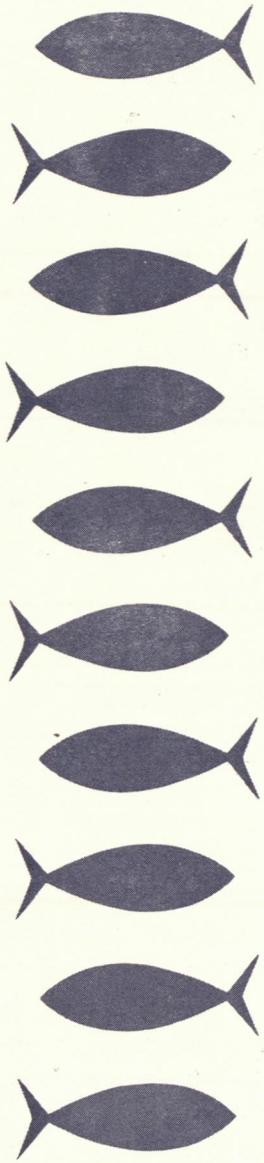
Southwest FISHERIES SCIENCE CENTER

HONOLULU LA JOLLA MONTEREY TIBURON



REPORT OF ACTIVITIES January-February

SOUTHWEST FISHERIES SCIENCE CENTER

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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

First Leg of 1992 AMLR Cruise Completed

On February 13, 1992, the NOAA Ship *Surveyor* returned to the port of Punta Arenas, Chile, completing the first portion of the U.S. Antarctic Marine Living Resources (AMLR) program's annual research cruise 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 research in this 15,000 square mile area of the Southern Ocean for four consecutive austral summers (Figure 1).

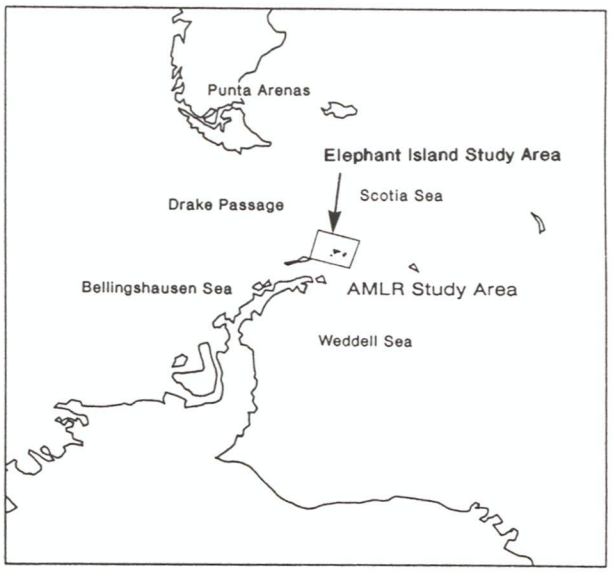

Figure 1. The 15,000 sq mi area of the Southern Ocean covered by the U.S. Antarctic Marine Living Resources program's annual research cruise. Square insert off the peninsula shows Elephant Island study area; the largest island in this insert is Seal Island.

As part of the AMLR program, the AERG provides information needed for formulation of U.S. policy on conservation and international management of resources living in the oceans surrounding Antarctica. The AERG also advises the U.S. delegation to the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), a part of the Antarctic treaty system.

The long-term objective of the AMLR field research program is to describe the functional relationships between krill (the keystone of the Antarctic marine ecosystem), their environment, and their predators (mainly penguins and seals). The field program is based on two working hypotheses: (1) krill predators respond to changes in the availability of their food, and (2) the distribution of krill is affected by both physical and biological aspects of their habitats. In addition to studies performed during the annual cruises, land-based studies are accomplished each season at a field camp located on Seal Island, a small island off the northwest coast of Elephant Island (Figure 1).

This year's cruise began on January 15, 1992, when the *Surveyor* departed from Punta Arenas, Chile, via the eastern end of the Strait of Magellan. During the crossing of Drake Passage, a series of expendable bathythermograph (XBT) observations were made by personnel from Chile's Servicio Hydrografica y Oceanografica de la Armada.

The ship arrived in the study area in the early hours of January 18. The first order of business was to offload fresh food provisions and other supplies to the field team on Seal Island, which was completed in approximately 12 hours due to cooperative weather conditions. On January 19, the scientific party initiated a large-area survey, consisting of a 72-station grid covering an area of approximately 11,025 nm^2 within the AMLR study area. Krill and other zooplankton were monitored in this area using a state-of-the-art acoustic survey system based on echo integration technology--a relatively mature methodology for relating total echo power to animal abundance. The system consists of a 120 kHz transducer mounted in a dead-weight towed body, towing and deck cables, a winch deployment system, a transceiver, a signal digitizer, software for echo integration and target strength analysis, a color monitor for initial processing and display, and a color printer. In addition, a UNIX workstation is used to manage and archive the high-volume data streams captured by the system.

The dead-weight towed body and an electro-hydraulic winch are components newly added to the acoustic system this year. Originally, the transducer was mounted in a V-fin towed body. However, during last year's cruise, the V-fin towed body was unstable at high ship speeds and sea states. Therefore, a new deployment was designed

and procured prior to this year's cruise, and it has performed flawlessly. The new deployment was tested successfully at vessel speeds of less than 1 knot and up to 13 knots.

During the large-area survey, the acoustic system was operated continuously at a speed of 8-10 knots, only pausing when the ship was on station. The intent of the large-area survey was to describe the thermohaline structure of the waters, phytoplankton biomass and productivity, major zooplankton constituents, and krill biomass. Operations at each station included (1) measurements of temperature, salinity, oxygen, light transmission, and fluorescence; (2) collection of discrete water samples using a conductivity-temperature-depth (CTD)/rosette apparatus 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 large plankton net to obtain samples of zooplankton and nektonic krill.

In past seasons, plankton samples were obtained using a bongo net. Although the bongo net was a good apparatus for collecting zooplankton, it did not yield adequate numbers of krill specimens. This year a new net design was employed which consists of a 6-ft Isaacs-Kidd Midwater Trawl (IKMT) fitted with a 505 micron nytex plankton net. This combination provided sufficient quantities of krill, as well as representative plankton samples.

The large-area survey was completed on February 2. In order to make up for time lost due to two medical evacuations of cruise participants, the last eight stations of the large-area survey were dropped. Based on the results from the large-area survey, two series of cross-shelf transects were then conducted at the shelf/slope break, which is located to the north of Elephant Island. This survey consisted of 16 stations, and station operations were the same as those completed during the large-area survey; acoustic data were also collected between stations.

During the large-area survey, a large proportion of nekton samples consisted of juvenile krill, suggesting a successful recruitment of krill from their 1991 spawn. This is in contrast to the two previous seasons which showed an overall poor recruitment of krill. In addition, high densities of krill were found over vast areas of the survey area. All indications are that this is a good year for krill which correlates with early reports of better-than-average reproductive success among their predators, penguins and seals.

A small-area acoustic survey was conducted to the north of Elephant Island on February 5 and 6; the survey was conducted at a speed of 10 knots over a 2-day period with no CTD/rosette casts or net-sampling stations. Based on the results of the small-area survey, directed sampling for krill was conducted using a Multiple-Opening-Closing-Net-Environmental-Sampling-System (MOCNESS). Krill samples were obtained in four areas of high krill density. The sampling effort was directed by simultaneous acoustic observations. The MOCNESS and acoustic teams found good quantitative agreement between the acoustic signal and the yield of krill from MOCNESS tows. Also, by comparing MOCNESS net catches to the acoustic signal, the acoustic team began to identify the acoustic signatures of several planktonic animals.

After again stopping at Seal Island to pick up two members of the field team, the *Surveyor* returned to Punta Arenas for a 5-day port call. During the port call, the ship took on supplies and received Leg II scientific personnel. The ship departed from Punta Arenas on February 18 to begin Leg II of the cruise. (J. Rosenberg [619] 546-5600)

Krill Predators on Seal Island are Studied

National Marine Mammal Laboratory scientists Peter Boveng, Michael Goebel, John Jansen, and Scott Manley arrived at Seal Island on December 2, 1991, on the tourist ship *World Discoveror*. As in past seasons, Society Expeditions, owner of the *World Discoveror*, made it possible for the scientists to arrive at the island's field camp early in the field season. Established 5 years ago, the camp is manned each year from early December to late March, during which time the team conducts foraging and reproductive behavior studies on krill predators (mainly penguins and seals).

After reactivating the camp, the team immediately began deployment of radio transmitters and time-depth recorders (TDRs) on fur seals; deployment was completed by December 12. The transmitters allow the scientists to continuously monitor foraging trips made by female fur seals as well as their visits ashore to nurse their pups. A count of fur seal pups on December 23 showed 285 births had occurred, 20 more than last year at this time, with approximately one more week of fur seal pupping remaining.

In early December, chinstrap penguins were busy incubating their eggs. TDRs were deployed on some of the chinstrap penguins in order to study foraging ecology. Once the egg incubation phase was concluded, the TDRs were recovered from the animals. The first chinstrap penguin chicks were observed on December 20, several days earlier than the first hatchings of last year, and by the end of December, hatching of chinstraps had peaked. Another species of penguin, the macaroni penguin (much less common on Seal Island than chinstraps), was also well into its hatching. In early January, TDRs were redeployed to compare foraging effort of the animals during the brooding stage with that of the incubation stage, both important parameters for estimation of prey requirements by land-breeding krill predators.

Another study involving chinstrap penguins was initiated in late December to determine the amount of food brought back to the nest. This study used automatic scales placed under the nests to measure the changes in weights of penguins from the time they depart from the nests (with empty stomachs) until they return from feeding. During the brooding period, the study provided information about the amount of food delivered by the parent birds to the chicks.

In the last days of December, a study of fur seal diet was begun; biweekly fur seal scat samples were collected. In addition, as part of a study on leopard seal predation of fur seal pups, two leopard seals were marked to allow recognition of individuals. A study was also begun to determine whether behavioral differences between male and female fur seal pups could be responsible for the substantial difference between male and female pup mortality that has been observed in previous years. The study used activity recorders, made from simple battery-powered liquid crystal display clocks, that allowed monitoring of the amount of time pups spent in the water. Time spent in the water presumably is related to the risk of capture by leopard seals, a major source of pup mortality in previous years.

