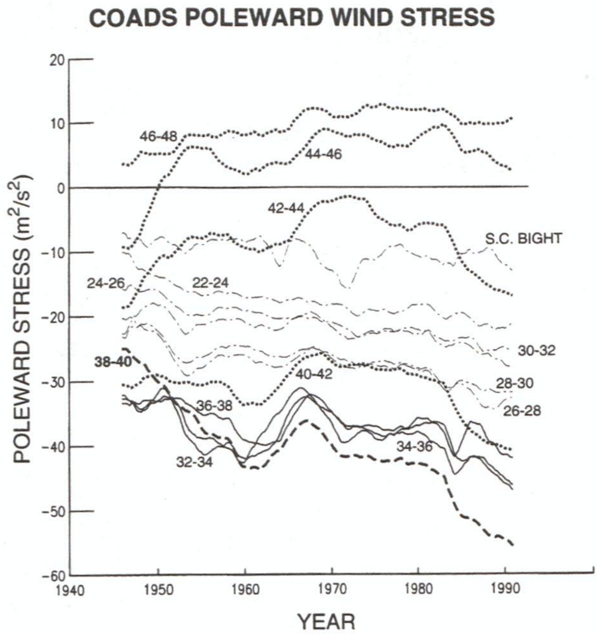


Figure 1. Time series of poleward wind stress trends for Comprehensive Ocean-Atmosphere Data Set (COADS) boxes. Dashed-dotted lines represent time series from southern region (22°-32° N). Solid lines represent time series from central region (32°-40° N). Bold dotted lines represent time series from northern region (40°-48° N). Bold dashed line represents 38°-40° N time series.

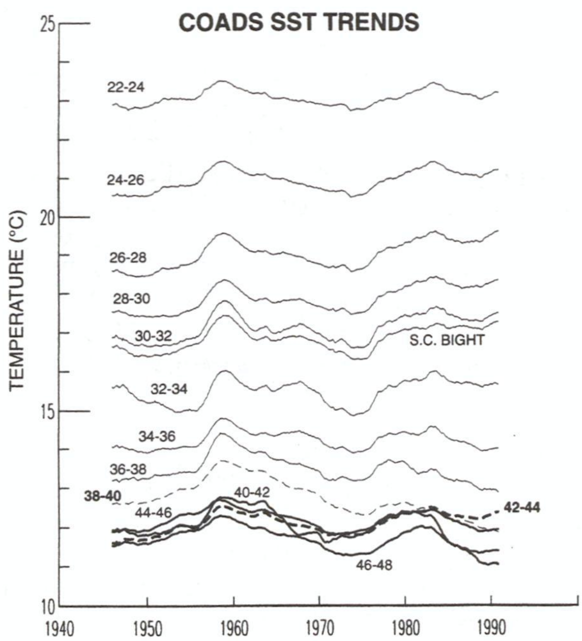


Figure 2. Time series of sea surface temperature (SST) trends for Comprehensive Ocean-Atmosphere Data Set (COADS) boxes. Fine lines denote time series south of 40° N. Bold lines denote time series north of 40° N. Fine and bold broken lines denote time series for 38°-40° N and 42°-44° N COADS boxes, respectively.

northern regions, 40°-44° N, equatorward stress decreased rapidly with distance north.

Two temporal phenomena are notable for their absence in the stress trend series. ENSO events (for example, 1957 and 1983) are not apparent in the series. The well-documented "regime shift" in the mid-1970s is not seen in the wind trends, either. However, a substantial increase in equatorward stress occurred about 1983 in the central region and north to about 44° N. Increasing equatorward (negative) stress over this period was noted in other areas as well. The net effect is that the zonal gradient in poleward stress off the northwestern United States has strengthened greatly over the last 45 years.

The SST trends are visually more correlated in space on interannual (1-5 year) scales than wind stress. As with the wind field, SST series separate into distinct regions. SSTs, decreased consistently with latitude south of about 40° N, but were nearly uniform north of 40° N. While ENSO wind events were ephemeral, warmer SSTs associated with ENSOs are more apparent. Interannual variations in the series (e.g., the 1957 ENSO) are most evident off central and southern California. In contrast to the 1957 event, the 1982 ENSO appears as a smaller local maximum in SST relative to adjacent periods. The obvious shift to warmer conditions in 1977, a shift not reflected in wind, suggests that decadal-scale SST variability in the CCS is controlled by basin-scale pressure and wind fields, rather than local wind forcing. The convergence of SST in the 38°-42° N region coincides geographically with the strong temporal change in stress at these latitudes. The series-length tendencies of the series are positive south of 34° N, but negative north of 36° N (save 42°-44° N). Since the mid-1980s, SST south of 32° N increased slightly, while SSTs to the north decreased in concert with increasing equatorward stress.

Poleward wind stress trend anomaly series, relative to the long-term mean at each latitude, reveals distinct heterogeneous spatial patterns as well. During no time period are the stress anomalies uniform over the entire region. SST trend anomalies, however, support the idea that decadal-scale variability in CCS SST is coherent throughout the system. Anomalously cool periods were seen prior to 1956 and for about 1968-1977. Warm events occurred during 1956-1968 (following the 1957 ENSO) and since 1977 (following the 1977 regime shift). These warm and cool periods are not coherent with any periods of anomalous wind stress.

In addition to latitudinal differences in CCS SST, a comparison of COADS coastal SSTs suggests there also are significant longitudinal differences. Analysis of COADS data separated into finer spatial (but coarser temporal) resolution supports this idea. These results clearly demonstrate the highly variable nature of the CCS environment in time and space, and argue against oversimplifying EBC climate change as a constant linear trend, or in terms of a record from a single location.

The spatial and temporal variability in the CCS wind stress and SST trends described here has key implications for fisheries; for example, in determining which time series or areas are more critical in terms of defining a stock's dominant environment. Regional differences also mean that highly migratory or spatially extensive stocks face a heterogeneous changing climate. To fully understand the implications of climate change on populations, fishery scientists must (1) evaluate the relative environmental differences in each area as they pertain to the climate signal and climate variability and (2) compare them to species distribution and behavior as a function of life stage. (F. Schwing, 408-648-9034)

Environment and Condition Factor in California Small Pelagic Fishes

Richard Parrish (fisheries biologist with the Pacific Fisheries Environmental Group, PFEG) and Donna Mallicoate (previously a statistician at PFEG) recently completed a study on the effects of environmental factors on the condition factors of mackerel, jack mackerel, and northern anchovy in Southern California.

A fish's condition factor is a measure of environmental conditions encountered by the fish and how it is affected by interactions among food availability, physical factors, and the physiology of the fish. The physiology of a fish is influenced by its age, sex, and reproductive state, as well as by abiotic factors (that is, temperature). Thus, condition factor is likely to vary in association with other population rates (namely, growth, natural mortality, age at maturity, and fecundity).

Condition factors in anchovy, which are lower on the food chain, were much less related to abiotic oceanographic factors than were mackerel and jack mackerel, which are higher on the food chain. However, the condition factors of all three species were highly correlated with the same oceanographic factors: sea level at San Diego and upwelling off of Baja California. Monthly condition factors in mackerel and jack mackerel had variation near decade scale, whereas anchovy were relatively fat or thin for periods of 1 to 2 years.

There were a number of similarities in the time series of condition factors in mackerel and jack mackerel. They had nearly identical seasonal cycles, similar decade scale trends, and their condition factor time series are strongly positively correlated (R = 0.68). Mackerel and jack mackerel condition factors were correlated with sea level (alongshore advection), Ekman transport (offshore advection), surface temperature, and surface salinity. Multiple regression analyses (including sea level, upwelling off of Baja California, and salinity) explained 80 percent of the variance in the annual condition factor of mackerel. The best model for jack mackerel explained 58 percent of the variance and included sea level, upwelling off of Baja California, and temperature.

The patterns of correlation between abiotic environmental factors and the condition factors of mackerel and jack mackerel suggest that the major source of variation is a very large-scale perturbation in the circulation of California Current system. This is seen in the negative correlations with sea level, and to a lesser degree, sea surface temperature and positive correlations with the Southern Oscillation Index. Upwelling off of Baja California was found to be a secondary, more regional source of variation.

Upwelling in the Southern California region and to the north of Point Conception did not appear to be associated with variations in the condition factors of mackerel, jack mackerel, or anchovy.

Mackerel condition factors were inversely related ($R = -0.64$) to sea level at San Diego (Fig. 3) and positively correlated ($R = .52$) with upwelling off of Baja California (Fig. 4). This implies that condition factors are controlled by abiotic environmental factors which determine the availability of food, that

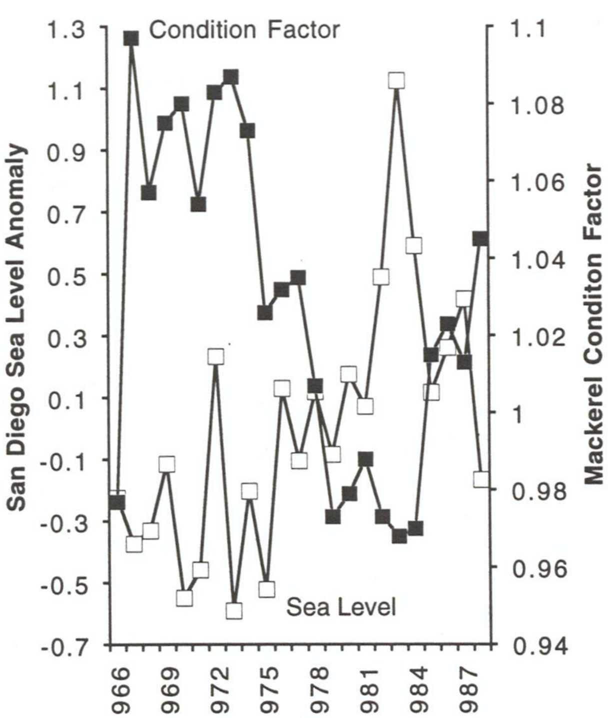


Figure 3. Relationship between the annual condition factor of Pacific mackerel and sea level at San Diego.

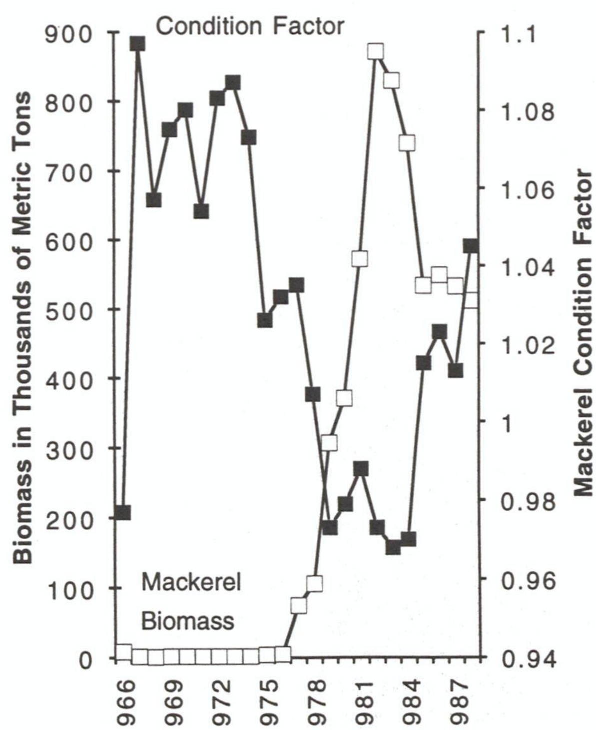


Figure 4. Relationship between the annual condition factor of Pacific mackerel and the upwelling index at 27° N off of Baja California.

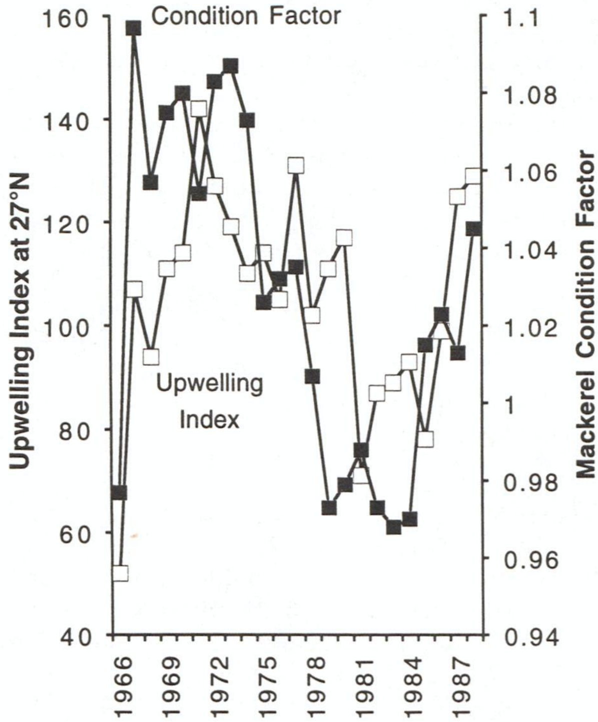


Figure 5. Relationship between the annual condition factor and biomass of Pacific mackerel.

is, increased equatorward flow of the California Current (decreased sea level) and increased upwelling off of Baja California.