In early January, the first sample of fur seal pup weights was collected in order to monitor the physical growth rates of fur seal pups. A total of 100 pups was weighed on a bimonthly basis throughout January and February, and the mean weights of male and female pups were about 1 kilogram heavier than those found this time last year. As part of the sampling process, pups were tagged for future estimations of survival and recruitment.

In mid-January, the field team welcomed a visiting Korean scientist, Hyoung-Chul Shin, to Seal Island. Shin remained on Seal Island through mid-February, learning methodologies to be used in his own Korean Antarctic Program. At this time, the *Surveyor* also resupplied the field camp and dropped off scientists Donald Croll and Hector Douglas, both of the National Marine Mammal Laboratory. Croll and Douglas replaced Boveng and Goebel, who left the island in mid-January and mid-February, respectively.

As in past seasons, sampling of chinstrap penguin diets revealed that krill was the preferred prey item. Penguins were observed coming ashore with large loads of food to deliver to their chicks, indicating that offshore prey availability was probably quite high. This observation correlated with the *Surveyor's* measurements of offshore krill abundance. Also, preliminary analyses of censuses of chinstrap penguin-breeding colonies indicated that the number of chicks raised on Seal Island this year was similar to that observed in 1989/90, one of the most productive years ever observed. Banding of chinstrap penguin chicks was completed in early February; a total of 2000 birds was banded at four study colonies. Resights of these banded birds in future years will allow for estimates of subadult and adult mortality rates.

In early February, both chinstrap and macaroni penguin chicks began to crech. Creching precedes fledging and is defined as that time when penguin chicks leave their nest rings to huddle together in small groups. When the chicks begin creching, the parents no longer take turns guarding them as they do during the brooding stage. Instead, both parents go to sea in search of food, which they bring back to feed the chicks. During the creching period, chicks only go back to their nest rings to be fed. When the chicks fledge, the parents cease feeding them. This year chinstrap penguin chicks began to fledge in mid-February.

The field team experienced remarkably calm and dry weather in the early part of the season, with sunny conditions producing air temperatures in the low 40s (°F). However, in February they experienced more typical weather for the island--high winds, driving rain, snow, and fog. Throughout the season, the team enjoyed spectacular views of large icebergs from many directions. Glacial ice deposited daily on the camp's beach ensured a good supply of fresh water for the camp. At the end of February, the team began preparing for their mid-March departure from Seal Island via the *Surveyor*. (J. Rosenberg [619] 546-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

ROV Line Transects and Bottom Trawls Compared

Management of renewable resources requires information about the abundance of the resource and the rate of renewal of that resource. Fisheries management has traditionally relied upon data from the fishery and from independent surveys for estimates of abundance, rate of harvest, and rate of renewal of the resource. These independent surveys, however, rely upon the same methodology as the fishery and are subject to the same biases.

As a part of the project to develop habitat-specific, stock-assessment methods for West Coast demersal fisheries resources, replicate trawls and remotely-operated-vehicle (ROV) line transects have been conducted in Monterey Bay. John Butler, Southwest Fisheries Science Center (SWFSC) La Jolla, and Pete Adams, SWFSC Tiburon, have conducted bottom trawls with a poly Aberdeen trawl on smooth bottom at depths of 100, 200, 400, 600, 800, 1000, 1200 and 1400 m on three *David Star Jordan* research-vessel cruises in April and September of 1991 and in January 1992. Charles Baxter and Bruce Robison, Monterey Bay Aquarium Research Institute (MBARI), along with Adams and Butler, have used the MBARI ROV to survey the same sites on *Pt. Lobos* research-vessel cruises. To date, ROV video transects have concentrated on 200 and 600 m sites to obtain replicates for gear comparison.

Abundance of fishes and invertebrates was estimated by Kathy Dahlin, SWFSC, using the swept-area trawl method and line-transect methods for ROV video transects. Using line transect techniques, the effective strip width for each species was calculated using the hazard-rate model. Visibility and behavior differ among species and is reflected in differing detection functions. Deviations from the model in Dover sole and thornyheads (Figures 1 and 2) suggest movement in response to the ROV. About 5 percent of the Dover sole and 15 percent of the thornyheads respond to the ROV in the field of view. Only 3 percent of the octopi respond to the ROV and the detection function closely fits the data (Figure 3).

Abundance estimates from the ROV transects were higher than estimates from the trawl at both 200 m and 600 m (Figures 4 and 5). ROV transects indicate estimates of 3 times more rockfish than does the trawl, 9 times as many flatfish, and 42 times as many skates. There were no octopi collected by the trawl while the ROV estimates indicate that there are 300,000 per sq km at 200 m. Similarly, at 600 m, the ROV estimates signify 11 times as many thornyheads, 5 times as many Dover sole, and 97 times as many eelpouts.

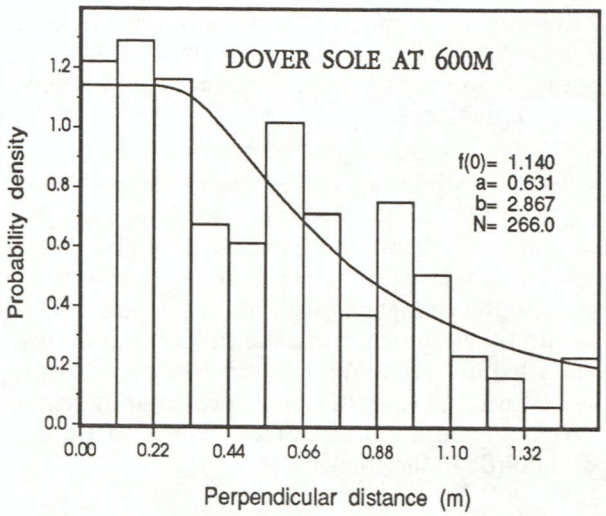

Figure 1. Numbers of Dover sole observed versus distance in meters from the track line at 600 m. Solid line is hazard-rate model fitted to the data.

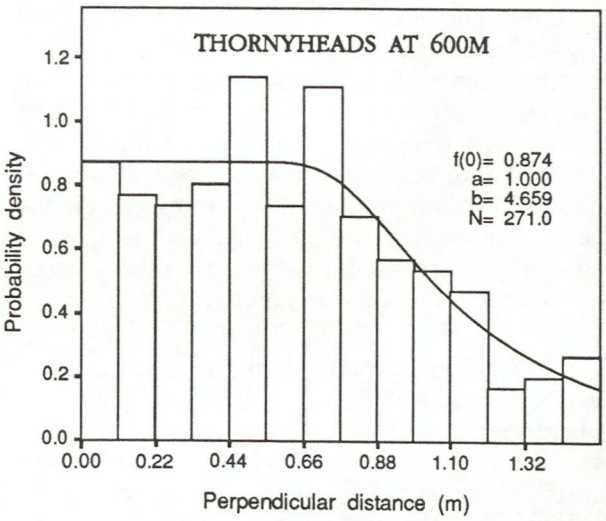

Figure 2. Numbers of thornyhead observed versus distance in meters from the track line at 600 m. Solid line is hazard-rate model fitted to the data.

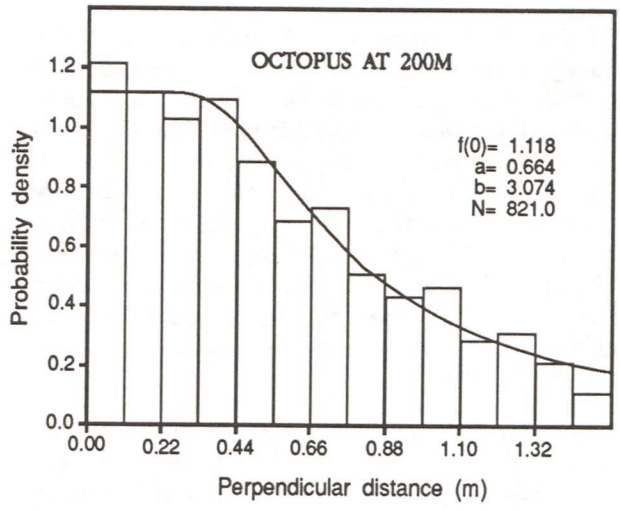

Figure 3. Numbers of octopi observed versus distance in meters from the track line at 200 m. Solid line is hazard-rate model fitted to the data.

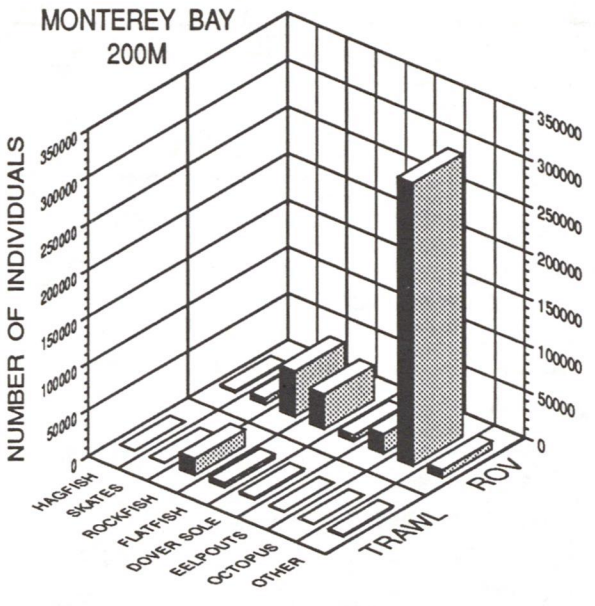

Figure 4. Abundance of important taxa at 200 m in Monterey Bay, California, estimated by trawl-swept area and ROV line transects.

The difference-of-abundance estimates from the ROV and trawl reflect catchability with differing gear. Many fish must avoid, or are not retained by, the net. The greater numbers of hagfish and eelpouts seen by the ROV are an example. The great abundance of octopi at 200 m, as seen by the ROV, may also reflect the cumulative effects of trawling on the bottom community in this area by fishermen from nearby ports. Since no octopi are

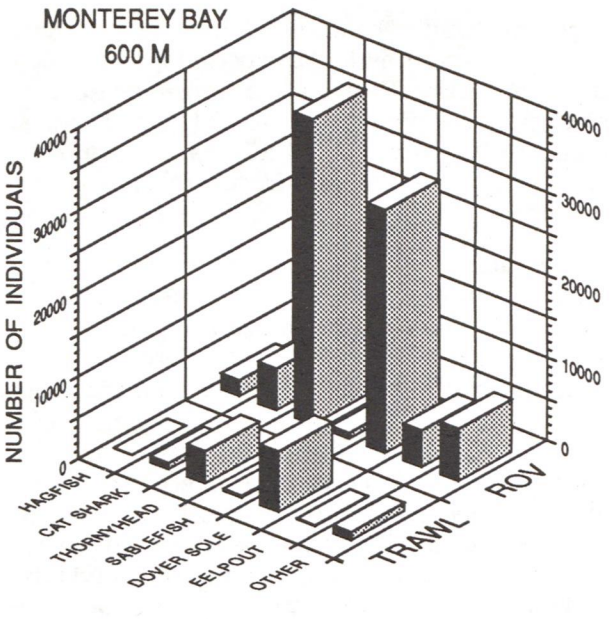

Figure 5. Abundance of important taxa at 600 m in Monterey Bay, California, estimated by trawl-swept area and ROV line transects.

retained by the trawl gear, their numbers increase while the numbers of finfishes decrease. (J. Butler [619] 546-5149)

MARINE MAMMAL DIVISION

La Jolla, California

Report on Pinniped and Cetacean Mortality in California Gillnet Fisheries: 1990-1991

During the late 1970s and early 1980s, there was a rapid expansion in the use of entangling nets (drift gillnet, set gillnet, multi-panel and trammel nets) in coastal California waters. The incidental kill of non-target species (including marine mammals) by these nets has become a focus of concern for state and national environmental and legislative bodies. In 1988, amendments to the Marine Mammal Protection Act enacted a temporary exemption program for five years. In the interim, collection of statistically reliable data on the status of marine mammal stocks and total incidental mortalities has been Congressionally mandated. In order to facilitate monitoring incidental mortality and its impact on marine mammal populations, the exemption

program classifies commercial fisheries into three categories according to the expected levels of incidental mortality: Category I. Frequent take of marine mammals incidental to fishing activities, Category II. Occasional take of marine mammals, and Category III. Rare or infrequent take of marine mammals.

Jay Barlow, task leader of the Coastal Marine Mammal Program and Peter Perkins, statistician, have completed a report on marine mammal mortality using data collected from California's gillnet fisheries for California halibut and Pacific angel shark (setnet) and for swordfish and pelagic sharks (driftnet), Category I, during the period July 1990 through June 1991. Using data collected by NMFS observers aboard Category I vessels, Barlow and Perkins used log-linear regression models to explore factors that may be correlated with mortality, and they attempted to identify any potentially useful predictors of mortality due to these setnet and driftnet fisheries for the period July 1990 to June 1991. Their report presents the results of the first year of a 3-year mortality assessment initiated in 1990, during which time National Marine Fisheries Service observer-technicians collected information on species composition, mortality, and life-history data from entangled cetaceans and pinnipeds.

For the setnet fishery, a total of 1541 net pulls (totaling 516 boat days or 509 trips) was observed.

Table 1. Estimated (est.) pinniped and cetacean kill rates and total kill by area and species for the setnet fishery. KPD = kill per day.

	Southern CA	Channel Islands	Central CA	TOTAL
Days of effort	6321	487	705	7513
Cal. Sea Lion				
Est. KPD	.197	1.40	.797	.331
Est. kill	1243	682	562	2487
Harbor Seal				
Est. KPD	.0726	.300	.304	.109
Est. kill	459	146	214	819
Northern Elephant Seal				
Est. KPD	.00468	0	.165	.0194
Est. kill	30	146	116	146
Harbor Porpoise				
Est. KPD	-	-	.0886	-
Est. kill	-	-	62	-

Of these, 1325 net pulls (427 days, including 2 partial days) were observed in the southern California mainland area, 24 net pulls (10 days including 2 partial days) were observed in the Channel Islands, and 192 net pulls (79 days) were observed in the central California area. For the driftnet fishery, there was a total of 205 net pulls observed (totaling 205 days or 60 trips--exactly one net pull per day). Of these, 128 were observed in the southern California mainland area, none were observed in the Channel Islands, and 77 were observed in the central California area.

Mortality estimates for setnet and driftnet fisheries are listed in Tables 1 and 2. Barlow and Perkins believe that the estimates of total pinniped mortality may by biased for several reasons. First, entan-

Table 2. Estimated (est.) pinniped and cetacean kill rates and total kill by species for the driftnet fishery. KPD = kill per day.

Days of Effort	4734
California Sea Lion:	
Est. KPD	.0195
Est. kill	92
Harbor Seal:	
Est. KPD	.00488
Est. kill	23
Northern Elephant Seal:	
Est. KPD	.0195
Est. kill	92
Common Dolphin:	
Est. KPD	.0829
Est. kill	393
Northern Right Whale Dolphin:	
Est. KPD	.0146
Est. kill	69
Risso's Dolphin:	
Est. KPD	.00976
Est kill	46
Dall's Porpoise:	
Est. KPD	.00976
Est. kill	46
Mesoplodon (Beaked Whales):	
Est. KPD	.00488
Est. kill	23
Short-Finned Pilot Whale:	
Est. KPD.	.00488
Est. kill	23

glement rates are not homogeneous in either location or season. Secondly, in the sampling scheme used to place observers aboard fishing vessels, Barlow and Perkins modeled the placement as random, yet actual placement is affected by the unavailability of some boats, the limited cooperation of some fishers, and safety considerations for the NMFS observers. Third, the entanglement rates, as well as the locations, times, and gear may not be representative of the fishery as a whole if some segments of the fishery are undersampled or not sampled at all (for example, distant fishing areas). Finally, the data indicate that some mortality data are recorded from a small number of trips with relatively high rates of entanglements, particularly multi-day trips in the Channel Islands where the level of observed fishing effort is lower, which leads to uncertainties on how accurate the estimated entanglement rates are.

Future management of marine mammal populations will likely be based on a percentage quota applied to the minimum estimate of abundance for each affected species. The mortality estimates obtained by Barlow and Perkins will be used in conjunction with the baseline-abundance estimates from ground, ship, and aerial surveys of marine mammals inhabiting California waters. (J. Barlow [619] 546-7178)

Annual Northern Elephant Seal Census Completed

The annual census of northern elephant seals on southern California's Channel Islands has recently been completed. Photographic survey flights over San Miguel, Santa Rosa, and San Nicolas Islands were conducted on February 3 and 17 to monitor the status of the elephant seal populations on those islands. Pup counts for the breeding sites on Santa Barbara Island were made from a small boat because cliffs overhang the major beaches and prevent the scientists from photographing them vertically. At Santa Barbara Island, a small rookery, pup counts were about 1/4 of last year's total. This is probably the result of the recent storms that often wash pups from the narrow beaches of this island. Counts of pups and adults at the other two islands will be made over the next 6 months using the photographs that were taken.

To scale photographs, the biologists have previously deployed (and retrieved) temporary targets at San Nicolas Island prior to the northern elephant seal photographic-survey flights. The targets are deployed at 50-meter intervals and the scientists use the known distance between the targets to calculate the altitude of the aircraft. With their new comparator, the biologists plan to begin monitoring the length distribution of reproductive females and the size and spacing of dominant males as indicators of population condition.

To minimize disturbance to the elephant seals, California sea lions, and harbor seals that are hauled out near most of the rookery sites, the scientists this year obtained approval to paint permanent targets on the rocks near the beaches. This should significantly reduce future disturbance to the seals and save the cost of trips to the islands to deploy and retrieve the temporary markers. The scientists say the targets still looked fine after the February storms. (M. Lowry [619] 546-7174)

Aerial Surveys of *Tursiops truncatus* Conducted Along the Southern California Coast

Marine mammal observers Jay Barlow, Karin Forney, and Joyce Sisson and data recorder Valerie Philbrick completed the first 1992 bimonthly survey of the California coast for bottlenose dolphin, *Tursiops truncatus*, on February 25 and 26. The survey was part of a series of 12 bimonthly aerial surveys, funded by the Office of Protected Resources and designed to obtain minimum abundance estimates for bottlenose dolphins along the southern California coast. Supplemental information on bottlenose calves and other species was also recorded on an opportunistic basis. On the first day of the survey, the observers flew from the U.S./Mexican border to Point Conception. The second day covered the same area in a southward direction. Both surveys were flown at an altitude of 700 ft (213 m) at an air speed of approximately 100 knots (185 km/hr). Distance to the beach was maintained at roughly 35 degrees declination angle (1000 ft or 300 m distance at 700 ft or 213 m altitude). The program SURVEY was used to record data.

Conditions were good the first survey day, with clear skies and Beaufort sea states of 1-3 (calm-to-a-gentle breeze). However, the water was turbid in many places (especially near rivers). Glare was minimal throughout the survey, and a total of 11 sightings of 164 bottlenose dolphins was made. While crossing the Camp Pendleton area, the observers were asked to drop to 2000 ft (610 m), where they spotted three additional groups of dolphins, with a total of at least 17 animals. The total number of animals should be regarded as a minimum because the turbid water conditions made an exact

count difficult. Group sizes ranged from 1 to 51, and at least 3 calves were sighted. Eight gray whales, *Eschrichtius robustus*, were also sighted.

On the second survey day, conditions were windier, with Beaufort sea states between 1 and 4 (calm-to-moderate breeze). Glare was generally higher than on the previous day, and the water was still turbid in many places. A total of 12 sightings of 157 bottlenose dolphins was made. On this survey day, the observers were diverted to 200 ft (61 m) altitude while flying over the Camp Pendleton area. At least two calves were sighted. Again, the total number of animals is a minimum count because of the difficulty in seeing animals in turbid waters. Group sizes ranged from 3 to 41. Five gray whales were also sighted during the survey, and a large, scattered school of common dolphins, *Delphinus delphis*, was seen from above 1000 ft (610 m) while en route to Point Conception before the survey.