The biomass of mackerel had an extreme variation during the period of the study and there was a strong negative correlation (R = -0.70) between mackerel condition factors and biomass (Fig. 5). However, it should be noted that sea level at San Diego and the population biomass of mackerel are highly correlated (R = .78) and it is therefore difficult to determine if condition factor is varying in response to the environment or population biomass. It is likely that both condition factor and population biomass are affected by environmental conditions associated with variations in sea level.

A further feature is that the 7-year minima in the mackerel condition factor (1978-84) preceded the peak in mackerel biomass. In fact, condition factor was low during the whole period of maximum population growth (1978-82) and it returned to high levels when the population was still at a very high level. (R. Parrish, 408-648-9033)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

1995 Billfish Newsletter Completed

The *Billfish Newsletter* is an annual publication produced by the Southwest Fisheries Science Center (SWFSC) as a service to the international angling community. The results of the 1993 International Billfish Angling Survey and the 1994 Cooperative Marine Game Fish Tagging Program are described in the 1995 issue. (D. Holts, 619-546-7186)

International Billfish Angling Survey

The Billfish Angler Survey provides the only estimates of billfish angling activities in the Pacific, Indo-Pacific and Indian Oceans. Collection of recreational billfish catch and effort data was started in 1969 by James Squire, Jr. (SWFSC, retired fishery biologist). The Program provides an index of catch and effort trends for several important recreational game fishing communities throughout the Pacific and Indian Oceans.

Billfish anglers responding to the Billfish Angler Survey for 1993 reported catching 3,378 billfish throughout the Pacific, Indo-Pacific and Indian Oceans. This included 1,042 sailfish, 1,021 striped marlin, 906 Pacific blue marlin, 238 spearfish, 166 black marlin, and 5 swordfish.

The majority of striped marlin were taken in Southern California, along the southern coast of Mexico's Baja peninsula and in the waters surrounding Hawaii. Blue marlin were most often reported from Hawaii, Baja California, Guam, and New Zealand. Black marlin were most often reported from Australia, Panama, and Baja California. Sailfish were reported caught in greatest numbers along the entire west coast of Mexico and Central America, and short-billed spearfish from Hawaii and Panama.

Total effort in number of angler-days reported for 1993 was 8,561 days—a decrease of 1.7 percent from the number of angler-days reported in 1992. The overall catch-per-unit of effort (CPUE) for 1993 was 0.40 billfish caught per angler-day (or 2.5 days fishing per billfish). This is similar to the 1990 and

Table 1. Results of the 1993 Billfish Angler Survey. Data in parentheses are values recorded in 1992. Days fished in the Atlantic Ocean totaled 139.

	Angler fishing days	Billfish per fishing day (CPUE)	Major species
PACIFIC OCEAN			
Hawaii	3,259 (3,379)	0.33 (0.28)	Blue marlin
So. California, United States	1,456 (2,220)	0.10 (0.12)	Striped marlin
Baja California, Mexico	1,278 (1,240)	0.60 (0.60)	Striped marlin
Guaymas, Mexico	24 (37)	0.29 (0.46)	Striped marlin
Mazatlan, Mexico	15 (23)	0.67 (0.96)	Sailfish
Puerto Vallarta, Mexico	41 (42)	0.46 (0.55)	Striped marlin
Manzanillo, Mexico	86 (28)	0.55 (0.61)	Sailfish
Acapulco, Mexico	72 (79)	1.54 (0.90)	Sailfish
Guatemala	101 (334)	2.89 (1.37)	Sailfish
Costa Rica	117 (234)	1.80 (2.03)	Sailfish
Panama	120 (38)	1.78 (1.97)	Sailfish
Peru	- (117)	- (0.41)	Sailfish
Japan	826 (38)	0.05 (0.16)	Blue marlin
Guam, United States	253 (102)	0.18 (0.29)	Blue marlin
Micronesia	5 (7)	0.20 (0.43)	Blue marlin
Fiji	13 (51)	0.23 (0.14)	Sailfish
Tahiti, French Polynesia	34 (83)	0.38 (0.47)	Blue marlin
Australia	156 (213)	0.53 (0.55)	Black marlin
New Zealand	135 (143)	0.27 (0.06)	Blue marlin
INDO-PACIFIC			
Papua New Guinea	46 (30)	0.22 (0.63)	Sailfish
Malaysia	- (35)	- (0.09)	Blue marlin
Thailand	3 (2)	0.33 (0.50)	Black marlin
Hong Kong (Pratas)	16 (31)	0.12 (0.16)	Blue marlin
INDIAN OCEAN			
Kenya	141 (142)	0.67 (1.07)	Sailfish
Mauritius	225 (11)	0.22 (0.09)	Blue marlin
Seychelles	- (43)	- (4.81)	Sailfish

1992 catch rates of 0.42 and 0.43 billfish/day, but only about 75 percent of the 1991 catch rate of 0.57 billfish/day (Table 1). (D. Holts, 619-546-7186)

Cooperative Marine Game Fish Tagging Program

The Billfish Tagging Report cards received in 1994 indicate a total of 750 billfish were tagged and released (Table 2). This is 34 percent fewer than in

Table 2. Summary of billfish tagged in 1994.

Area	Species	Total
PACIFIC OCEAN		
So. California, United States	Blue marlin	2
	Striped marlin	82
Hawaii, United States	Blue marlin	184
	Black marlin	10
	Striped marlin	120
	Sailfish	1
	Short-billed spearfish	55
	Broadbill swordfish	46
Baja California, Mexico	Blue marlin	20
	Black marlin	2
	Striped marlin	51
	Sailfish	23
Manzanillo/ Acapulco, Mexico	Blue marlin	2
	Striped marlin	1
	Sailfish	9
Panama	Black marlin	6
	Striped marlin	1
	Sailfish	37
Colombia	Sailfish	11
Hong Kong	Black marlin	1
Guam, United States	Blue marlin	35
	Black marlin	1
	Sailfish	5
	Short-billed spearfish	2
Fiji	Blue marlin	13
	Black marlin	2
	Striped marlin	1
	Sailfish	11
Tahiti	Blue marlin	3
	Striped marlin	1
	Sailfish	1
Australia	Black marlin	1
INDIAN OCEAN		
Kenya	Sailfish	3
Mauritius	Blue marlin	1
Seychelles	Sailfish	1
ATLANTIC		
Grand Banks	Broadbill swordfish	5
TOTAL		**750**

1993 (1,135) and the lowest number of releases recorded since 1985. Decreased tagging of blue marlin and striped marlin were noted from Hawaii, while increases in tagging were seen for blue marlin and sailfish in Fiji and Guam. The cause of this observed decrease is not known although swings of 30 to 40 percent in numbers of tag releases are not uncommon between years.

Thirteen billfish tags were returned in 1994. Four were from blue marlin, seven from striped marlin, one from a swordfish and one from a shortfin mako shark. Of the four blue marlin, only two had been reported tagged and released. Both of those were tagged near Kailua-Kona, and moved west over periods of 292 and 317 days (Fig. 1). Of the two blue marlin not reported released, one was recovered northwest of Kauai and the other in the South Pacific near Tahiti.

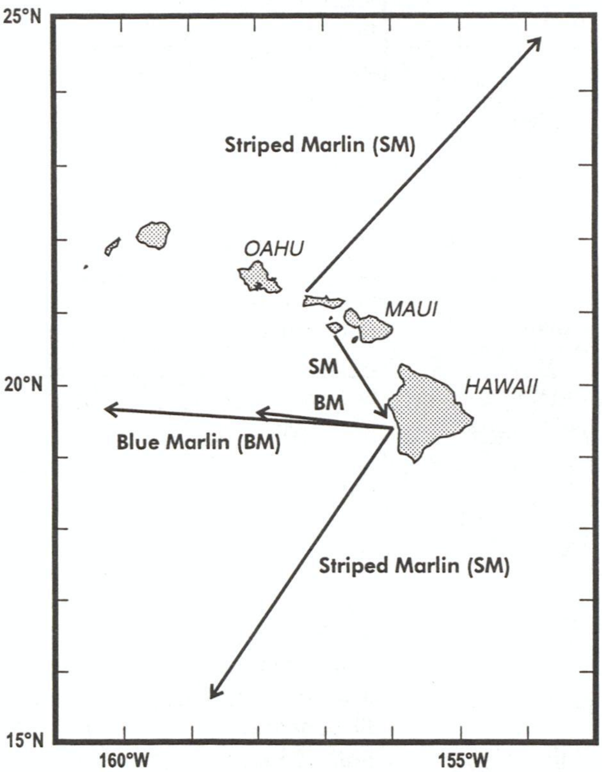


Figure 1. Movements of blue and striped marlin tagged and recovered from the waters off Hawaii.

Seven striped marlin were recovered during the year. Three of these were tagged and recovered in the waters off Hawaii. These varied in time at large from 18 to 327 days (Fig. 1). Three other striped marlin released along the coast of Baja California Sur were recovered nearby after 8, 29, and 75 days (Fig. 2). The striped marlin at liberty for eight days had been in our recovery database since November 1988. We received the Billfish Tagging Report with the release information in March 1994 (a little late but greatly appreciated nonetheless). One striped marlin tagged at Santa Catalina Island, California, moved 933 km (580 miles) south to Thetis Bank, Mexico, in 149 days.

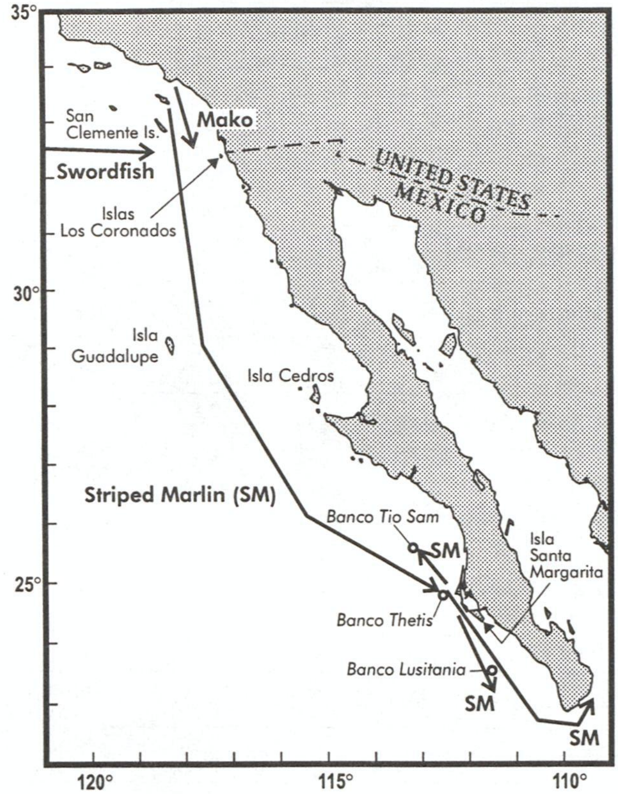


Figure 2. Movements of tagged gamefish recovered off Southern California and Baja California.

The longest movement reported this year was from a swordfish tagged northwest of Hawaii which moved east-northeast 1,859 miles (2,990 km) to just south of San Clemente Island, California, in 610 days (1.67 years). The fish reported at liberty for the longest period was a shortfin mako shark tagged at the "Rigs" near San Pedro, California, in 1988 and recovered southwest of San Diego, California, 1,859 days (5.1 years) later. This shark had gained nearly 100 pounds.

The data presented are the result of cooperation by billfish anglers, sportfishing clubs, and affiliated agencies with the Southwest Fisheries Science Center. The efforts of anglers, fishermen, and colleagues are greatly appreciated. (D. Holts, 619-546-7186)

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

Paper Presented at the South Pacific Tuna Treaty Meeting

Gary Sakagawa, fishery biologist, Southwest Fisheries Science Center (SWFSC), presented a paper at the South Pacific Tuna Treaty Meeting in Nadi, Fiji, in March. The paper, authored by Atilio L. Coan, Jr. (mathematician, SWFSC), Doug Prescott (computer specialist, SWFSC), and Gordon Yamasaki (fishery biologist, Southwest Region [SWR], American Samoa), is titled "The 1994 U.S. purse seine fishery for tropical tunas in the western Pacific Ocean." Authors reviewed performance of the fleet fishing under the South Pacific Tuna Treaty in 1994, as inferred from collected logbook, landings, and size and species composition information. The paper was published as a SWFSC Administrative Report (LJ-95-10).

Forty-seven of the 48 licensed U.S. purse seiners fishing under the South Pacific Tuna Treaty in 1994 caught a preliminary estimate of 190,500 metric tons (t) of yellowfin, skipjack, and bigeye tuna. While catches in 1994 decreased approximately 1 percent from those in 1993, the 1994 yellowfin tuna catch (55,300 t) was the highest recorded by the fleet since it started fishing in the area in 1976. Since canneries pay the same price for yellowfin and bigeye tunas, the 1994 catch of yellowfin tuna also includes bigeye tuna. Species composition sampling of the landings revealed that 4 percent (2,200 t) of the 1994 yellowfin tuna catch was actually bigeye tuna.

Average sizes of yellowfin tuna in the 1994 catch (78 cm) were generally larger than those in 1993 catches (70 cm). Average sizes of skipjack tuna in 1994 catches (55 cm) were slightly smaller than in 1993 (57 cm). Larger fish continue to be caught in sets made on school fish (school sets) than in sets on floating objects (log sets, Fig. 3).