The information obtained from these surveys will be used to estimate the minimum abundance of coastal bottlenose dolphins along the California coast and will be useful in determining the effects of commercial fisheries on their populations.
(K. Forney [619] 546-7171)

BIOLOGICAL ASSESSMENT PROGRAM

Marine Mammal Tagging and Tracking Workshop, Warrenton, Virginia

Susan Chivers, fishery biologist, participated in the Marine Mammal Tagging and Tracking Workshop held February 11-13, 1992, in Warrenton, Virginia. The purpose of the workshop was to review progress made in the field since the 1987 workshop that had been held in Seattle, Washington, and to identify specific areas for future research and development. The use and development of both radio tags and satellite tags were considered.

Approximately 60 participants from a multitude of disciplines attended the meeting. A steering committee of the Marine Mammal Commission, U.S. Department of the Interior, Minerals Management Service, Office of Naval Research, and National Marine Fisheries Service (NMFS) representatives organized the workshop. After a day of talks to review progress made and to identify the current state-of-the-art technology, three working groups were convened to discuss particular aspects of concern. The working groups discussed (1) tag attachment, deployment, and retrieval; (2) instrumentation; and (3) data collection, management, and analysis.

The working group on tag attachment primarily focused on the attachment of satellite tags to cetacean species. The saddle mount for small cetaceans and the ballistic tag for large whales seem to be the most promising. The size of satellite tags is now much smaller than previous tags, and the tags are evolving into even smaller sizes, which are limited primarily by battery size. Although several successful tag deployments have been made, attachment longevity still needs to be improved. The second group, the instrumentation group, identified two areas of development: (1) to provide 3-D animal position data--geographic position, depth, and temperature--which would answer many management-related questions, and (2) a more complicated tag with a selection of sensors available to answer ecological and physiological questions about animals. Radio tags are also important to the second tag type because of the significance of behavioral data in answering research questions. The third working group discussed ways to collect and manage data in a way that would ease incorporating data from other sources (e.g., oceanographic data).

The consensus of the workshop was that a lot of progress has been made since the 1987 workshop but that more work is needed, particularly with regard to studies of small cetaceans. A report of the workshop and recommendations will be made available by the Northeast Fisheries Science Center. Susanne Montgomery is the editor of the report.
(S. Chivers [619] 546-7093)

Genetic Studies of Marine Mammal Stock Structure

Understanding the stock structure of exploited populations of marine mammals is critical to proper management. Since the turn of the century, the concept of managing local self-sustaining populations as opposed to the typologically defined species has been recognized as necessary. The problem has been to establish a working definition of what taxa level to establish as a "management" unit and to find "tools" of adequate resolution to discriminate the chosen level. The Southwest Fisheries Science Center's (SWFSC) Marine Mammal Division has described an approach to the first part of the problem that incorporates the concepts of phylogeny and gene flow. Four hierarchial levels are defined, the highest having the greatest probability

of being an evolutionarily significant unit and, of course, then deserving individual management status.

Experimental efforts toward solving the second part of the problem, finding tools of adequate resolution, are currently yielding results. These efforts are supported in part by funds from Headquarter's Protected Species Office. The approach of the Biological Assessment Program is to determine the DNA sequence of individual animals, which is grounded in the fundamental assertion that at some degree of resolution (number of individual samples examined and the fraction of the genome examined), all organisms are genetically distinct from each other.

Briefly, the procedure involves extracting all the DNA (both nuclear and mitochondrial) from salt-preserved skin samples. The specific region of the DNA to be analyzed is amplified with the polymerase chain reaction (PCR) procedure, which is initiated by oligomer primers (approximately 20 base-pair fragments of DNA) that attach to regions of the DNA flanking the desired target region of unknown-sequence DNA. (One has to know the sequence of the flanking regions, but generally they are in very conserved regions, i.e., where sequences are the same across a wide range of taxa.) The use of the ultra-sensitive PCR allows us to focus on the specific region of the 16,000 base-pair mitochondrial DNA (mtDNA). This fast-evolving, 1000-base-pair D-loop region is ideal for intra-specific studies. In addition, PCR is being used on the less-rapidly evolving region, such as the cytochrome b gene, for higher level systematic studies. After amplification, the sequence is determined by dideoxy-chain termination methods.

The sequence information is used to build phylogenies using established computer-based methods; however, what is new in the Marine Mammal Division's approach is to use this phylogenetic information to calculate gene flow, or average dispersal distances. By doing so, the biologists can hopefully provide a quantitative measure of "stockness" that can be incorporated into existing analytical population-abundance methodology.

The genetics work to date, has been supervised by Andrew Dizon, Biological Assessment Program leader, and William Perrin, senior scientist. One of the initial steps in the process of developing a molecular genetics laboratory has been to set up a tissue and DNA archiving system. Fisheries Biologist Jerry Kashiwada has been given this task. In addition to studies which are currently under way, stored within SWFSC's freezers are considerably more samples from a variety of taxa. Investigators from literally around the world have SWFSC sample kits, and SWFSC biologists expect to build the collection to an even greater extent. The key to the success is the relative ease of collecting tissue (a few square centimeters of skin) and preserving it (basically in a simple salt solution at room temperature).

To a large extent, the success of this program is due to the work of Patricia Rosel, Scripps Institution of Oceanography graduate student, who designed the PCR (and sequencing) primers and developed or refined many of the existing laboratory protocols to work well with marine mammals. The Phocoenidae study is the primary focus of her thesis. Preliminary results, presented at the 9th Biennial Conference on the Biology of Marine Mammals (Dec 5-9, 1991, in Chicago, Illinois), demonstrated that the stocks of harbor porpoise from the northeast Pacific were relatively discrete. Her analysis of the different species may lead to a modification of current taxonomies.

Also, Dizon and John Heyning, of the Los Angeles County Museum of Natural History, have been collaborating with Rosel on an analysis of stock structure of the common dolphin. Results from that study were also presented at the marine mammal conference in Chicago and show that the short-beaked form of the eastern tropical Pacific (ETP) common dolphin is more closely related to the Black Sea common dolphin than to the long-beaked ETP form. The sequence differences between the two sympatric forms are fixed in each individual, indicating total reproductive isolation between groups. Interestingly enough, although genetic and morphological results are indicative of separate species status, current management practice is to lump the two groups together.

Studies involving other populations are just getting under way. In anticipation of an extensive collection of samples from Dr. Linda Jones of the National Marine Mammal Laboratory (NMML), Dizon sequenced four northern right whale dolphin samples. Virtually nothing is known about the stock structure of these dolphins although they figure prominently in fishing mortalities. And though little can be determined regarding intraspecific structure with four samples, the success with the samples indicates that the primers work for these species. Eric Archer, Angelica Garcia, and Rick LeDuc, graduate students at Scripps Institution of Oceanography, are under the supervision of William Perrin along with Rosel. Archer is doing a

comprehensive assessment of world-wide striped dolphin species. Garcia is re-analyzing earlier work by Dizon and Perrin on the genetic relationship of eastern and whitebelly spinner dolphins. Archer, Garcia, and LeDuc used a less-sensitive genetic technique, restriction length polymorphisms. Garcia will be determining sequences of the same sample set that Dizon and Perrin used, and LeDuc is developing a molecular taxonomy of selected delphinids. Dizon speculates that due to the abundant geographic variation coupled with the lack of obvious reproductive barriers, many of the higher order taxonomic relationships are equivocal on several taxonomic levels--from superfamily down to species. (A. Dizon [619] 546-7089)

HONOLULU LABORATORY

Honolulu, Hawaii

INSULAR RESOURCES INVESTIGATION

Status Report Completed for Lobster Stocks in the Northwestern Hawaiian Islands

The seventh annual status of the stocks report for spiny lobster, *Panulirus marginatus*, and slipper lobster, *Scyllarides squammosus*, was completed in February 1992 by Wayne Haight, fishery biologist, and Jeffrey Polovina, leader of the Insular Resources Investigation. Their analysis of commercial logbook and research data indicated that low recruitment of spiny lobster to Maro Reef continued in 1991. Evidence of poor spiny lobster recruitment to Laysan Island, a commercially unexploited area, supports the hypothesis that spiny lobster recruitment to portions of the Northwestern Hawaiian Islands (NWHI) is affected by perturbations in average meso-scale oceanographic conditions. The fluctuations in spiny lobster recruitment appeared to be limited to the northern portion of the NWHI, as recruitment of spiny lobster to more-southerly Gardner Pinnacles and Necker Island remained constant during the same time period.

The indications of the spiny lobster stocks nearing overexploitation prompted an emergency action by the Western Pacific Regional Fishery Management Council, which closed the NWHI commercial lobster fishery from May 8 to November 11, 1991. Fishing recommenced on November 12 and continued through the end of the year.

Total fishing effort in 1991 was 295,000 trap-hauls, resulting in 35,000 slipper and 131,000 spiny lobsters for a combined catch-per-unit effort (CPUE) of 0.56 lobster per trap-haul. This represents a 15% decrease in CPUE from the 1990 level, and the lowest CPUE since the fishery began in 1976.

Because of continued poor recruitment to Maro Reef, overexploitation of the spiny lobster stocks in the NWHI could result if fishing pressure is not controlled in the future. An amendment to the fishery management plan was proposed to create a limited-entry fishery and a July-December fishing season as well as to impose an annual catch quota which would provide adequate protection of the stocks and allow sustainable exploitation. However, the amendment has been delayed by the Presidential moratorium on regulations. The fishing industry and the Council determined that a target quota level, which would allow an average annual fleet CPUE of 1.0 lobster per trap-haul, would, in combination with other management measures, provide adequate protection of the stocks and allow sustainable exploitation.

This annual fleet CPUE was determined by Haight and Polovina. They used a dynamic CPUE-based model to estimate mortality and recruitment of the NWHI lobster stocks. These estimates were used to formulate a commercial CPUE-based catch curve which would, on the average, result in an annual commercial CPUE catch quota of 1.0 lobster per trap-haul, while allowing the population to rebound to sustainable levels. The annual commercial catch quota will be set by the Council after the first month of commercial fishing each year. (J. Polovina [808] 546-1218)

FISHERY MANAGEMENT AND PERFORMANCE INVESTIGATION

Hawaii's Lobster Fishery, 1991

Preliminary summaries have been completed for the lobster fishery in the Northwestern Hawaiian Islands (NWHI) in 1991, according to Fishery Technician Robert Dollar. As a result of the nearly 6-month closure of the lobster fishery from May 8 to November, 1991, only 9 vessels were active in the fishery in 1991 (20 trips), compared to 14 vessels in 1990 (45 trips). Since the lobster fishery reopened on November 12, 1991, four relatively small vessels reportedly have been fishing and have had good catch rates when weather conditions allow. One other vessel sank in transit to the grounds.

A more detailed discussion of the 1991 lobster fishery will be included in an annual report by the Fishery Management and Performance Investigation. (S. Pooley [808] 943-1216)

Hawaii's Longline Fishery, 1991

Preliminary fourth-quarter and annual summaries of the western Pacific domestic longline fishery in 1991 have been completed, according to Fishery Technician Robert Dollar. In the fourth quarter, 106 vessels were active in Hawaii (360 trips). Throughout 1991, 140 vessels were active (1,666 trips), and set 12.2 million hooks. Broadbill swordfish, *Xiphias gladius*, (*N*=61,000 fish) made up the largest component of the landings in 1991, followed by bigeye tuna, *Thunnus obesus*, (*N* = 39,500) and mahimahi, *Coryphaena hippurus*, (*N* = 38,000). Sharks (*N* = 71,000) constituted the largest component of the catch, but relatively few were kept (*N* = 4,500).

Approximately half the fishing effort was within the 200-mile Exclusive Economic Zone (EEZ) of the main Hawaiian Islands, where bigeye tuna made up the largest portion of the landings. About 15% of the fishing effort was within the 200-mile EEZ of the NWHI, where broadbill swordfish made up the largest portion of the landings. About one-third of the effort was outside Hawaii's EEZ, with most landings being broadbill swordfish.

The 1991 catch and effort by the longline fishery could not be directly compared with data from previous years because the logbook program in which fishermen are required to report such data has only been in effect since mid-November 1990. However, the average weights from the dockside and wholesale market monitoring in Honolulu suggest that landings of broadbill swordfish more than doubled in 1991 to about 8.7 million pounds (round weight). Landings of bigeye tuna (3.4 million pounds) were about the same as during the previous year, while landings of yellowfin tuna, *T. albacares* (1.5 million pounds), were down substantially.

True bluefin tuna, *T. thynnus*, were landed in small numbers by longline vessels. However, the average size of these bluefin was relatively small (100-200 pounds round weight).

A more detailed assessment of the 1991 western Pacific domestic longline fishery will be available in an annual report prepared by staff of the Fishery Monitoring and Performance Investigation. (S. Pooley [808] 943-1216)

Low Volume at Year-end in Hawaii's Market

Fresh fish landings in Honolulu were particularly low in volume at the end of 1991, according to Fishery Biologists Kurt Kawamoto and Russell Ito. Seasonal sales of fresh tuna and bottomfish usually peak at year-end because local custom requires fresh fish at family and work-place gatherings. However, the Honolulu auction handled almost no fish on December 24, 1991. Although 43 longliners off-loaded their catches between the weekend of December 28-29 and New Year's Eve, volume remained low because of poor weather and low catch rates.

Prices varied substantially at year-end, with some high-quality bigeye tuna selling for over $21 per pound (round weight). However, lower-priced yellowfin tuna were available for only $5-6 per pound. Notably, imports of fresh yellowfin tuna also were prevalent. Nonetheless, prices are expected to remain relatively high through March 1992 because of seasonal demand as well as the diminished supply due to many of the longline vessels tying up for Chinese New Year in mid-February.

The volume of skipjack tuna, *Katsuwonus pelamis*, also was very low as a result of poor weather. Because the availability of tuna has remained low and prices have been good for swordfish, longliners have continued to concentrate on swordfish.

Landings of bottomfish also were very low because of very low catch rates and poor weather. Pink snapper, *Pristipomoides filamentosus*, sold for as much as $19.50 per pound, and red snapper, *Etelis coruscans*, for as much as $22.50 per pound. (S. Pooley [808] 943-1216)

PELAGIC RESOURCES INVESTIGATION

Fine Tuning Tuna Fishing: Timing Bites of Fish with Chips

The paper "Depth, capture time, and hooked longevity of longline-caught pelagic fish: timing bites of fish with chips" by Fishery Biologist Christofer H. Boggs has been accepted by **Fishery Bulletin** for publication in 1992. Boggs' paper describes research using hook timers and time-depth recorders (TDRs) attached to longline gear to measure the depth of capture of pelagic species off Hawaii in January 1989 and January-February 1990. Data on the effects of depth on the selectivity and efficiency of longline gear are essential for stock-as-

sessment work using catch-per-unit effort (CPUE) by different gear types. Furthermore, targeting specific depths can improve longline catches of target species such as bigeye tuna, *Thunnus obesus*, and reduce catches of billfish and other species that may be important to small-scale fisheries operating in the same area.

Predicted longline depth--based on catenary geometry, line length, and distance between floats--differs from true depth because of ocean currents and other factors, yet studies often infer rather than measure depth. Furthermore, fish may be caught while the hooks are sinking during gear deployment or rising during gear retrieval, making capture depths impossible to estimate without knowing capture time. Previous studies using TDRs have interpreted depth fluctuations as the time of capture, but few such measurements exist. It has been assumed that capture occurs when the gear has settled, with capture depth estimated as settled hook depth.

In Boggs' study, hook timers--each containing a microchip clock to indicate when the hook was struck--were used to measure the time of capture and to provide data on the survival times of hooked fish. Accurate estimates of settled gear depth were made by attaching TDRs to the longline. Recorded longline depths differed greatly from predicted depths, indicating that TDRs are essential for describing depth distributions of fish catch by longline (Figure 1).

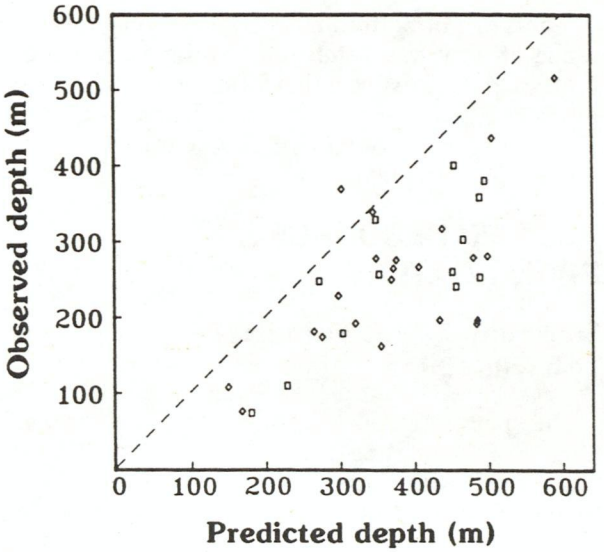

Figure 1. The relationship between predicted and observed set depths in 1989 (squares) and 1990 (diamonds). Observed depths were measured with time-depth recorders and predicted depths were calculated from the shortening rate and the mainline length per basket, assuming a catenary shape.

Without hook-timer data, many fish appeared to be caught at depths greater than where they actually were caught (unconfirmed depths, Figure 2). Only the depths of hooks that caught fish while settled (i.e., not sinking or rising) provided confirmed data on the depth of capture. For example, mahimahi, *Coryphaena hippurus*, had unconfirmed capture depths of <420 m and confirmed capture depths of <190 m, with most being <100 m. Similarly, striped marlin, *Tetrapturus audax*; whitetip shark, *Carcharhinus longimanus*; blue shark, *Prionace glauca*; and wahoo, *Acanthocybium solandri*, had unconfirmed depths of <350-420 m, but had confirmed depths of <200-230 m (Figure 2). Fish habitats were described in terms of the depths at which fish appeared to be most abundant (Figure 3).

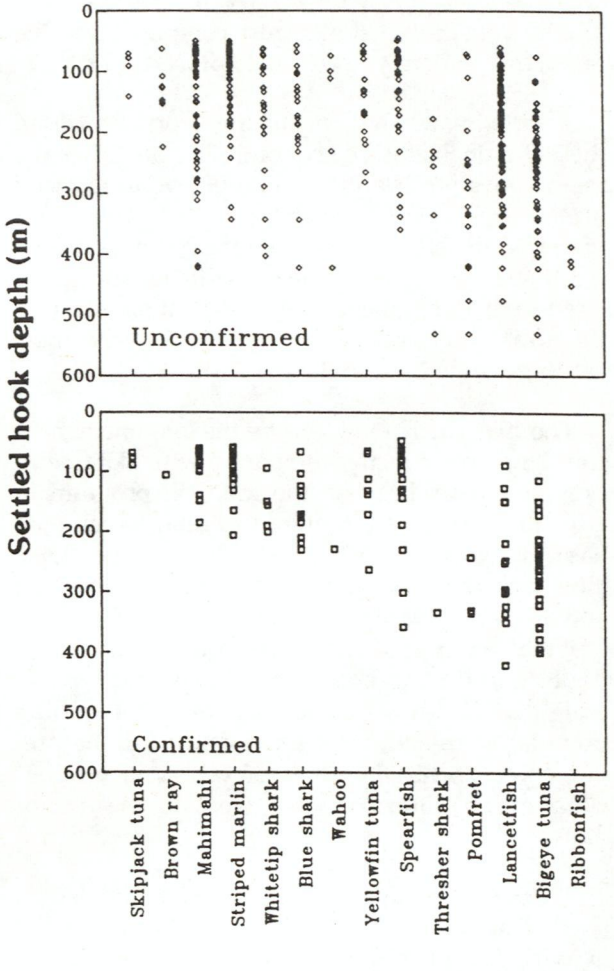

Figure 2. Hook depths for catches of 14 frequently caught taxa in a study off Hawaii in 1989 and 1990 (combined). Settled hook depths are shown for all hooks that caught fish (unconfirmed) and for those hooks that caught fish while settled (i.e., not sinking or rising) as indicated by data from hook timers