The U.S. fleet was more dispersed in 1994 than in 1993, and fished farther to the east (Fig. 4). In 1994, the majority of the purse seine sets (83 percent) in the central-western Pacific were on free swimming schools of yellowfin, skipjack, and bigeye tunas. The fleet made fewer trips and spent fewer days per trip than in 1993, probably due to its closer proximity to its major landing port in American Samoa. Catch rates in 1994

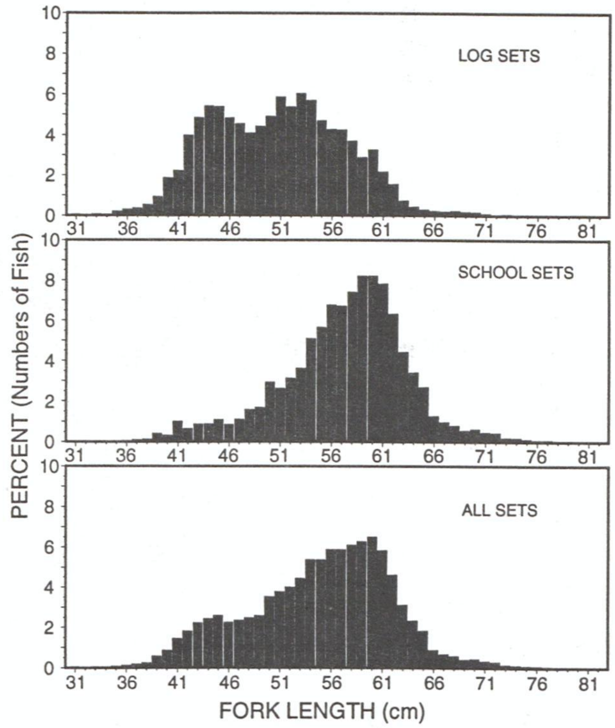
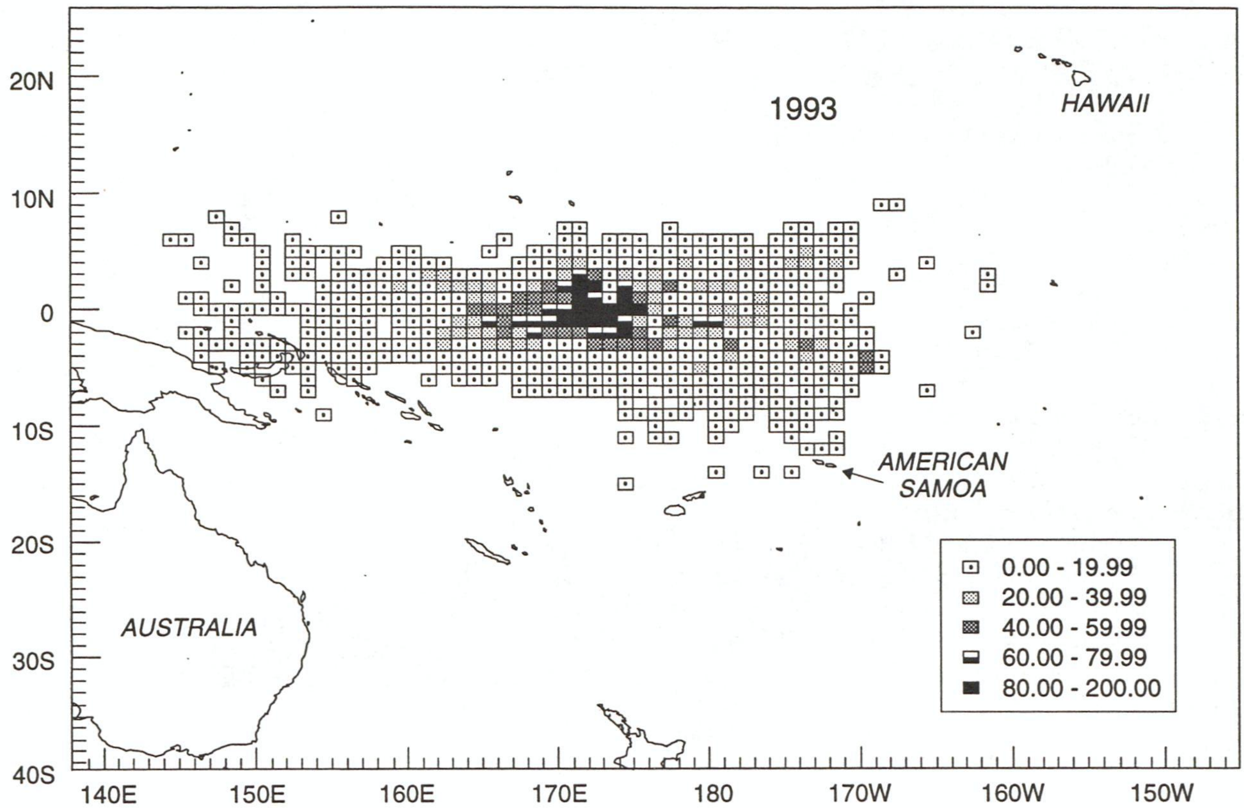


Figure 3. Length-frequency distribution of skipjack tuna in log sets, school sets, and all sets caught by U.S. purse seiners in the central-western Pacific Ocean in 1994.

(26 t of tuna/day fished) increased approximately 4 percent from those in 1993 (25 t/day fished) and can be mainly attributed to increased yellowfin tuna catch rates.

The fleet landed approximately 66 percent of its 1994 catches directly to canneries or transshipment vessels in Pago Pago, American Samoa. Other transshipment ports included Tinian, Majuro, Kosrae, Rabaul, Tarawa, and Pohnpei. Catches were transshipped mainly to American Samoa (70 percent), Thailand (11 percent), Puerto Rico (9 percent), and Italy (7 percent).

Forty-seven of the 48 licensed vessels continued to fish in 1995. The SWFSC and SWR will continue to collect landings, logbooks, and size and species composition from these vessels. Ongoing length-weight sampling will also be continued. The SWR will also continue port sampling of sizes of fish landed by U.S. vessels in Tinian and will expand the sampling to include foreign purse seiners unloading in Tinian. (A. Coan, 619-546-7079)



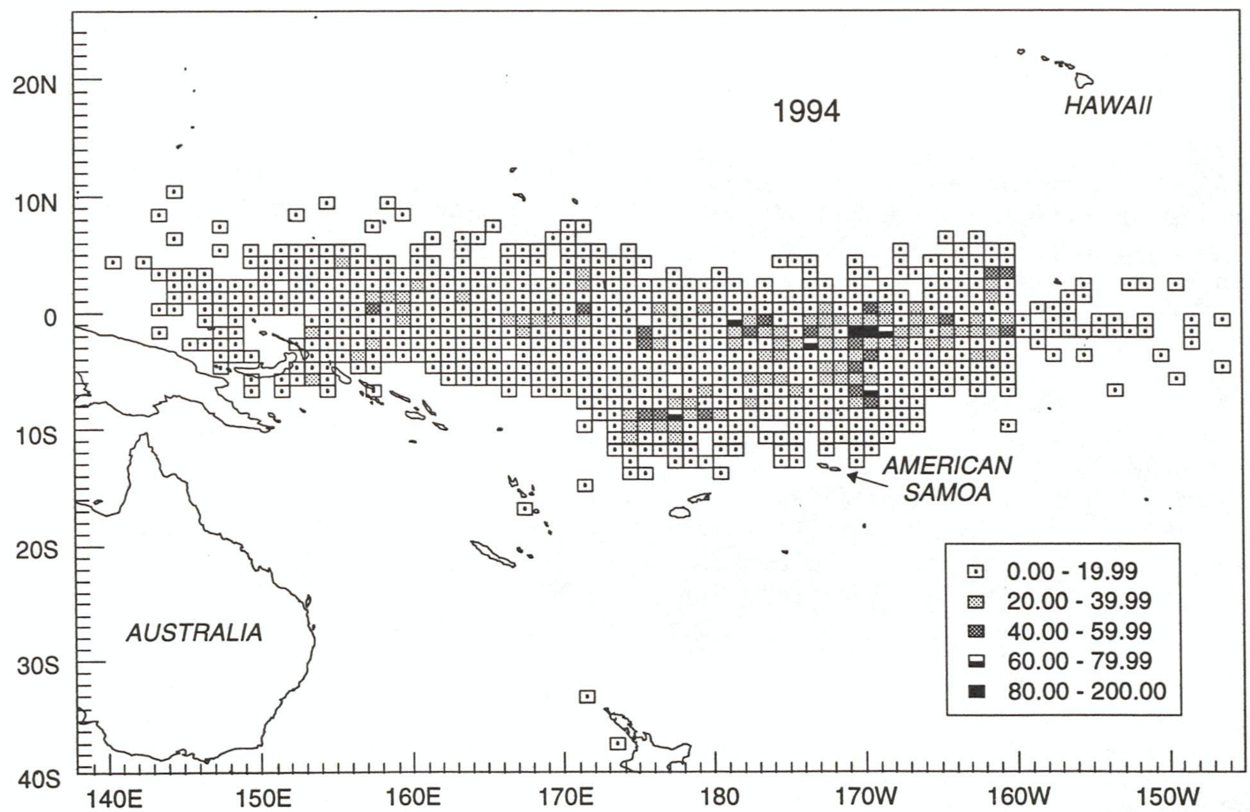


Figure 4. Geographical distribution of fishing effort (days fished) in 1993 and 1994 for U.S. purse seiners fishing for tunas in the central-western Pacific Ocean.

Seychelles Purse Seine Data Updated

Fishery Biologist Alan Jackson updated the third quarter 1994 Seychelles Fishing Authority data on the tuna purse seine fishery in the western Indian Ocean. The data, based on logbook returns from fishing vessels, are summarized in Lotus spreadsheets and cover the period 1983 to the present. Estimates of catch for the current quarter may be revised when logbooks are eventually received for fishing trips completed too late for inclusion in this data set.

The number of vessels participating monthly in the purse seine fishery in the western Indian Ocean during the third quarter of 1994 averaged 35 (15 French, 12 Spanish, 4 Belizean, 3 Mauritian, and 1 Panamanian)—a considerable decrease from the average of 49 vessels recorded for the same period last year. This decrease is partially due to the complete disappearance of the Japanese fleet from this fishery. The number of Japanese purse seiners declined in 1993 from 11 in January to 1 in December. No Japanese seiner has participated in this fishery since January 1994. The monthly average number of vessels participating during the first three quarters of 1994 was 37—down from 51 vessels the previous year. The number of vessel days fished in the third quarter of 1994 was 2,532—down 32 percent from the previous year. The number of vessel days fished for the first three quarters of 1994 was 7,814—down 30 percent.

Purse seine catches of skipjack tuna, yellowfin tuna, and other tunas in the western Indian Ocean in the third quarter of 1994 totaled 51,500 t—down 28 percent from the previous year. The species breakdown is 66 percent skipjack tuna, 17 percent yellowfin tuna, and 17 percent other tunas. For the first three quarters of 1994, the catches totaled 176,200 t—down 14 percent—and were composed of 49 percent skipjack tuna, 39 percent yellowfin tuna and 12 percent other tunas (Fig. 5).

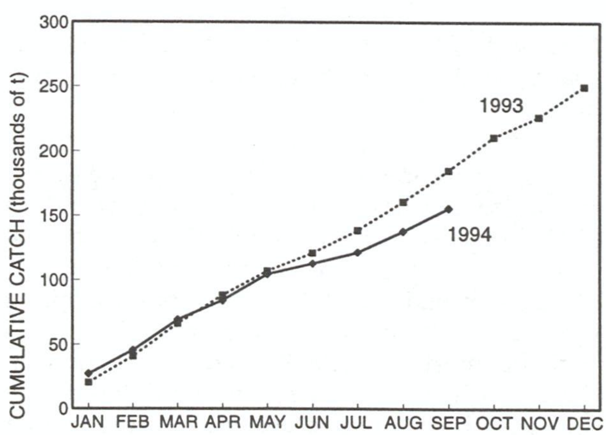


Figure 5. Cumulative catches (metric tons) of yellowfin and skipjack tuna by purse seiners in the western Indian Ocean, 1993-94.

The catch rate for all tuna species for the third quarter of 1994 was 20 t per day fished—up 5 percent from the previous year. Catch rates for skipjack and yellowfin tunas were 13 and 4 t per day fished, respectively. For the first three quarters of 1994, the catch rate for all tunas was 23 t per day fished—up 28 percent—with skipjack and yellowfin tuna catch rates of 11 and 9 t per day fished, respectively (Fig. 6). (A. Jackson, 619-546-7048)

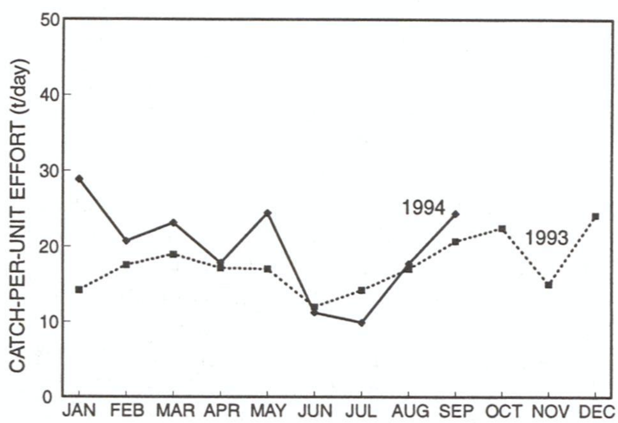


Figure 6. Yellowfin and skipjack catch rates (metric tons/day fished) for purse seiners fishing in the western Indian Ocean, 1993-94.