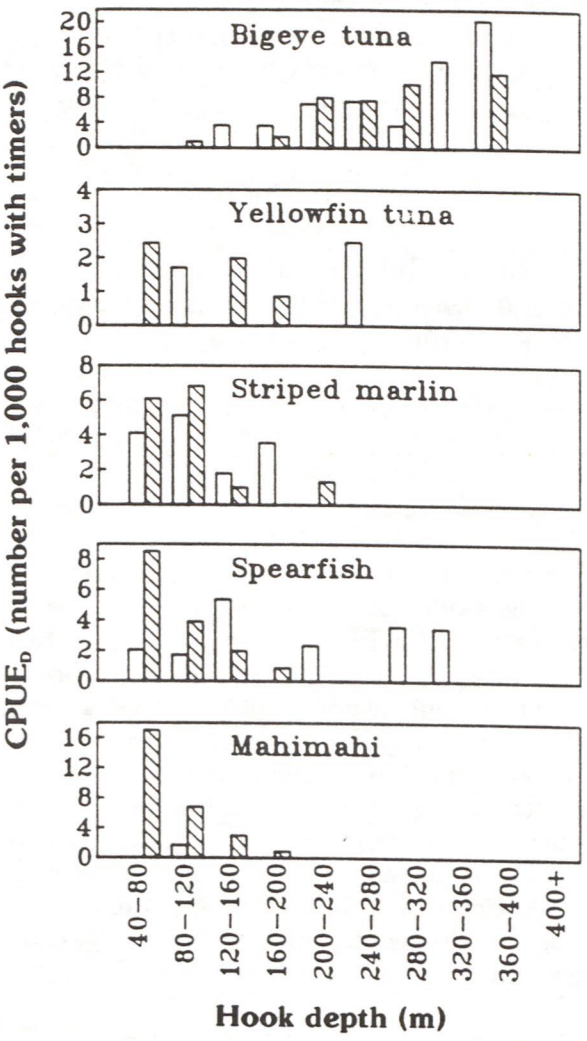

Figure 3. Indices of fish abundance versus depth, calculated as the number of fish caught per 1,000 hooks with timers ($CPUE_D$) in 10 depth strata. Indices for 1989 (open bars) and 1990 (cross-hatched bars) are based on fish captured while the gear was settled (as confirmed by hook timers).

Hook timers indicated that 32% of the striped marlin; 21% of the spearfish, *Tetrapturus angustirostris*; 28% of the mahimahi; and 12% of the bigeye tuna and yellowfin tuna, *Thunnus albacares*, were caught on sinking or rising hooks. However, most (>60%) of the two *Tetrapturus* spp. and mahimahi were caught on settled hooks (not sinking or rising) at depths of <120 m. Most bigeye tuna were caught at depths of >200 m. The efficiency of deep gear (with hooks at about 100-300 m) was estimated to be 3-4 times as great as regular gear (with hooks at about 100-180 m) in catching bigeye tuna, but only half as efficient in catching striped marlin and spearfish. A proposed new gear configuration with

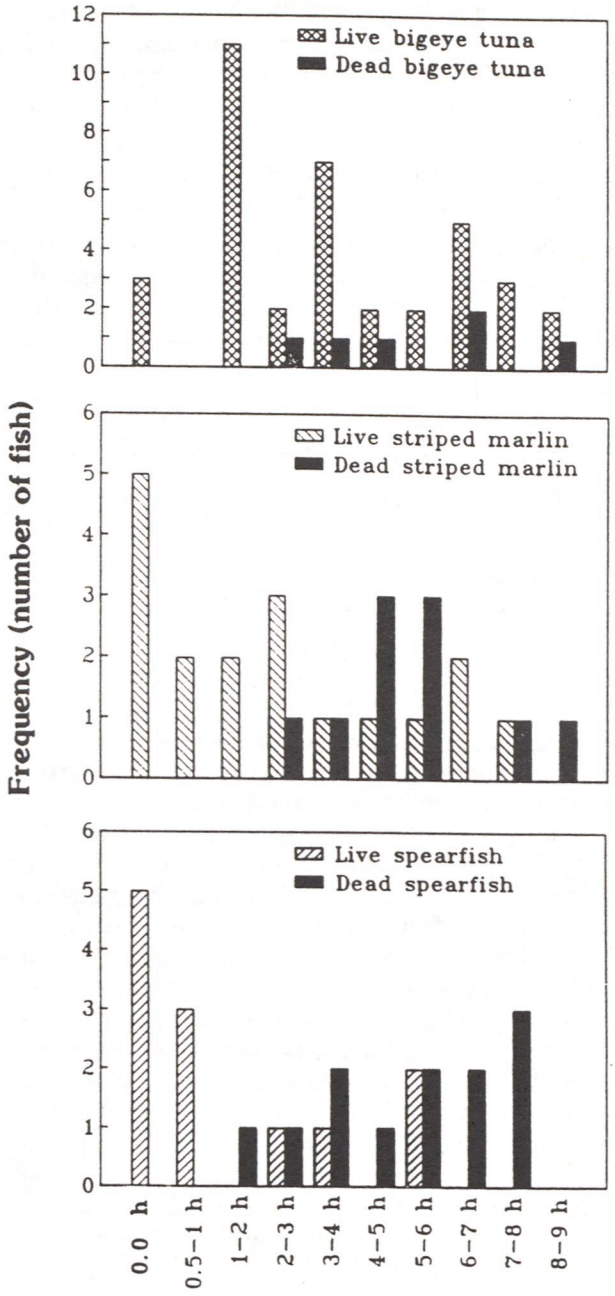

Figure 4. The condition (alive or dead) of three important species in relation to the elapsed time between capture and recovery as indicated by hook timers, during a study off Hawaii in 1989 and 1990 (combined).

hooks at about 180-300 m was predicted to be only about 25% as efficient as regular gear in catching striped marlin and spearfish. Eliminating shallow hooks could substantially reduce the bycatch of *Tetrapturus* spp. and other recreationally important billfish without reducing fishing efficiency for bigeye tuna.

Bigeye tuna, striped marlin, and spearfish survived up to 5-9 hours after capture (Figure 4), and over 50% of the 12 most frequently caught taxa were alive when retrieved. Some live fish (29 bigeye tuna and 35 striped marlin) were tagged and released after long poles had been used to insert the tags and to cut the leader so that fish remained in the water. Two bigeye tuna and one striped marlin were recaptured 3-10 months later, indicating that fish released from longline gear are viable and that the release of some species could be an effective management option. (C. Boggs [808] 943-1222)

PROTECTED SPECIES INVESTIGATION

Hawaiian Monk Seal Recovery Team Meets in Honolulu

The Hawaiian Monk Seal Recovery Team met in Honolulu January 15-17, 1992, to review the 1991 research accomplishments and 1992 research plans of the Protected Species Investigation's Marine Mammal Research Program (MMRP). Prior to the meeting, Recovery Team members had received a copy of a letter from the Marine Mammal Commission to Bill Fox, Assistant Administrator for Fisheries, resulting from the Commission's review in November 1991 of the MMRP's monk seal research and recovery activities. While the Commission had recommended that less effort be placed on population monitoring as a top-priority item and more effort be placed on species restoration tasks and habitat-use research, the Recovery Team restated its position that population monitoring is a top-priority need. For the first time, fiscal year 1992 base funding and add-on funding are sufficient so that field effort can be expanded to address the priorities of both the Commission and the Recovery Team.

In response to the Commission's and the Recovery Team's recommendations, the MMRP, during its 1992 field season, will monitor all five major monk seal breeding populations (Laysan and Lisianski Islands, French Frigate Shoals, Pearl and Hermes Reef, and Kure Atoll) as well as implement a pilot project directed at reducing adult-male mobbing attacks on females. In addition, small female pups will be collected for rehabilitation, prey items will be determined from scat and spew analyses, and dive recorders and satellite transmitters will be deployed to initiate an assessment of habitat use patterns. (W. Gilmartin [808] 943-1239)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

Non-linear Relationships between Northern Anchovy Larval Abundance and Environmental Changes

Recent collaborative work by the Climate and Eastern Ocean Systems (CEOS) Program at Pacific Fisheries Environmental Group (PFEG) has provided new evidence of non-linear relationships between northern anchovy larval abundance and several measures of environmental change, primarily indices of coastal upwelling and 10-meter sea temperature. Environmental and ecological time series (covering several decades in the California Current region) are now available. If some strong relationships do exist between environmental fluctuations and fish population dynamics, ecologists are now in a good position to identify emergent patterns. The California Cooperative Oceanic Fisheries Investigations (CalCOFI) data represent one of the most impressive marine data sets available, covering a multi-decadal time period for the entire southern California ecosystem.

Since 1951, larvae from the central population of the northern anchovy, *Engraulis mordax*, have been sampled over the entire range of its distribution. Environmental data have been collected independently and during the sampling cruises. Analyses of the relationships between two or more fundamental variables have most commonly employed linear statistical methods or used an a priori transformation, such as a logarithmic transformation. However, the lack of a linear relationship does not necessarily mean the absence of a tight link. Recently developed nonlinear statistical methods provide useful tools to explore structure between different sets of variables. Annual mean abundance of northern anchovy larvae in the principal reproductive area (lat. 32°N-34°N, long. 117.5°W-119.0°W) was calculated by averaging all sampled stations. From 1951 to 1990, thirty-two years were intensively sampled; a total of 3,257 stations was represented. Anchovy biomass during this period was variable. Total biomass was estimated by combining

available fisheries data and information from sonar and egg-production surveys.

Temperature has a strong effect on larval growth and consequently on larval-stage duration. To test for the relevance of low-frequency temperature variability, temperature collected at each sampling station at 10-meter depth was averaged over the year.

Coastal upwelling, a dominant oceanographic process off the California coast, is the result of a wind-driven offshore flow of surface water. The consistent presence of massive populations of small pelagic clupeid fishes in coastal upwelling regions around the world suggests a strong link between the population dynamics of these fishes and the upwelling process. An estimate of the upwelling intensity is given by the offshore component of the Ekman transport. This index tracks variability in the main features of the upwelling process: the offshore flow of coastal water, the coastal enrichment by the upward nutrient input, and the mixing of the surface layers by the wind. The gross effect of low-frequency variations in the upwelling process on the northern-anchovy reproductive area from 1951 to 1990 is evaluated by an annual upwelling index derived from monthly values at 33°N, 119°W.