TIBURON LABORATORY

Tiburon, California

GROUNDFISH COMMUNITIES INVESTIGATION

Underwater Visual Counts and Salmon Diet Used to Evaluate Recruitment of Rockfishes

Evaluation of rockfish, *Sebastes* spp., recruitment based on underwater visual counts and the occurrence of recruits in the diet of the king salmon, *Oncorhynchus tshawytscha*, has been a major goal of the Groundfish Communities Investigation since 1983. Current-year assessments have been presented annually in the SWFSC Report of Activities

Table 1. Numbers of recruits (*Sebastes* spp.) counted near shore during August and September, 1983-1994. Values are mean number (standard error in parentheses) counted per minute. n = number of 1-min counts.

MENDOCINO												
Species	1983 n=36	1984 n=57	1985 n=50	1986 n=103	1987 n=112	1988 n=62	1989 n=181	1990 n=99	1991 n=80	1992 n=120	1993 n=90	1994 n=120
Yellowtail rockfish, *S. flavidus*	0.00 (0.00)	6.58 (2.29)	115.60 (21.26)	6.01 (1.50)	102.66 (11.08)	59.47 (10.23)	1.29 (0.35)	1.93 (0.90)	8.14 (3.04)	0.09 (0.05)	0.24 (0.14)	0.03 (0.01)
Blue rockfish, *S. mystinus*	0.27 (0.09)	1.49 (0.30)	70.56 (15.32)	7.83 (1.88)	181.04 (26.19)	75.89 (10.18)	6.08 (0.94)	0.76 (0.17)	0.64 (0.16)	0.26 (0.06)	6.21 (1.40)	0.59 (0.16)
SONOMA												
Species	1983 no data	1984 n=57	1985 n=50	1986 n=60	1987 n=56	1988 n=62	1989 n=186	1990 n=100	1991 n=79	1992 n=40	1993 n=100	1994 n=80
Yellowtail rockfish, *S. flavidus*		4.39 (1.48)	135.17 (26.00)	6.73 (2.29)	89.39 (18.42)	39.92 (7.94)	1.54 (0.42)	0.12 (0.05)	38.33 (6.40)	0.49 (0.29)	1.14 (0.78)	0.28 (0.11)
Blue rockfish, *S. mystinus*		4.89 (1.29)	117.63 (19.50)	15.27 (3.81)	328.05 (52.15)	175.06 (16.76)	7.19 (0.93)	0.66 (0.12)	13.58 (1.82)	1.01 (0.25)	2.96 (0.87)	2.15 (0.43)

series and, since 1986, in the Tiburon Laboratory's annual Recruitment Report. Fishery Biologist Dan Howard has conducted underwater counts at sites 100 km apart on the Sonoma and Mendocino coasts, while Fishery Biologist Kelly Silberberg has examined salmon diets from specimens caught in the Gulf of the Farallones. Despite considerable difference in locations and methods, the results have been in agreement. This has continued through 1994, when the year classes of most, though not all, rockfish species were found to be exceptionally weak.

The underwater counts have focused on the two rockfishes most consistently numerous as recruits in the nearshore habitats: the blue rockfish, *Sebastes mystinus*, and the yellowtail rockfish, *S. flavidus*. Both species recruited poorly during 1994 (Table 1). At the Mendocino sites, fewer blue rockfish recruits occurred only during 1983 and 1992 (the two El Niño years) and fewer yellowtail rockfish recruits occurred only in 1983. Recruitment was just slightly better for both species at the Sonoma sites.

Although the underwater counts begin with the earliest arriving recruits, usually in late May, the evaluation of year-class strength has been based on numbers present during late August and early September. This is done mainly to allow for the effects of predation, which varies in intensity with size of year-class and is most evident during June and July. During most years, the late August-early September counts miss the period of greatest abundance, which usually is in June or July. But in 1994, recruits were scarce until mid-July, and numbers during the assessment period were at maximum levels.

In contrast to the scarcity of blue and yellowtail rockfish recruits in 1994, for the third consecutive year, there was relatively heavy recruitment of the copper rockfish, *S. caurinus*. Before 1992, only 1983 was a strong recruitment year for copper rockfish. That was at the height of the earlier strong El Niño, which suggests that copper rockfish recruitment off northern California is enhanced by El Niño conditions. In this connection, it may be significant that copper rockfish recruits have always arrived in midsummer, 2 to 3 months after the others; however, they occur mostly in the surface canopy of *Nereocystis*, where they cannot be seen during the counts, and therefore are not included in the assessments.

The occurrence of *Sebastes* recruits in the diet of the king salmon has been monitored each year since 1980. Samples are taken throughout the period that recruits are consumed by this predator, which usually is from mid-May to late June, but sometimes begins in late April or ends in early July. During this period of most years, king salmon feed mainly on the shortbelly rockfish, *S. jordani*, which has had an interannual pattern of occurrence in its diet similar to those of blue and yellowtail rockfish in the nearshore habitats. It is apparent, therefore, that fundamental similarities exist in the early life history of these three species.

No *Sebastes* recruits were found among the gut contents of salmon examined during 1994. Only two other years produced this result—1983 and 1992. These are earlier El Niño years, which suggests that recruitment of shortbelly rockfish, like recruitment of blue and yellowtail rockfish, suffers under El Niño conditions. (E. Hobson and P. Adams, 415-435-3149)

GROUNDFISH ANALYSIS INVESTIGATION

Synopticity Assumption Evaluated

Ichthyoplankton surveys are typically performed by sampling a series of specific geographic locations (that is, stations) over the course of a research cruise. The resulting data are often summarized by assuming that all the samples were collected at one time and that any variation in catch is attributable only to a spatial effect. This is called the synopticity assumption. It is based on the idea that "short-term" temporal variation affects ichthyoplankton catch rates much less than changes in geographic location.

Investigators at the Tiburon Laboratory have been interested in evaluating this assumption, particularly with respect to diel variation in catch rates of larval *Sebastes* spp. Prior work by Ahlstrom, Morse, and others has shown that nocturnal catches are often higher than diurnal catches, although the full extent of this contrast, especially its dependence on other factors such as larval size, water clarity, and mixed layer depth, has not been adequately studied.

To assess pure short-term temporal variability in the catch rates of larval fish, an 11-day cruise by the research vessel *David Starr Jordan* was recently completed (cruise DSJ-9502). During the cruise, CalCOFI station 63.55 (latitude 37°13.55′ N; longitude 122°49.28′ W) was occupied for 11 consecutive days. This station, which has produced high catch rates of larval *Sebastes* spp. during previous Tiburon and CalCOFI cruises, lies over the continental slope (water depth = 250 m) in an area immediately south of Pioneer Canyon. This site is known to harbor large concentrations of shortbelly rockfish, *Sebastes jordani*, which spawn between January and March.

The station was sampled once every two hours, when a CalCOFI plankton tow was conducted using bongo gear (505-μm mesh) with an attached time-depth recorder. Following completion of the tow, a conductivity-temperature-depth (CTD) cast was conducted. The Seacat SBE-19 CTD was configured with a photosynthetic-available-radiation (PAR) sensor to measure in situ light levels. In addition, the vessel's acoustic Doppler current profiler (ADCP) was used to monitor temporal variability in currents at the station.

During the cruise, weather conditions were ideal and an uninterrupted series of 123 plankton tows and CTD casts was collected. The plankton samples will be sent to the Morski Instytut Rybacki in Szczecin, Poland. At the sorting center, the ichthyoplankton will be sorted, identified, enumerated, and measured. From these data, it will be possible to estimate short-term temporal

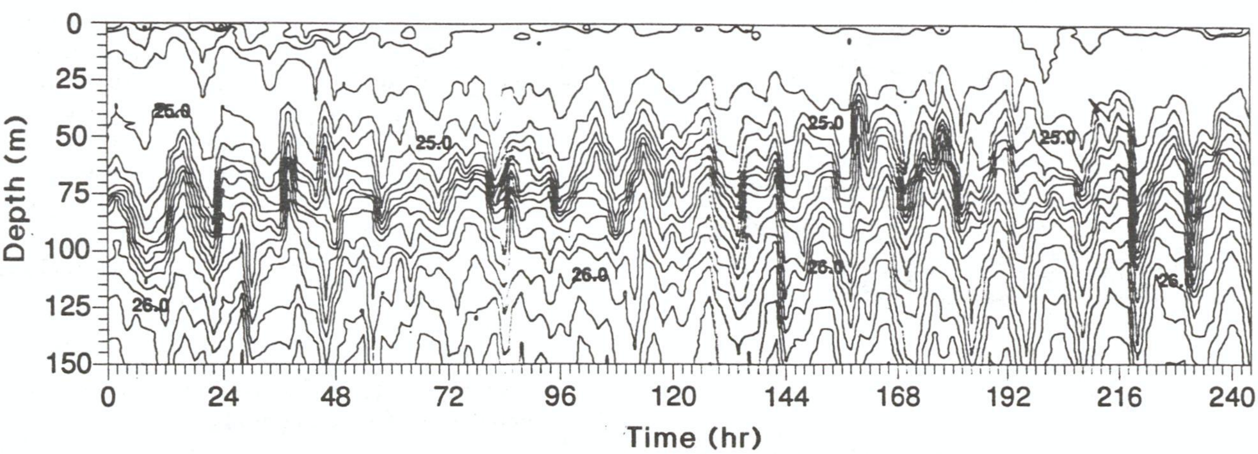


Figure 1. Density structure of the water column at CalCOFI station 63.55 over a 10-day period (February 3-14, 1995). The isopycnal pattern, that is, lines of constant density (σ_t), shows clearly the occurrence of internal waves.

effects on catch rates of different size categories and taxa of larval fish. Because no gaps occurred in the regular 2-hour sampling schedule, the data are perfectly suited for time series analysis—a mathematical procedure that quantifies temporal variation into elements in the frequency domain. A diel cycle in larval selectivity, for example, will be evident as a spectral density peak at frequency 0.04167 cycle/hour, equivalent to one cycle every 24 hours.

The CTD data have been processed and preliminary analyses have been completed. Results show that during the experiment, sea surface water temperatures were at least 1.5 °C warmer than normal. There was striking evidence of internal wave activity at the site (Fig. 1). The pycnocline underwent rapid vertical excursions of 40 m or more, which had the effect of expanding and shrinking the mixed layer. The periodicity of these waves appears to have been related to the 12-hour semidiurnal tidal cycle, particularly during the last four days of the cruise.

Data collected by the CTD PAR sensor show diel variation in available light throughout the water column (Fig. 2). There were subtle differences from one day to the next that seemed to be related primarily to cloud cover. After further processing, these data, like changes in mixed layer depth, may be used as covariates in a model explaining selectivity patterns of larval fish. (S. Ralston, 415-435-3149)

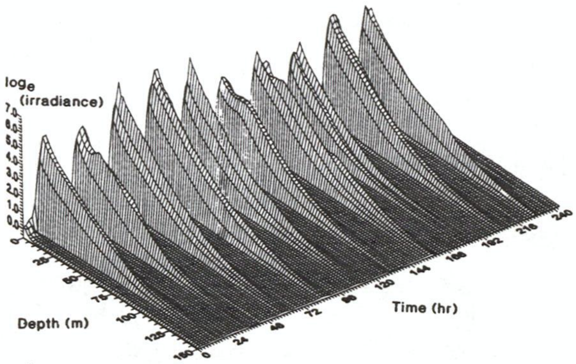


Figure 2. In situ measurements of light level from a photosynthetic-available-radiation sensor deployed during conductivity-temperature-depth casts.

GROUNDFISH PHYSIOLOGICAL ECOLOGY INVESTIGATION

Study of the Physiological Ecology of Juvenile Chinook Salmon in the San Francisco Estuary Initiated

Chinook salmon runs in the Sacramento-San Joaquin River drainage and the San Francisco Estuary are experiencing continued pressure on their vitality. The winter run is listed as endangered and the spring run is declining. Only the fall run is relatively stable. All runs face challenges characteristic of intensely agricultural and urbanized estuaries. The welfare of the species has amplified consequences for the economic future of California, including the development and agriculture in the Central Valley and southern California, municipal and industrial development of the Bay-Delta region, and the coastal communities that rely on salmon as a source of commercial and recreational income.

To manage salmon stocks effectively as a component of freshwater resources, greater knowledge is required of the environmental requirements necessary for fish to survive and prosper. We do not know whether the aquatic environment within the river-delta-bay complex is detrimental to the propagation of salmon stocks or if there is interannual variability in the health of outmigrating juveniles. Specifically, we do not know the residence time within, or rate of juvenile migration through, the sequential segments of the river-estuary and the importance of various habitats (for instance, channels, flats, marshes) to their growth, physiological status (or health), and survival.

To address these issues, the Physiological Ecology Investigation has initiated a study of outmigrating juvenile fall-run chinook salmon. Our purpose is to better understand their development within the San Francisco Bay-Delta and to gain greater insight into which habitats are particularly important to growth, health, and survival. Knowledge of these factors for fall-run juveniles may help us understand the challenges to growth and survival for the endangered winter run and other runs of chinook salmon as well.