Iterative algorithms have been recently developed that extend linear multiple regression analysis to generalized additive models. These models are additive in empirically estimated transformations of the data. The algorithms converge to optimal solutions for a given criterion (such as the maximum correlation between the transformed dependent variable and the transformed predictor variables). These procedures, which are not yet widely used in ecology, provide a method for exploring the form of the relationships between the dependent and the predictor variables when the forms of these relationships are unknown a priori.

Empirical, objective identification of possible nonlinear relationships are also made possible. The relationships between the variables were initially explored by plotting the raw data (Figure 1). No significant relationship was found between numbers of anchovy larvae and the temperature index. When numbers of larvae are plotted versus the upwelling index, low numbers of larvae are observed for both weak and strong upwelling intensities. High numbers of larvae are to be found for moderate upwelling index values; near 1.5 m^3/sec per meter of coastline. Number of larvae and the total anchovy biomass appear to be positively correlated; however, the data are scattered for high biomass values. A linear regression analysis using biomass and upwelling as predictor variables explained only 37% of the variance in number of larvae and the effect of upwelling on number of larvae was not significant. A generalized additive

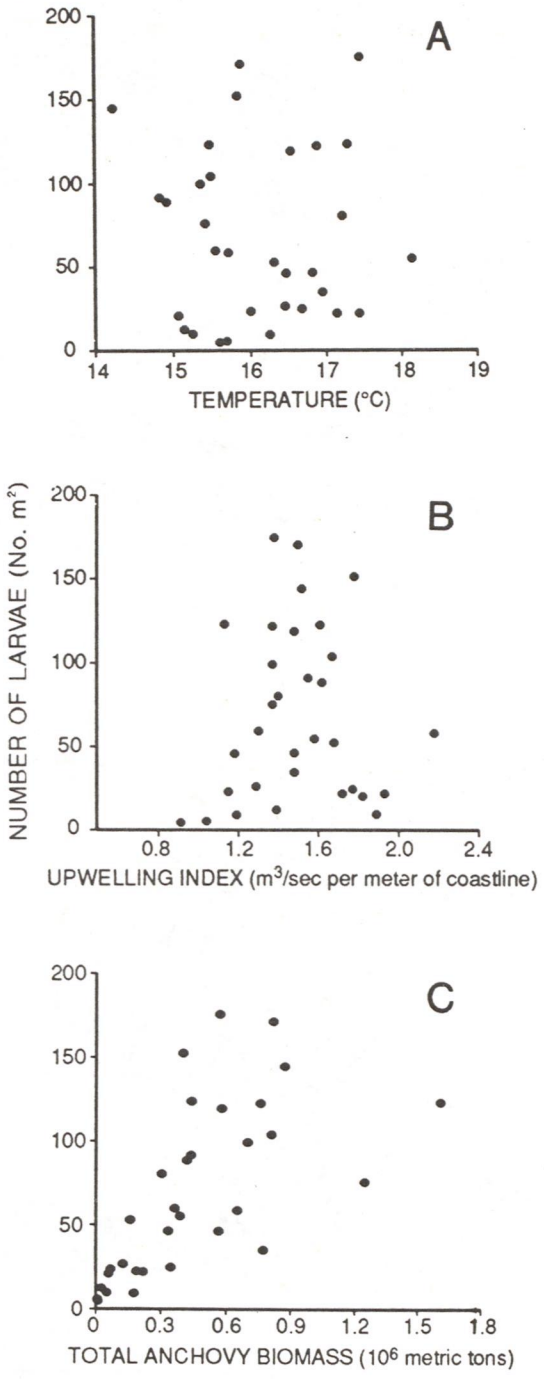

Figure 1. Mean annual number of northern anchovy larvae ($No \cdot m^{-2}$) from 1951 to 1990 versus: (A) mean temperature at 10 meter depth, (B) mean annual upwelling index, and (C) total anchovy biomass.

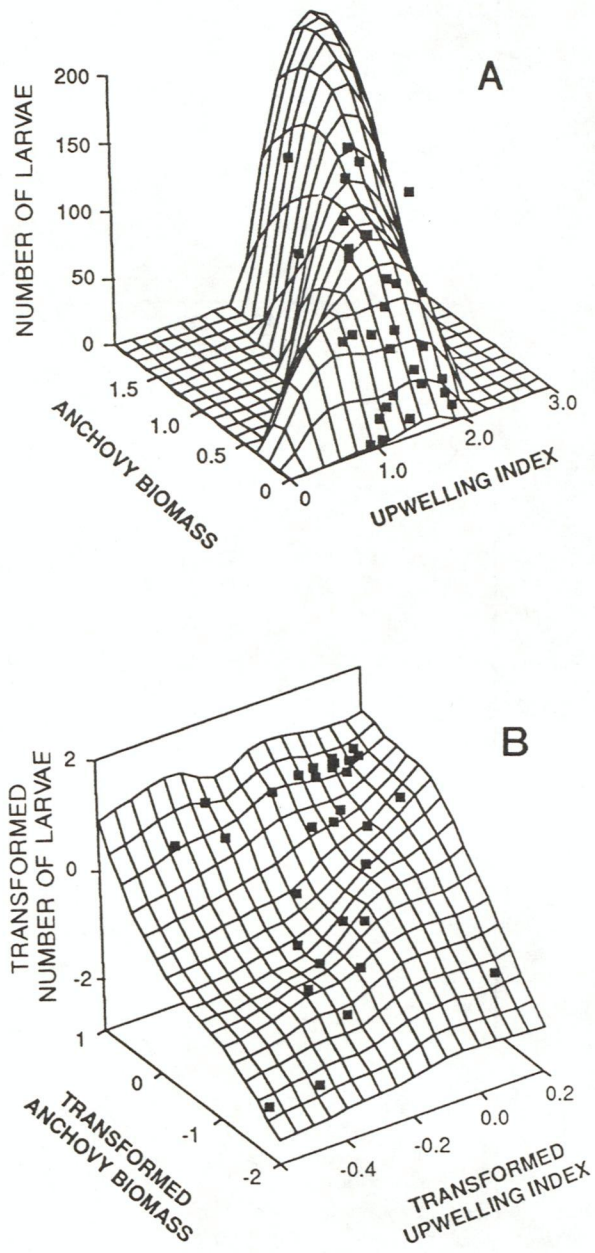

Figure 2. Interpolated three-dimensional surfaces (using distance-weighted least squares) and the location of the actual values (squares) for: (A) the original data (number of larvae versus upwelling index and total anchovy biomass). This interpolated 3-D surface shows similar nonlinear relationships between number of larvae and upwelling index and also number of larval and anchovy biomass as obtained from the alternative conditional expectation (ACE) algorithm; and (B) the empirically transformed data obtained from the ACE algorithm.

model for the same variables explained 84% of the variability in number of larvae. The estimated transformation of number of larvae is close to logarithmic in shape. The upwelling transformation is nearly dome shaped with a maximum value around 1.5 m^3/sec per meter of coastline. The transformation of the total biomass is approximately linear up to a value around 0.5 million metric tons, but no real increase occurs above this value. When either the upwelling or the total anchovy biomass is considered in the analysis separately, each explains, respectively, 24% and 61% of the number of larvae variance; in each case the shape of the transformation (figures not presented) is similar to that obtained when both were incorporated in the analysis.

Estimating a generalized additive model for number of anchovy larvae, adult biomass and upwelling can be viewed as an attempt, under additive restrictions, to empirically linearize the three-dimensional surface formed from these observations. An interpolated estimate of the three-dimensional surface of the original data using distance-weighted least squares (Figure 2A), shows the dome-like relationship between number of larvae and upwelling as well as the asymptotic relationship between number of larvae and adult biomass. The interpolated estimate of the three-dimensional surface for the transformed values of the observations is nearly linear in all directions, which shows that the transformations successfully linearize the data (Figure 2B).

For the northern anchovy, the relationship between larval number and upwelling intensity is nonlinear, suggesting that upwelling can be either beneficial or detrimental, depending on its intensity. Abundance of surviving larvae increases from low to moderate upwelling intensity, possibly because of the beneficial effect of increased food production and contact rates. It decreases for strong upwelling, possibly due to offshore transport and wind-driven turbulent mixing. Optimal conditions for a high number of surviving larvae correspond therefore to moderate upwelling intensity. These results are in striking conformity to other studies that have indicated that larval survival and recruitment success are regulated by a combination of different factors, each of which may depend in some way on upwelling intensity rather than a single key factor. (P. Cury, C. Roy, R. Mendelssohn, A. Bakun, D. Husby and R. Parrish [408] 646-3311)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

Seychelles Purse Seine Data Updated

Gary Rensink, biological technician, has completed updating third quarter 1991 purse-seine tuna-fishery statistics for the western Indian Ocean, taken from the Seychelles Fishing Authority. Data are summarized in LOTUS spreadsheets.

The number of vessels participating in the purse seine fishery in the western Indian Ocean during the third quarter of 1991 averaged 45 (17 French, 19 Spanish, 3 Mauritian, 1 Panamanian, 4 Japanese, and 1 Seychelles), slightly higher than the average of 44 vessels recorded for the same period in 1990.

The third quarter catch rates averaged 19.2 metric tons (t)/day, slightly better than the 18.7 t/day recorded for the same period in 1990 (Figure 1). Catch rates were up 9% for yellowfin (7.2 t/day), and down 7% for skipjack (10.8 t/day) from those of the same period in 1990.

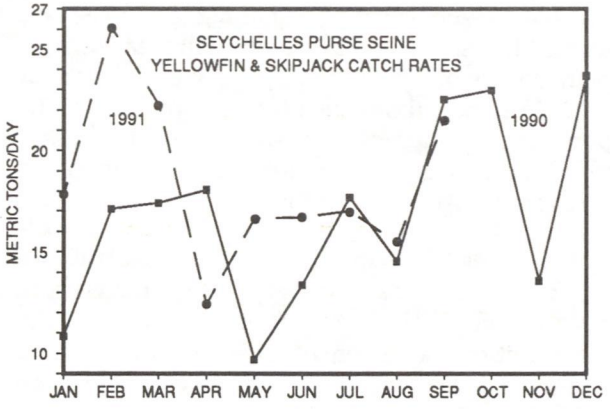

Figure 1. Catch rates (metric tons/day fished) for purse seiners fishing in the western Indian Ocean, 1990-91.