The study is intended to last three to five years and focus on the following goals:

- Determine residence times and migration rates of fall-run juvenile salmon through segments of the river-estuary system (that is, Sacramento and San Joaquin Rivers, Delta, San Pablo Bay, San Francisco Bay);

- Determine growth, feeding, energy status, pathology, and contaminant accumulation in each segment of the migration path;
- Improve understanding of the relative significance of each segment and consequences of its degradation to salmon stocks; and
- Determine interannual variation in physiological status and relate to variation in annual environmental conditions.

During the period of outmigration (April to June), specimens of fall-run juvenile salmon will be obtained from specified habitats within each segment of the river-estuary system. Sampling of each segment will be repeated several times during this period. Habitat types may include marshes, intertidal and subtidal flats, channels, and grass beds.

To estimate the residence time within segments of the river-estuary, specimens at each collection site will be aged by assessing daily otolith increments. If sufficient fish are available, a portion of the catch will be tagged and released for subsequent recapture to improve estimates of residence time. Additionally, data from tags on captured hatchery-released juvenile salmon will be used to supplement migration data.

Laboratory analyses of physiological status and feeding, including assessment of length, weight, condition indices, lipid and protein content, stomach contents, contaminant analysis of tissues and stomach contents, and pathology, will be conducted on juvenile salmon from each segment of their migration path. These analyses are designed to distinguish the relative importance of each segment to the feeding, development, and contaminant accumulation of the salmon population.

In concert with fish collections, water quality data (depth profiles of temperature, conductivity, dissolved oxygen, pH, turbidity, total dissolved solids) will be recorded from established stations within each river-estuary segment to characterize the physical environment at the times of capture. These data will be integrated with other water quality and quantity data and plankton abundance and juvenile salmon abundance estimates obtained from other state and Federal agencies (for example, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Bureau of Reclamation, California Department of Fish and Game, Department of Water Resources) to determine interrelationships of physiological status, abundance, and environmental factors. Assuming that there are significant annual variations in salmon and environmental variables, the study will document the relationship of physiological status to environmental conditions.

This project will provide information on the relative importance of specific habitats and the consequences of their degradation to the health and viability of chinook salmon in the Sacramento-San Joaquin Rivers and San Francisco Estuary system. Knowledge of the extent to which each habitat and migration-path segment contributes to growth, physiological condition, contaminant burden, feeding, and residence time will assist resource managers responsible for equitable water allocations, endangered species protection, land use planning, and fisheries to improve their decision making related to salmon and other beneficial uses of natural resources. (B. MacFarlane, 415-435-3149)

INFORMATION TECHNOLOGY SERVICES

IT-95 Database Redesign Project Guided by Oracle Consultants

In the December 1993 Southwest Fisheries Regional Area's Information Technology 1995 (IT-95) Transition Plan, the process was outlined for the transfer of the Center's computer operations from the VAX and IBM host systems to the new NMFS Control Data distributed hardware and software platforms. In accordance to this plan, the SWFSC computer specialists in La Jolla, California, and Honolulu, Hawaii, began the database redesign tasks.

During the ensuing months, the SWFSC data managers and computer specialists gained experience on the relational database concept through formal and customized ORACLE classes provided by the ORACLE Education Center, the ORACLE computer-based, self-training sessions, and the hands-on development process to redesign two of the existing databases. The learning experience revealed the critical need for guidance from an experienced ORACLE design specialist in the system redesign and implementation processes. The data managers determined that a feasible solution was to contract highly qualified and experienced ORACLE design and CASE specialists to provide us the consulting support in the redesign projects.

Under the revised plan, the ORACLE Corporation Federal Division, a GSA authorized vendor, would be contracted to provide experienced ORACLE consultants to advise and teach the technical database development teams at the SWFSC sites. Using the ORACLE CASE tool and methodology, the consultants would work with the technical teams and guide them in creating the database physical design. For the databases under current redesign development, the consultants would review the design with the teams and determine if the design structure meets their needs. If restructuring is necessary, the teams would receive guidance in modifying the design. Using the ORACLE methodology, the consultants would also work with the teams and guide them in effective database administration, maintenance and processing techniques. The support services include providing input to the needs of the Center's system architecture and training the development teams on database administration, optimizing the redesigned systems, data validation rules, use of ORACLE utilities, standard application program interfaces, and efficient data extraction and data loading techniques. A by-product of this consulting contract is transferring knowledge to the Center's staff of computer specialists for designing new systems and optimizing, maintaining, and supporting developed systems. (D. D. Roll, 619-546-7057)

PUBLICATIONS

Published

This published list encompasses publications for the year 1994 for the Southwest Fisheries Science Center, as of press time (April 1995). Abstracts are provided for those publications being listed for the first time (not listed in previous 1994 Reports of Activities).

Adams, P. B. 1994. An examination of the 1992 and 1993 commercial and recreational lingcod sampling in Oregon and California. Appendix J. *In* Status of the Pacific coast groundfish fishing throughout 1994 and recommended biological catches for 1995. Pacific Fishery Management Council, Portland, Oregon.

Aguirre, A. A., G. H. Balazs, B. Zimmerman, and F. D. Galey. 1994. Organic contaminants and trace metals in the tissues of green turtles (*Chelonia mydas*) afflicted with fibropapillomas in the Hawaiian Islands. Mar. Pollut. Bull. 28(2):109-114.

———, ———, ———, and T. R. Spraker. 1994. Evaluation of Hawaiian green turtles (*Chelonia mydas*) for potential pathogens associated with fibropapillomas. J. Wildl. Dis. 30(1):8-15.

Atkinson, S., B. L. Becker, T. C. Johanos, J. R. Pietraszek, and B. C. S. Kuhn. 1994. Reproductive morphology and status of female Hawaiian monk seals (*Monachus schauinslandi*) fatally injured by adult male seals. J. Reprod. Fertil. 100:225-230.

Balazs, G. H. 1994. Homeward bound: Satellite tracking of Hawaiian green turtles from nesting beaches to foraging pastures, pp. 205-208. *In* B. A. Schroeder, and B. E. Witherington (comps.), Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation, 23-27 February 1993. U.S. Dep. Commer., NOAA Tech. Memo., NMFS-SEFSC-341.

———, P. Craig, B. R. Winton, and R. K. Miya. 1994. Satellite telemetry of green turtles nesting at French Frigate Shoals, Hawaii, and Rose Atoll, American Samoa, pp. 184-187. *In* K. A. Bjorndal, A. B. Bolten, D. A. Johnson, and P. J. Eliazar (comps.), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation, March 1-5, 1994, Hilton Head, South Carolina. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SEFSC-351.

———, W. C. Dudley, L. E. Hallacher, J. P. Coney, and S. K. Koga. 1994. Ecology and cultural significance of sea turtles at Punalu-u, Hawaii, pp. 10-13. *In* K. A. Bjorndal, A. B. Bolten, D. A. Johnson, and P. J. Eliazar (comps.), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation, March 1-5, 1994, Hilton Head, South Carolina. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SEFSC-351.

———, R. K. Miya, and M. A. Finn. 1994. Aspects of green turtles in their feeding, resting, and cleaning areas off Waikiki Beach, pp. 15-18. *In* B. A. Schroeder, and B. E. Witherington (comps.), Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation, 23-27 February 1993. U.S. Dep. Commer., NOAA Tech. Memo., NMFS-SEFSC-341.

———, and S. G. Pooley. 1994. Research plan to assess marine turtle hooking mortality: Results of an expert workshop held in Honolulu, Hawaii, November 16-18, 1993. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-201, 166 p.

Barlow, J. 1994. An assessment of the 1994 status of harbor porpoise in California. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-205, 17 p.

———. 1994. Recent information on the status of large whales in California waters. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-203, 27 p.

———, R. W. Baird, J. E. Heyning, K. Wynne, A. M. Manville, L. F. Lowry, D. Hanan, J. Sese, and V. N.

Burkanov. A review of cetacean and pinniped mortality in coastal fisheries along the west coast of the USA and Canada and the east coast of the Russian Federation, pp. 405-26. *In* W. F. Perrin, G. P. Donovan, and J. Barlow (eds.). International Whaling Commission, Report of the Workshop on Mortality of Cetaceans in Passive Fishing Nets and Traps. International Whaling Commission. Special Issue No. 15.

———, and T. Lee. 1994. The estimation of perpendicular sighting distance on SWFSC research vessel surveys for cetaceans: 1974 to 1991. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-207, 46 p.

Bartoo, N., and T.J. Foreman. 1994. A review of the biology and fisheries for North Pacific albacore (*Thunnus alalunga*), pp. 173-187. *In* R. S. Shomura, J. Majkowski, and S. Langi (eds.), Interactions of Pacific tuna fisheries. Proceedings of the first FAO Expert Consultation on Interactions of Pacific Tuna Fisheries. 3-11 December 1991. Noumea, New Caledonia. Volume 2: Papers on biology and fisheries.

———, D. Holts, and C. Brown. 1994. Evidence of interactions between high seas drift gillnet fisheries and the North American troll fishery for albacore, pp. 214-227. *In* R. S. Shomura, J. Majkowski, and S. Langi (eds.), Interactions of Pacific tuna fisheries. Proceedings of the first FAO Expert Consultation on Interactions of Pacific Tuna Fisheries. 3-11 December 1991. Noumea, New Caledonia. Volume 1: Summary report and papers on interaction.

Becker, B. L., P. A. Ching, L. M. Hiruki, and S. A. Zur. 1994. The Hawaiian monk seal on Laysan Island, 1987 and 1989. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-213, 20 p.

Bigelow, K. A. 1994. Age and growth of the oceanic squid *Onychoteuthis borealijaponica* in the North Pacific. Fish. Bull., U.S. 92(1):13-25.

Bjorge, A., R. L. Brownell, G. P. Donovan, and W. F. Perrin. 1994. Significant direct and incidental catches of small cetaceans. A report by the Scientific Committee of the International Whaling Commission to the United Nations Conference on Environment and Development (UNCED), pp. 73-130. *In* W. F. Perrin, G. P. Donovan, and J. Barlow (eds.). International Whaling Commission, Report of the Workshop on Mortality of Cetaceans in Passive Fishing Nets and Traps. International Whaling Commission. Special Issue No. 15.

Blood, D. M., A. C. Matarese, and M. M. Yoklavich. 1994. Embryonic development of walleye pollock, *Theragra chalcogramma*, from Shelikof Strait, Gulf of Alaska. Fish. Bull., U.S. 92(2):207-222.

Boehlert, G. W., and B. C. Mundy. 1994. Vertical and onshore-offshore distributional patterns of tuna larvae in relation to physical habitat features. Mar. Ecol. Prog. Ser. 107:1-13.

———, C. D. Wilson, and K. Mizuno. 1994. Populations of the sternoptychid fish *Maurolicus muelleri* on Seamounts in the central North Pacific. Pacific Science 48(1):57-59.

Boggs, C. H. 1994. Methods for analyzing interactions of limited-range fisheries: Hawaii's pelagic fisheries, pp. 74-91. *In* R. S. Shomura, J. Majkowski and S. Langi (eds.), Interactions of Pacific tuna fisheries. Proceedings of the first FAO Expert Consultation on Interactions of Pacific Tuna Fisheries. 3-11 December 1991. Noumea, New Caledonia. Volume 1: Summary report and papers on interaction.

Brill, R. W. 1994. A review of temperature and oxygen tolerance studies of tunas pertinent to fisheries oceanography, movement models and stock assessments. Fish. Oceanogr. 3(3):204-216.

———, H. Dewar, and J. B. Graham. 1994. Basic concepts relevant to heat transfer in fishes, and their use in measuring the physiological the rmoregulatory abilities of tunas. Environ. Biol. Fishes 40:109-124.

———, and D. R. Jones. 1994. The influence of hematocrit, temperature, and shear rate on the viscosity of blood from a high-energy-demand teleost, the yellowfin tuna, *Thunnus albacares*. J. exp. Biol. 189:199-212.

Carretta, J. V., M. S. Lynn, and C. A. LeDuc. 1994. Right whale (*Eubalena glacialis*) sighting off San Clemente Island, California. Mar. Mamm. Sci. 10(1):101-105.

Chave, E. H., and B. C. Mundy. 1994. Deep-sea benthic fish of the Hawaiian Archipelago, Cross Seamount, and Johnston Atoll. Pac. Sci. 48(4):367-409.

Chivers, S. J., and D. P. DeMaster. 1994. Evaluation of biological indices for three eastern Pacific dolphin species. J. Wildl. Manage. 58(3):470-478.

Coan, A. L., Jr. 1994. U.S.A. distant-water and artisanal fisheries for yellowfin tuna in the Central and Western Pacific, pp. 138-152. *In* R. S. Shomura, J. Majkowski, and S. Langi (eds.), Food and Agriculture of the United Nations, Rome, Italy. Proceedings of the First FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, 3-11 December 1991, Noumea, New Caledonia. Volume 2: Papers on biology and fisheries.

Craig, M. P., J. L. Megyesi, C. S. Hall, J. L. Glueck, L. P. Laniawe, E. A. Delaney, S. S. Keefer, M. A. McDermond, M. Schulz, G. L. Nakai, B. L. Becker, L. M. Hiruki, and R. J. Morrow. 1994. The Hawaiian monk seal at French Frigate Shoals, 1990-91. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-210, 70 p.

DeMartini, E. E., A. M. Barnett, T. D. Johnson, and R. F. Ambrose. 1994. Growth and production estimates for biomass-dominant fishes on a southern California artificial reef. Fifth International Conference on

Aquatic Habitat Enhancement, November 3-7, 1991, Long Beach, California. Bull. Mar. Sci. 55(2-3):484-500.

Somatic growth and somatic and gonadal production were estimated during May-November 1989 for six species, comprising most of the standing crop biomass of the fishes on a shallow (10- to 15-m deep), 14-year-old, quarry rock reef (Torrey Pines Artificial Reef #2, TPAR), off La Jolla, California. Growth was estimated from weight-converted length increments of 142 Floy-tagged individuals at liberty for a median of 187 days. Somatic growth rates varied three- to fourfold among the six species. Somatic production varied more than somatic growth rates (by a factor of 15). Egg production was estimated for females of three taxa (four species) as the product of the weight of batch egg production and spawning frequency. Weight-specific egg production varied twofold among these three taxa. Despite likely substantial underestimates of gametic materials, gonadal production ranged from a large fraction to a large multiple of somatic production among the four species. Our observations suggest that the elaboration of tissue related to yield is nontrivial and represents a major component of energy flow through the fishes in this reef system and perhaps others.

———, K. C. Landgraf, and S. Ralston. 1994. A recharacterization of the age-length and growth relationships of Hawaiian snapper, *Pristipomoides filamentosus*. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-199, 14 p.

Dizon, A. E., W. F. Perrin, and P. A. Akin. 1994. Stocks of dolphins (*Stenella* spp. and *Delphinus delphis*) in the eastern tropical Pacific: a phylogeographic classification. NOAA Technical Report NMFS 119.

Eldridge, M. B. 1994. Hook-and-line fishing study at Cordell Bank, California, 1986-1991. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-197, 24 p.

Everson, A. 1994. Fishery data collection system for fishery utilization study of Kaneohe Bay: two-year interim report. Department of Land and Natural Resources, Division of Aquatic Resources, State of Hawaii. Technical Report 94-01, 45 p.

Fiedler, P. C. 1994. Seasonal and interannual variability of coastal zone color scanner phytoplankton pigments and winds in the eastern tropical Pacific. J. Geophys. Res. 99(C9):18,371-18,384.

———, and S. B. Reilly. 1994. Interannual variability of dolphin habitats in the eastern tropical Pacific. II: Effects on abundances estimated from tuna vessel sightings, 1975-1990. Fish. Bull., U.S. 92(2):451-463.

Finn, M. A., and M. A. Rice. 1994. Hawaiian monk seal observations at Necker Island, 1993. 'Elepaio 55:7-10.

Forney, K. A. 1994. Recent information on the status of odontocetes in Californian waters. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-202, 87 p.

Frazier, J. G., H. L. Fierstine, S. C. Beavers, F. Achaval, H. Suganuma, R. L. Pitman, Y. Yamaguchi, and C. M. Prigioni. 1994. Impalement of marine turtles (Reptilia, Chelonia: Cheloniidae and Dermochelyidae) by billfishes (Osteichthyes, Perciformes: Istiophoridae and Xiphiidae). Environ. Biol. Fishes 39:85-96.

Gilpatrick, J. W., Jr., and M. S. Lynn. 1994. A test of two photogrammetric measuring instruments used to determine dolphin lengths from vertical aerial photographs. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-196, 14 p.

Graham, J. B., H. Dewar, N. C. Lai, K. E. Korsmeyer, P. A. Fields, T. Knower, R. E. Shadwick, R. Shabetai, and R. W. Brill. 1994. Swimming physiology of pelagic fishes, pp. 63-74. *In* L. Maddock, Q. Bone, and J. M. V. Rayner (eds.), Mechanics and physiology of animal swimming. Cambridge University Press, Cambridge.

Herrick, S. F., Jr., I. Strand, D. Squires, M. Miller, D. Lipton, J. Walden, and S. Freese. 1994. Application of benefit-cost analysis to fisheries allocation decisions: the case of Alaska walleye pollock and Pacific cod. N. Am. J. Fish. Manage. 14:726-741.

Hewitt, R. P., and D. A. Demer. 1994. Acoustic estimates of krill biomass in the elephant island area: 1984-1993. CCAMLR Science 1:1-5.

Hobson, E. S. 1994. Ecological relations in the evolution of acanthoptergian fishes of warm-temperate communities of the northeastern Pacific. Environ. Biol. Fishes 40:49-90.

Huppert, D. D., and T. W. Mittleman. 1994. Economic effects of the United Nations moratorium on high-seas driftnet fishing. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-194, 62 p.

Ito, R. Y., R. E. Dollar, and K. E. Kawamoto. 1994. The Hawaiian longline fishery for swordfish. (Abstr.) International Symposium on Pacific Swordfish: Development of Fisheries, Markets, and Biological Research. Ensenada, Baja California, Mexico, December 11-14, 1994.

———, D. R. Hawn, and B. B. Collette. 1994. First record of the butterfly kingfish, *Gasterochisma melampus* (Scombridae), from the North Pacific Ocean. Japan. J. Ichthyol. 40(4):482-486.

Jacobson, L. D., N. C. H. Lo, and J. T. Barnes. 1994. A biomass-based assessment model for northern anchovy , *Engraulis mordax*. Fish. Bull., U.S. 92(4): 641-652.

Jefferson, T. A., B. E. Currey, and N. A. Black. 1994. Harbor porpoise mortality in the Monterey Bay halibut gillnet fishery, 1989, pp. 445-448, *In* W. F. Perrin, G. P. Donovan, and J. Barlow (eds.). International Whaling Commission, Report of the Workshop on Mortality of Cetaceans in Passive Fishing Nets and Traps. International Whaling Commission. Special Issue No. 15.

———, A. C. Myrick, Jr., and S. J. Chivers. 1994. Small cetacean dissection and sampling: A field guide. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-198, 54 p.

Johanos, T. C. B. L. Becker, T. J. Ragen. 1994. Annual reproductive cycle of the female Hawaiian monk seal (*Monachus schauinslandi*). Mar. Mamm. Sci. 10(1): 13-30.

Johnson, T. D., A. M. Barnett, E. E. DeMartini, L. L. Craft, R. F. Ambrose, and L. J. Purcell. 1994. Fish production and habitat utilization on a southern California artificial reef. Fifth International Conference on Aquatic Habitat Enhancement, November 3-7, 1991, Long Beach, California. Bull. Mar. Sci. 55(2-3):709-723.

The feeding habits of fish, their production, and their fidelity to the reef habitat were estimated on and near Torrey Pines Artificial Reef (TPAR) during April-October 1989. Taxonomic and biomass analysis of gut contents and benthic resources suggested that at least 70% of the diet of reef fish was derived from the reef itself, and another 20-25% from the ecotone. For most reef fishes, suitable prey was 100 times more abundant in the reef habitat than in adjacent sand habitats. Estimates of somatic production by tagged fish were based on standing stocks, size distribution, and growth rates, and by untagged species, on changes in mean length of a cohort or population biomass over time. Estimated total production of the fish on TPAR was 116 kg or 649 kg•ha^{-1}, more than a third of it as gonadal production by the six target species. Production by the sand-bottom fish assemblage, estimated from literature-derived somatic and gonadal production rates and the biomass of trawled fish, was 73 kg•hectare•year^{-1}. Calculated reef production was, therefore, about nine times greater than the production of sand-bottom fish. From 30 to 70% of the four species of tagged fish (sheephead, rock wrasse, black perch, and garibaldi) that could be captured by divers were recaptured after 7 months, indicating a high degree of fidelity to the reef. Recapture of 12% of tagged kelp bass via hook-and-line caught 1 year later by a sport fishing boat indicate that kelp bass, too, remained associated with the reef for long periods.

Keen, J. E., K. L. Cousins, A. P. Farrell, R. W. Brill, and K. R. Olson. 1994. Exogenously-applied and endogenously-derived atrial natriuretic peptide in the yellowfin tuna (*Thunnus albacares*): cardiovascular responses, plasma natriuretic peptide concentration, and distribution of immunoreactive granules. (Abstr.) Conference proceedings of the American Physiological Society, San Diego, California, October 29-November 2, 1994.

Kleiber, P. 1994. Types of tuna fishery interaction in the Pacific Ocean and methods of assessing interaction, pp. 61-73. *In* R. S. Shomura, J. Majkowski, and S. Langi (eds.), Food and Agriculture of the United Nations, Rome, Italy. Proceedings of the First FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, 3-11 December 1991, Noumea, New Caledonia. Volume 1: Summary report and papers on interaction.

———, and B. Baker. 1994. Assessment of interaction between North Pacific albacore, *Thunnus alalunga*, fisheries by use of a simulation model, pp. 213. (Abstr.) *In* R. S. Shomura, J. Majkowski, and S. Langi (eds.), Food and Agriculture of the United Nations, Rome, Italy. Proceedings of the First FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, 3-11 December 1991, Noumea, New Caledonia. Volume 1: Summary report and papers on interaction.

———, and A. Fonteneau. 1994. Assessment of skipjack fishery interaction in the eastern tropical Atlantic using tagging data, pp. 94-107. *In* R. S. Shomura, J. Majkowski, and S. Langi (eds.), Food and Agriculture of the United Nations, Rome, Italy. Proceedings of the First FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, 3-11 December 1991, Noumea, New Caledonia. Volume 1: Summary report and papers on interaction.

Knutz, T., P. Koske, J. Reppin, G. Boehlert, and M. Seki. 1994. GEK-measurements of surface currents along the Hawaiian Ridge. (Abstr.) EOS, Trans. Am. Geophys. Union. 75 (3):24.

Larson, R. J., W. H. Lenarz, and S. Ralston. 1994. The distribution of pelagic juvenile rockfish of the genus *Sebastes* in the upwelling region off central California. Calif. Coop. Oceanic Fish. Invest. Rep. 35:175-221.

Lau, B. B., and E. E. DeMartini. 1994. An evaluation of oocyte size in multiple regressions predicting gonad weight from body weight: A test using Hawaiian ehu, *Etelis carbunculus*. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-212, 17 p.

Lee, T. 1994. Report on cetacean aerial survey data collected between the years of 1974 and 1982. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-195, 62 p.

Lenarz, W. H. 1994. Estimation of weight-length relationships from group measurements. Fish. Bull., U.S. 92(1):198-202.

Lombard, K. B., B. L. Becker, M. P. Craig, G. C. Spencer, and K. Hague-Bechard. 1994. The Hawaiian monk seal on Laysan Island, 1990. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-206, 16 p.

Losey, G. S., G. H. Balazs, and L. A. Privitera. 1994. Cleaning symbiosis between the wrasse, *Thalassoma duperry*, and the green turtle, *Chelonia mydas*. Copeia 1994(3):684-690.

MacCall, A. D., and K. Tatsukawa. 1994. Theoretical effects of habitat selection on distribution and productivity of whales. Rep. int. Whal. Commn 44:407-411.

Mangels, K. F., and T. Gerrodette. 1994. Report of cetacean sightings during a marine mammal survey in the eastern tropical Pacific Ocean aboard the NOAA ships *McArthur* and *David Starr Jordan*, July 28 - November 2, 1992. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-200, 74 p.

———, and ———. 1994. Report of cetacean sightings during a marine mammal survey in the eastern Pacific Ocean and the Gulf of California aboard the NOAA ships *McArthur* and *David Starr Jordan*, July 28 - November 6, 1993. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-211, 92 p.

Mitchell P. C., J. L. Megyesi, C. S. Hall, J. L. Glueck, L. P. Laniawe, E. A. Delaney, S. S. Keefer, M. A. Mcdermond, M. Schulz, G. L. Nakai, B. L. Becker, L. M. Hiruki, and R. J. Morrow. 1994. The Hawaiian monk seal at French Frigate Shoals, 1990-91. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-210, 70 p.

Miyazaki, N., and W. F. Perrin. 1994. Rough-toothed dolphin—*Steno bredanensis* (Lesson, 1828), pp. 1-22. *In* S. R. Ridgway, and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins. Academic Press, NY.

Moffitt, R. B. 1994. Pearl oysters in Hawaii. Hawaiian Shell News. 42(4):3-4.

Mundy, B. C. 1 994. Policies, legislation, and other activities related to nonindigenous marine organisms in the State of Hawaii, pp. 103-109. *In* Nonindigenous Estuarine & Marine Organisms (NEMO), Proceedings of the Conference and Workshop, Seattle, Washington, April 20-22, 1993.

In Hawaii, introduced species issues in the marine environment are addressed primarily by state legislation. All importations of organisms into the state must be by permit, and the state can confiscate illegally imported organisms (Chapter 150, Revised Laws of Hawaii and Act 104, 1991 Session Laws of Hawaii). Authority is delegated to the Hawaii Department of Agriculture (HDOA) by Hawaii Administrative Rules Chapter 4-71. Permit requests are reviewed by six HDOA advisory committees consisting of s tate, federal, and academic representatives. Policies for many species are set by lists specifying conditions for importation including (1) a list of conditionally approved organisms which may be freely imported, (2) a list of restricted organisms which may be imported only under controlled conditions, and (3) a list of prohibited organisms not to be imported for any reason. The release of all nonnative aquatic life into any waters of the state is prohibited, except with an additional permit, by Act 256 of 1993. Unintentional introductions are addressed only by empowerment of HDOA to inspect and confiscate organisms without permits. Resolutions specifically directed toward unintentional introductions of marine organisms were introduced in the state legislature in 1993.

Norton, J. G., D. R. Cayan, and D. R. McLain. 1994. Near and distant connection of atmospheric systems to ocean temperature change in the coastal California Current region. *In* K. T. Redmond, and V. L. Tharp (eds.), Proceedings of the Tenth Annual Pacific Climate (PACLIM) Workshop, April 4-7, 1993. California Department of Water Resources, Interagency Ecological Studies Program Report 36.

———, and D. R. McLain. 1994. Diagnostic Patterns of Seasonal and Interannual Temperature Variation off the West Coast of the United States: Local and Remote Large Scale Atmospheric Forcing. J. Geophys. Res. 99(8):16019-16030.

———, and S. J. Crooke. 1994. Occasional Availability of Dolphin, *Coryphaena hippurus*, to Southern California Commercial Passenger Fishing Vessel Anglers: Observations and Hypotheses. Calif. Coop. Oceanic Fish. Invest. Rep. 35:230-239.

Okechi, J. K., and J. J. Polovina. 1994. The spiny lobster fishery of Kenya, pp. 103-107. *In* B. F. Phillips, J. S. Cobb, and J. Kittaka (eds.), Spiny Lobster Management, Blackwell Scientific Publications, Ltd., Cambridge, MA.

Oliver, C. W., W. A. Armstrong, and J. A. Young. 1994. Development of an airborne LIDAR system to detect tunas in the eastern tropical Pacific purse-seine fishery. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-204, 67 p.

Parrish, F. A., and J. J. Polovina. 1994. Habitat thresholds and bottlenecks in production of the spiny lobster (*Panulirus marginatus*) in the Northwestern Hawaiian Islands. Bull. Mar. Sci. 54(1):151-163.

Perrin, P. M., and Brownell, R. L. 1994. A brief review of stock identity in small marine cetaceans in relation to assessment of driftnet mortality in the North Pacific, pp. 393-402. *In* W. F. Perrin, G. P. Donovan, and J. Barlow (eds.). International Whaling Commission, Report of the Workshop on Mortality of Cetaceans in Passive Fishing Nets and Traps. International Whaling Commission. Special Issue No. 15.

———, D. K. Caldwell, and M. C. Caldwell. 1994. Atlantic spotted dolphin—*Stenella frontalis* (G. Cuvier, 1829), pp. 173-190. *In* S. R. Ridgway, and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins. Academic Press, NY.

———, G. P. Donovan, and J. Barlow (eds.). 1994. International Whaling Commission, Report of the Workshop on Mortality of Cetaceans in Passive Fishing Nets and Traps. International Whaling Commission. Special Issue No. 15.

———, ———, and ———. 1994. International Whaling Commission. Report of the Workshop on Mortality of

Cetaceans in Passive Fishing nets and traps, pp. 1-71. *In* W. F. Perrin, G. P. Donovan, and J. Barlow (eds.). International Whaling Commission, Report of the Workshop on Mortality of Cetaceans in Passive Fishing Nets and Traps. International Whaling Commission. Special Issue No. 15.

———, and J. W. Gilpatrick, Jr. 1994. Spinner dolphin—*Stenella longirostris* (Gray, 1828), pp. 99-128. *In* S. R. Ridgway, and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins. Academic Press, NY.

———, and A. A. Hohn. 1994. Pantropical spotted dolphin—*Stenella attenuata*, pp. 71-98. *In* S. R. Ridgway, and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins. Academic Press, NY.

———, S. Leatherwood, and A. Collet. 1994. Fraser's dolphin—*Lagenodelphis hosei* (Fraser, 1956), pp. 225-240. *In* S. R. Ridgway, and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins. Academic Press, NY.

———, and J. G. Mead. 1994. Clymene dolphin—*Stenella clymene* (Gray, 1846), pp. 161-172. *In* S. R. Ridgway, and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins. Academic Press, NY.

———, G. D. Schnell, D. J. Hough, J. W. Gilpatrick, Jr., and J. V. Kashiwada. 1994. Reexamination of geographic variation in cranial morphology of the pantropical spotted dolphin, *Stenella attenuata*, in the eastern Pacific. Fish. Bull., U.S. 92(2):324-346.

———, C. E. Wilson, and F. I. Archer II. 1994. Striped dolphin—*Stenella coeruleoalba* (Meyen, 1833), pp. 129-160. *In* S. R. Ridgway, and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins. Academic Press, NY.

———, A. V. Yablokov, J. Barlow, and M. V. Mina. 1994. Comparison of the resolving power of metric and non-metric cranial characters in defining geographical populations of dolphins. Natural History Museum of Los Angeles County, Contributions in Science 447:1-15.

Resolving power was compared to multivariate analysis of 31 metric and 26 non-metric characters for three geographical samples of skulls of the common dolphin, *Delphinus delphis*: eastern tropical Pacific (73 specimens), western and mid-North Atlantic (71), and Black Sea (37). The samples from the three areas differed significantly in both the metric and non-metric characters. The metric characters had higher discriminating power (97.8% correct classification by jackknife method) than the non-metric characters (82.5%), both were efficient. The results of an analysis of combined metric and non-metric data are consistent with a hypothesis of non-neutrality of the non-metric characters. Because of their apparent lesser revolving power and because of difficulties concerning repeatability, it is recommended that non-metric characters be used in dolphin population studies only in combination with metric characters and that special attention be paid to controlling conditions to maximize comparability of data sets.

Perryman, W. L., D. W. K. Au, S. Leatherwood, and T. A. Jefferson. 1994. Melon-headed whale—*Peponocephala electra* (Gray, 1846), pp. 363-386. *In* S. R. Ridgway, and R. Harrison (eds.), Handbook of Marine Mammals, Volume 5: The First Book of Dolphins. Academic Press, NY.

———, and M. S. Lynn. 1994. Examination of stock and school structure of striped dolphin (*Stenella coeruleoalba*) in the eastern Pacific from aerial photogrammetry. Fish. Bull., U.S. 92(1):122-131.

Polovina, J. 1994. The case of the missing lobsters. Nat. Hist. 103(2):50-59.

———. 1994. The lobster fishery in the North-western Hawaiian Islands, pp. 83-90. *In* B. F. Phillips, J. S. Cobb, and J. Kittaka (eds.), Spiny Lobster Management, Blackwell Scientific Publications, Ltd., Cambridge, MA.

———, and B. B. Lau. 1994. Temporal and spatial distribution of catches of tiger sharks, *Galeocerdo cuvier*, in the Pacific longline fishery around the Hawaiian Islands. Mar. Fish. Rev. 55(3):1-3.

———, and G. T. Mitchum. 1994. Spiny lobster recruitment and sea level: results of a 1990 forecast. Fish. Bull., U.S. 92(1):203-205.

———, ———, N. E. Graham, M. P. Craig, E. E. DeMartini, and E. N. Flint. 1994. Physical and biological consequences of a climate event in the central North Pacific. Fish. Oceanogr. 3(1):15-21.

Reilly, S. B., and P. C. Fiedler. 1994. Interannual variability of dolphin habitats in the eastern tropical Pacific. I: Research vessel surveys, 1986-1990. Fish. Bull., U.S. 92(2):434-450.

Rogers, J. B. 1994. Preliminary status of the splitnose rockfish stock in 1994. Appendix H. *In* Status of the Pacific Coast groundfish fishery through 1994 and recommended acceptable biological catches for 1995. Pacific Fishery Management Council, Portland, Oregon.

Rosenfeld, L. K., F. B. Schwing, N. Garfield, and D. E. Tracy. 1994. Bifurcated flow from an upwelling center: a cold water source for Monterey Bay. Continental Shelf Research 14:931-964.

Russell, D. J., and G. H. Balazs. 1994. Colonization by the alien marine alga *Hypnea musciformis* (Wulfen) J. Ag. (Rhodophyta: Gigartinales) in the Hawaiian Islands and its utilization by the green turtle, *Chelonia mydas* L. Aquat. Bot. 47:53-60.

———, and ———. 1994. Utilization of alien algal species by sea turtles in Hawaii, pp. 93-96. *In* Nonindigenous Estuarine & Marine Organisms (NEMO), Proceedings of the Conference and Workshop, Seattle, Washington, April 20-23, 1993.

Seventeen species of marine macro-algae, plus one variant or morph, have been introduced to Oahu, Hawaii, since 1950. Although one came by ship, most of the introductions were in conjunction with marine agronomy projects and were transported to Hawaii by air from California, Florida, and the Philippines. The alien species *Acanthophora spicifera* (Vahl) Boerg. and *Hypnea musciformis* (Wulfen) J. Ag. have become wide-spread and have displaced two native algal species, while adding to the total biomass of the reef. These aliens plus five other introduced algal species are presently being used as food sources by the Hawaiian green turtle (*Chelonia mydas* L.), a species considered endangered worldwide. Our research is the first known documentation of introduced algae being incorporated into the diet of the green turtle and represents only one of many changes the introduction of fast-growing alien primary producers may cause in the food web.

Sakuma, K. M., H. A. Parker, S. Ralston, F. B. Schwing, D. M. Husby, and E. M. Armstrong. 1994. The physical oceanography off the central California coast during February-March and May-June, 1992: A summary of CTD data from pelagic young-of-the-year rockfish surveys. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-208, 169 p.

———, ———, ———, ———, ———, ———. 1994. The physical oceanography off the central California coast during March and May-June, 1993: a summary of CTD data from pelagic young-of-the-year rockfish surveys. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-209, 168 p.

Salvadó, C. A. M.. 1994. Discrete population field theory for tag analysis and fishery modeling, pp. 122-136. *In* R. S. Shomura, J. Majkowski, and S. Langi (eds.), Interactions of Pacific tuna fisheries. Proceedings of the first FAO Expert Consultation on Interactions of Pacific Tuna Fisheries. 3-11 December 1991. Noumea, New Caledonia. Volume 1: Summary report and papers on interaction.

Schwing, F. B., and R. Mendelssohn. 1994. Evidence for increased coastal upwelling in the California Current System due to climate variability. EOS, Trans. Am. Geophys. Union. 75(44):346.

Seki, M. P., and D. A. Somerton. 1994. Feeding ecology and daily ration of the pelagic armorhead, *Pseudopentaceros wheeleri*, at Southeast Hancock Seamount. Environ. Biol. Fishes 39:73-84.

Skillman, R. A. 1994. Central Pacific swordfish status report. (Abstr.) International Symposium on Pacific Swordfish: Development of Fisheries, Markets, and Biological Research. Ensenada, Baja California, Mexico, December 11-14, 1994.

Squires, D. 1994. Firm behavior under input rationing. Journal of Econometrics 61:235-257.

———. 1994. Sources of growth in marine fishing industries. Marine Policy 18(1):5-18.

———, M. Alauddin, and J. Kirkley. 1994. Individual transferable quota markets and investment decisions in the fixed gear sablefish industry. J. Environ. Econ. Manage. 27:185-204.

Steiner, M. T., N. Garfield, and F. B. Schwing. 1994. Net non-tidal transport estimates for the Gulf of the Farallones, 1991-1992. EOS, Trans. Am. Geophys. Union. 75(44):336.

Townsend, R. E., and S. G. Pooley. 1994. Comprehensive property rights: fishery trusts. International Council for the Exploration of the Seas (ICES), 82nd statutory meeting, September 22-30, 1994, St. John's, Newfoundland, Canada.

———, and ———. 1994. Effort reduction under limited entry: attrition versus fractional licenses in the Hawaii longline fleet. N. Am. J. Fish. Manage. 14:297-306.

Uchiyama, J. H., R. A. Skillman, and J. D. Sampaga. 1994. Ageing of North Pacific swordfish using hard parts. (Abstr.) International Symposium on Pacific Swordfish: Development of Fisheries, Markets, and Biological Research. Ensenada, Baja California, Mexico, December 11-14, 1994.

Wilson, C. D., and M. P. Seki. 1994. Biology and population characteristics of *Squalus mitsukurii* from a seamount in the central North Pacific Ocean. Fish. Bull., U.S. 92(4):851-864.

Approved by Science and Research Director, SWR

This list is for those publications approved by the Science and Research Director in January-March 1995 for all laboratories.

DeMartini, E. E. Sheltering and foraging substrate uses of the arc-eye hawkfish, *Paracirrhites arcatus* (Pisces: Cirrhitidae). For consideration for publication in Bulletin of Marine Science.

———, and T. J. Donaldson. Morph-habitat relations in the arc-eye hawkfish, *Paracirrhites arcatus* (Pisces: Cirrhitidae) at two complementary spatial scales. For consideration for publication in Copeia.

Ito, R. Y., R. A. Dollar, and K. E. Kawamoto. The Hawaii-based longline fishery for swordfish. For consideration for publication in Proceedings of the International Symposium on Pacific Swordfish: Development of Fisheries, Markets, and Biological Research, Ensenada, Baja California, Mexico, December 11-14, 1994.

Laidig, T. E., K. M. Sakuma, and M. Nishimoto. Description of pelagic larval and juvenile *Sebastes saxicola* with an examination of larval growth. For consideration for publication in Fishery Bulletin, U.S.

Lenarz, W. H., D. VenTresca, W. M. Graham, F. B. Schwing, and F. Chavez. Explorations of El Niños and associated biological population dynamics of central California. For consideration for publication in California Cooperative Oceanic Fisheries Investigation Reports.

Mundy, B. C., and A. R. Everson. Western Pacific oceanic ecosystems. For consideration for publication in Status and Trends of the Nation's Living Resources, a National Biological Service publication.

Niethammer, K. R., G. H. Balazs, J. S. Hatfield, G. L. Nakai, and J. L. Megyesi. Reproductive biology of the green turtle (*Chelonia mydas*) at Tern Island, French Frigate Shoals, Hawaii. For consideration for publication in Journal of Herpetology.

Ralston, S., E. B. Brothers, D. A. Roberts, and K. M. Sakuma. Ageing accuracy of larval *Sebastes jordani*. For consideration for publication in Fishery Bulletin, U.S.

Sakuma, K. M., and S. Ralston. Distributional patterns of late larval groundfish off central California in relation to hydrographic features during 1992 and 1993. For consideration for publication in Fishery Bulletin, U.S.

Skillman, R. A. Review of central Pacific swordfish fishery development, biology, and research direction. For consideration for publication in Proceedings of the International Symposium on Pacific Swordfish: Development of Fisheries, Markets, and Biological Research, Ensenada, Baja California, Mexico, December 11-14, 1994.

———. Swordfish symposium: summary of biology session. For consideration for publication in Proceedings of the International Symposium on Pacific Swordfish: Development of Fisheries, Markets, and Biological Research, Ensenada, Baja California, Mexico, December 11-14, 1994.

Woodbury, D. Reduction of widow and yellowtail rockfish otolith growth during the 1983 El Niño. For consideration for publication in California Cooperative Oceanic Fisheries Investigation Reports.

Administrative Reports

Administrative Reports are strictly for internal use only and are not to be cited or treated as publications.

Honolulu

Aguirre, A. A. 1994. Cellular and hormonal responses to stress and spirorchid trematode eggs of Hawaiian green turtles (*Chelonia mydas*) with and without fibropapillomas. SWFSC Admin. Rep., Honolulu, H-94-4C, 39 p.

———, and T. K. Graczyk. 1994. ELISA test for the detection of anti-blood fluke (*Carettacola, Hapalotrema, and Learedius*) antibodies in juvenile green turtles (*Chelonia mydas*) with and without fibropapillomas in the Hawaiian Islands. SWFSC Admin. Rep., Honolulu, H-94-09C, 15 p.

———, and T. R. Spraker. 1995. Pathology associated with cardiovascular trematodes and fibropapillomas in green turtles (*Chelonia mydas*) from the Hawaiian Islands. SWFSC Admin. Rep., Honolulu, LJ-95-01C, 20 p.

DeMartini, E. E., F. A. Parrish, and J. D. Parrish. 1994. Temporal comparisons of reef fish populations at Midway Atoll, Northwestern Hawaiian Islands. SWFSC Admin. Rep., Honolulu, H-94-05, 56 p.

Dollar, R. A. 1994. Annual report of the 1993 western Pacific longline fishery. SWFSC Admin. Rep., Honolulu, H-94-06, 38 p.

Eberhardt, L. L., and K. V. Eberhardt. 1994. The Hawaiian monk seal on Midway Atoll, 1994. SWFSC Admin. Rep., Honolulu, H-94-08, 14 p.

Haight, W. R., and G. T. DiNardo. 1995. Status of lobster stocks in the Northwestern Hawaiian Islands. SWFSC Admin. Rep., Honolulu, LJ-95-03, 17 p.

Hamilton, M. 1994. NWHI bottomfish fishery 1993 vessel activities, costs and economic returns. SWFSC Admin. Rep., Honolulu, H-94-01C, 36 p.

Hamm, D. C., F. Dowdell, and M. M. Quach. 1994. Fishery statistics of the western Pacific, Volume IX. SWFSC Admin. Rep., Honolulu, H-94-02, 171 p.

Herbst, L. H., E. R. Jacobson, and P. A. Klein. 1994. Progress toward development of diagnostic tests for green turtle fibropapillomatosis. Part II. Identifying antigens for diagnostic test development: Experimental transmission of green turtle fibropapillomatosis using cell-free tumor extracts. SWFSC Admin. Rep., Honolulu, H-94-11C, 20 p.

———, and P. A. Klein. 1994. Progress toward development of diagnostic tests for green turtle fibropapillomatosis. Part I. Monoclonal antibodies for the measurement of class-specific antibody responses in the green turtle, *Chelonia mydas*. SWFSC Admin. Rep., Honolulu, H-94-10C, 19 p.

Kawamoto, K. E. 1994. Northwestern Hawaiian Islands bottomfish fishery, 1993. SWFSC Admin. Rep., Honolulu, H-94-07, 31 p.

Kikkawa, B. S. 1994. Western Pacific Fishery Information Network Island Data Assessment (WIDA) Project: Small-boat fishery survey in Guam, 1980-91. SWFSC Admin. Rep., Honolulu, H-94-03, 75 p.

Wetherall, J. A., W. R. Haight, and G. T. DiNardo. 1995. Computation of the preliminary 1995 catch quota for the Northwestern Hawaiian Islands lobster fishery. SWFSC Admin. Rep., Honolulu, LJ-95-04, 35 p.

La Jolla

Arenas, P., T. J. Barnes, and L. D. Jacobson. 1994. Fishery and biological data for northern anchovy taken in Mexican waters, 1978-1989. SWFSC Admin. Rep., La Jolla, LJ-94-03, 24 p.

Armstrong, W. A. 1994. Revised and edited field notes: 1993 dolphin-tuna tracking study, 6 November 1993 - 5 December 1993. SWFSC Admin. Rep., La Jolla, LJ-94-06, 38 p.

Childers, J., and L. Halko. 1994. Length frequency database description: California Department of Fish and Game gill net market samples. SWFSC Admin. Rep., La Jolla, LJ-94-01, 52 p.

———, and F. R. Miller. 1994. Summary of the 1993 U.S. North and South Pacific albacore troll fisheries. SWFSC Admin. Rep., La Jolla, LJ-94-18, 54 p.

Dotson, R., L. Jacobson, and C. H. N. Lo. 1994. Fish spotter data from the special 1993 survey, SWFSC Admin. Rep., La Jolla, LJ-94-12, 34 p.

Edwards, E. F. 1995. Second dolphin-safe research planning workshop: March 14-17, 1994, report and recommendations. SWFSC Admin. Rep., La Jolla, LJ-95-05, 46 p.

———. 1995. Summary of U.S. tuna purse-seine fleet characteristics as related to dolphin mortality in the eastern tropical Pacific Ocean, 1991-1994. SWFSC Admin. Rep., La Jolla, LJ-95-04, 13 p.

———, and P. C. Perkins. 1994. Estimated tuna bycatch from dolphin, school, and log sets in the eastern tropical Pacific Ocean: U.S. Fleet, 1989-1992. SWFSC Admin. Rep., La Jolla, LJ-94-23, 18 p.

Farley, T. D. 1995. 1995. Geographic variation in dorsal fin color of short-beaked common dolphins, *Delphinus delphis*, in the eastern Pacific Ocean. SWFSC Admin. Rep., La Jolla, LJ-95-06, 18 p.

Gerrodette, T., M. A. Donahue, S. R. Benson, K. F. Mangels, T. Lee, S. Keagy. 1995. Database of cetacean photographs at the Southwest Fisheries Science Center. SWFSC Admin. Rep., La Jolla, LJ-95-07, 58 p.

Herrick, Jr., S. J., K. Salvanes, and D. Squires. 1994. Environmental regulation and technical efficiency: the case of tuna-dolphin fishing. SWFSC Admin. Rep., La Jolla, LJ-94-22, 34 p.

Holts, D. B., N. W. Bartoo, and D. W. Bedford. 1994. Swordfish tracking in the Southern California Bight. SWFSC Admin. Rep., La Jolla, LJ-94-15, 9 p.

Hunter, J. R., and James H. Churnside (eds.). 1995. Airborne fishery assessment technology—A NOAA workshop report. SWFSC Admin. Rep., La Jolla, LJ-95-02, 71 p.

Jacobson, L. D., E. Konno, and J. P. Pertierra. 1994. Status of Pacific mackerel and trends in abundance during 1978-1993 (with data tables). SWFSC Admin. Rep., La Jolla, LJ-94-08, 32, p.

———, and N. C. H. Lo. 1994. Spawning biomass of the northern anchovy in 1994. SWFSC Admin. Rep., La Jolla, LJ-94-17, 63 p.

Mackett, D. J. (comp.). 1994. Current year operation plans for fiscal year 1994. SWFSC Admin. Rep., La Jolla, LJ-94-04, 186 p.

———, L. Jacobson, A. MacCall, S. Pooley, W. Silverthorne, D. Squires, and C. Thomson. 1994. A plan for establishing a system to deliver sociological and cultural information to support fishery management, recovery of protected species, and coastal ecosystem health. SWFSC Admin. Rep., La Jolla, LJ-94-10, 16 p.

Myrick, A. C., Jr. 1995. Documentation of progress of stress research projects for future reference. SWFSC Admin. Rep., La Jolla, LJ-95-01, 14 p.

Oliver, C. W. 1994. Description of the "LIDAR.C version 1.20" software incorporated into an airborne LIDAR system to detect tunas in the eastern tropical Pacific purse-seine fishery. SWFSC Admin. Rep., La Jolla, LJ-94-21, 113 p.

———, C. W. 1994. Description of the "LIDAR.C version 1.40" software incorporated into an airborne LIDAR system to detect tunas in the eastern tropical Pacific purse-seine fishery. SWFSC Admin. Rep., La Jolla, LJ-94-16, 106 p.

Perkins, C. P., J. Barlow, and M. Beeson. 1994. Report on pinniped and cetacean mortality in California gillnet fisheries: 1988-90. SWFSC Admin. Rep., La Jolla, LJ-94-11, 16 p.

———, and E. F. Edwards. 1994. A mixture mode for estimating bycatch from data with many zero observations: Tuna bycatch in the eastern tropical Pacific Ocean. SWFSC Admin. Rep., La Jolla, LJ-94-07, 28 p.

Perrin, W. F., and C. Edelstam. 1994. Small marine cetaceans of the Southwest Asia/Indo-Malay Region: Background paper for meeting of Scientific Council of Convention on Migratory Species of Wildlife, Nairobi, Kenya, 4-5 June 1993. SWFSC Admin. Rep., La Jolla, LJ-94-09, 28 p.

Rosenberg, J. E. (ed.). 1994. AMLR 1993/94 field season report: objectives, accomplishments, and tentative conclusions. SWFSC Admin. Rep., La Jolla, LJ-94-13, 117 p.

Taylor., B. L. 1995. Defining "population" to meet management objectives for marine mammals. SWFSC Admin. Rep., La Jolla, LJ-95-03, 22 p.

———, and D. P. DeMaster. 1994. Comparison of mortality limits of marine mammal management regimes. SWFSC Admin. Rep., La Jolla, LJ-94-20.

Thomson, C., T. Bishop, and J. Morgan. 1994. Status of the California coastal pelagic fisheries in 1993. SWFSC Admin. Rep., La Jolla, LJ-94-14, 59 p.

Tillman, M. F. 1994. Director's Report to the 45th Tuna Conference on tuna and tuna-related activities at the Southwest Fisheries Science Center for the period May 1, 1993, to April 30, 1994. SWFSC Admin. Rep., La Jolla, LJ-94-05, 29 p.

———. 1995. Director's report to the 46th Tuna Conference on tuna and tuna-related activities at the Southwest Fisheries Science Center for the period May 1, 1994, to April 30, 1995. SWFSC Admin. Rep., La Jolla, LJ-95-08, 9 p.

Wade, P. R. 1994. Managing populations under the Marine Mammal Protection Act of 1994: A strategy for selecting values for N_{MIN}, the maximum abundance estimate, and F_R, the recovery factor. SWFSC Admin. Rep., La Jolla, LJ-94-19, 26 p.

Williams, R., and D. Mackett. 1994. Results of a joint planning workshop for relocation of the NMFS/SWFSC Tiburon Laboratory to Santa Cruz, California. SWFSC Admin. Rep., La Jolla, LJ-94-24.

Zemsky, V. A., and E. G. Sazhinov. 1994. Distribution and abundance of the pygmy blue whale. (Translated from Russian by V. S. Gurevich, edited by M. A. Donahue, and R. L. Brownell, Jr.) SWFSC Admin. Rep., La Jolla, LJ-94-02, 21 p.

Tiburon

Eldridge, M. B. (ed.). 1994. Progress in rockfish recruitment studies, SWFSC Admin. Rep., Tiburon, T-94-01, 55 p.

UNITED STATES
DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
SOUTHWEST FISHERIES SCIENCE CENTER
8604 LA JOLLA SHORES DRIVE
P.O. BOX 271
LA JOLLA, CALIFORNIA 92038-0271

OFFICIAL BUSINESS
PENALITY FOR PRIVATE USE, $300

THIRD CLASS