Yellowfin and skipjack tuna catches during the third quarter of 1991 were 51,260 t, down 8% from those of the same period in 1990. The cumulative total for the year as of September totaled 149,017 t, 4% lower than that recorded for the same period in 1990 (Figure 2). The decrease is largely due to poor fishing conditions for skipjack tuna.

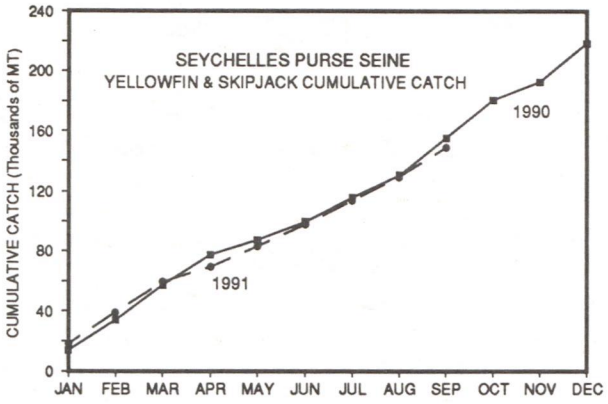

Figure 2. Cumulative catches (metric tons) of yellowfin and skipjack tuna by purse seiners in the western Indian Ocean, 1990-91.

The breakdown of tuna catch for the third quarter of 1991 is 38% yellowfin, 56% skipjack, and 6% other tuna. For the same period in 1990, the breakdown was 34% yellowfin, 64% skipjack, and 2% other tuna. (G. Rensink [619] 546-7192)

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

Trends in Billfish Angler Catch Rates

Since 1969, the National Marine Fisheries Service (NMFS) has conducted an annual postcard survey to obtain a sample of billfish catch-per-unit effort (CPUE) for the major recreational billfish fishing locations in the Pacific. A postcard survey is currently being conducted to determine catch rates for 1991, and results for 1990 have been tabulated.

In 1990, the total number of fishing days reported by billfish anglers responding to the survey was 15,606. This number of angler days resulted in a catch of 5,827 billfish for a catch rate of 0.42 billfish per day.

For the locations having normally high catch rates for striped marlin, the CPUE increased. The 1990 CPUE for Baja California, Mexico, was 0.73 fish/day, up from 0.67 fish/day in 1989. Off Ecuador, CPUE increased from 0.61 in 1989 to 0.80 fish/day in 1990.

The trend in CPUE that is of interest to many anglers involves blue marlin fishing about Hawaii, which is due to recent increases in commercial longline fishing about the Islands. The CPUE in 1990 for blue marlin remained at a level of 0.24 fish per angler day, approximately the same as recorded in 1989. An increasing CPUE had been recorded for Hawaii during the four previous surveys.

In the western Pacific, blue marlin catch rates for Guam showed an increase to 0.32 fish-per-day, up from the 0.23 fish-per-day recorded in 1989.

These results, as well as a complete review of catch rates recorded for other parts of the Pacific, Indo-Pacific, and Indian Ocean, will be included in the *1992 Billfish Newsletter* scheduled for release in May, 1992. (J. Squire [619] 546-7072)

Report of the 1991 North Pacific Albacore Fishery-observer Project

In 1990 and 1991, Southwest Fisheries Science Center (SWFSC), in cooperation with the Western Fishboat Owners Association, conducted a high-seas impact-assessment program to determine the effects of North Pacific driftnet fisheries on albacore, *Thunnus alalunga*. Albacore that encounter driftnets and escape often bear identifiable external net marks which provide evidence of interaction between albacore and the net fishery.

In the North Pacific, the small-mesh net fishery of about 600 vessels from Japan, Taiwan, and the Republic of Korea concentrate on catching the flying squid, *Ommastrephes bartrami*. This fishery catches albacore incidentally. The large-mesh fleet of about 160 vessels from Japan and Taiwan targets its effort on catching albacore. In addition, Japan and Taiwan have a longline fleet catching albacore in the North Pacific.

Catches and catch-per-effort of the U.S. albacore troll and Japanese pole-and-line fisheries for albacore have declined continuously since the 1970s. To better determine the effects of the more recent driftnet fisheries on the albacore resource, the SWFSC continued a catch-sampling program at sea in 1991.

National Marine Fisheries Service (NMFS) biological technicians made four trips on different U.S. albacore trollers in the North Pacific. Time at sea totaled 154 days, and during this time, 12,466 albacore were examined for net damage.

In 1991, 96.9% of albacore examined showed no visible indications of having been caught in a drift gillnet. The remaining albacore (3.1%) showed various signs of damage. The amount of net-damaged fish in 1991 was much less than observed during the 1990 program, which documented 12.1% of the albacore as being net marked.

The sizes of fish caught in the drift gillnets were the same as those 2-, 3-, and 4-year-old age classes which are typically caught in the U.S.-troll albacore catch.

A higher proportion of new net damage was noted in the western portion of the fishing area than in the eastern portion. This increase in damaged fish is presumed to be due to the location of sampling, which was closer to the foreign drift-gillnet fisheries than was the sampling in the eastern portion of the troll fishing area. (N. Bartoo [619] 546-7073)

PELAGIC ECOSYSTEM MODEL DEVELOPMENT PROGRAM

Tuna Movement Based on Tag Recapture Data

Operations Research Analyst Carlos Salvadó has completed a general theoretical model for analyzing movement of tunas and for estimating the population dynamics parameters by means of tag recapture data. The model uses the Green function, and it considers each release of tagged tunas, performed in a short time and in a small area (zone), a point source of tagged tuna which may be used for studying the migration of the population. The population dynamics of the tunas is better understood when tagged fish are released throughout the core range of the population.

This model is stochastic and is equivalent to a Markovian process of movement of tunas from zone to zone. The Green function is a measure of the probability of movement of tunas from one location to another. The parameters in the model include catchability, natural death rate, and advective velocity and diffusivity and can be estimated by maximum-likelihood methods or by computing the movements of the Green function. This latter technique is simpler and requires less computations.

The next phase of study is under way and will involve a series of simulations to determine the sensitivity of parameter estimates to errors in input values and data. (C. Salvadó [619] 546-7052)

TIBURON LABORATORY

Tiburon, California

GROUNDFISH PHYSIOLOGICAL ECOLOGY INVESTIGATION

The Cost of Supporting Embryos and Larvae in Yellowtail Rockfish

Field and laboratory researchers have found that yellowtail rockfish, *Sebastes flavidus*, have high reproductive potential, vary annually in reproductive effort, and vary physiologically in their ability to resorb eggs and forego reproduction. Two years of laboratory studies designed to determine the rate of gestation by monitoring intra-ovarian development of embryos and larvae have shown that maternal behavior changes as gestation progresses. Gestating fish were inactive, did not feed, and hyperventilated near parturition (giving birth), all of which impact maternal energy budgets.

New research, supported in part by Sea Grant, has been initiated that measures changes in metabolic costs during gestation. Seven separate experiments have been conducted which measure the oxygen consumption of adult yellowtail rockfish in tunnel respirometers. Test animals represented reproductive maturity states of late vitellogenesis, early and late embryogenesis, with larvae present, and the post-parturition, spent condition. For comparison, biologists also measured respiration in adult nonreproducing females that had been held in isolation from males for over one year as well as the respiration in male fish. Concluding experiments are scheduled for March, but preliminary results showed several interesting findings. Initial measurements of oxygen consumption conducted for 48 continuous hours demonstrated that fish require at least 12 hours for acclimation before accurate measures of routine metabolism can be made.

Fish in all experiments also reacted to changes in ambient light conditions–laboratory lights went off or on in a normal diel pattern. At least one hour was required for metabolism to stabilize after dawn or dusk. At the conclusion of these experiments, the researchers hope to be able to determine not only the temporal patterns of metabolism, but also the time and developmental stage at which metabolism increases and the absolute value in terms of energy costs of this type of reproductive strategy.
(M. Eldridge [415] 435-3140)

GROUNDFISH COMMUNITIES INVESTIGATION

Physical Condition of Spawning Female Blue Rockfish Improved During 1992

The possibility that recruitment by the blue rockfish is influenced by feeding conditions experienced by the adults of that species has been studied since November 1987 by Fishery Biologists Ted Hobson, Tony Chess, and Dan Howard of the Groundfish Communities Investigation. Results through 1990, reported last year in Admin. Rep. T-91-01, showed that the physical condition of adult females during the January-February spawning season is strongly influenced by feeding conditions during the previous summer and fall. There also were indications that recruitment resulting from this spawning season is influenced as well.

Those findings have gained support from work completed during the past year, when summer-fall feeding was considerably better than it had been during the same periods of 1989 and 1990 (Figure 1). Furthermore, while the gut contents were slightly lower in volume than during 1988 (and the incidence of empty guts was somewhat increased), the quality of the diet was higher than during the three previous years. Gelatinous zooplankters are the preferred foods of this species (for plant materials taken when other foods are less available, see Hobson and Chess 1988,

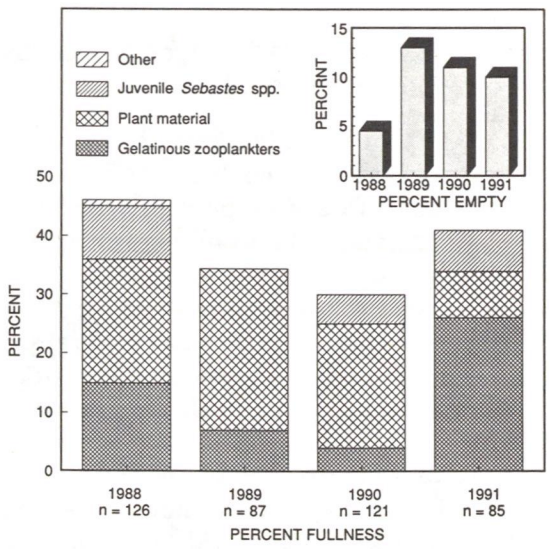

Figure 1. Feeding by adult female *Sebastes mystinus* from June to November, 1988-1991.

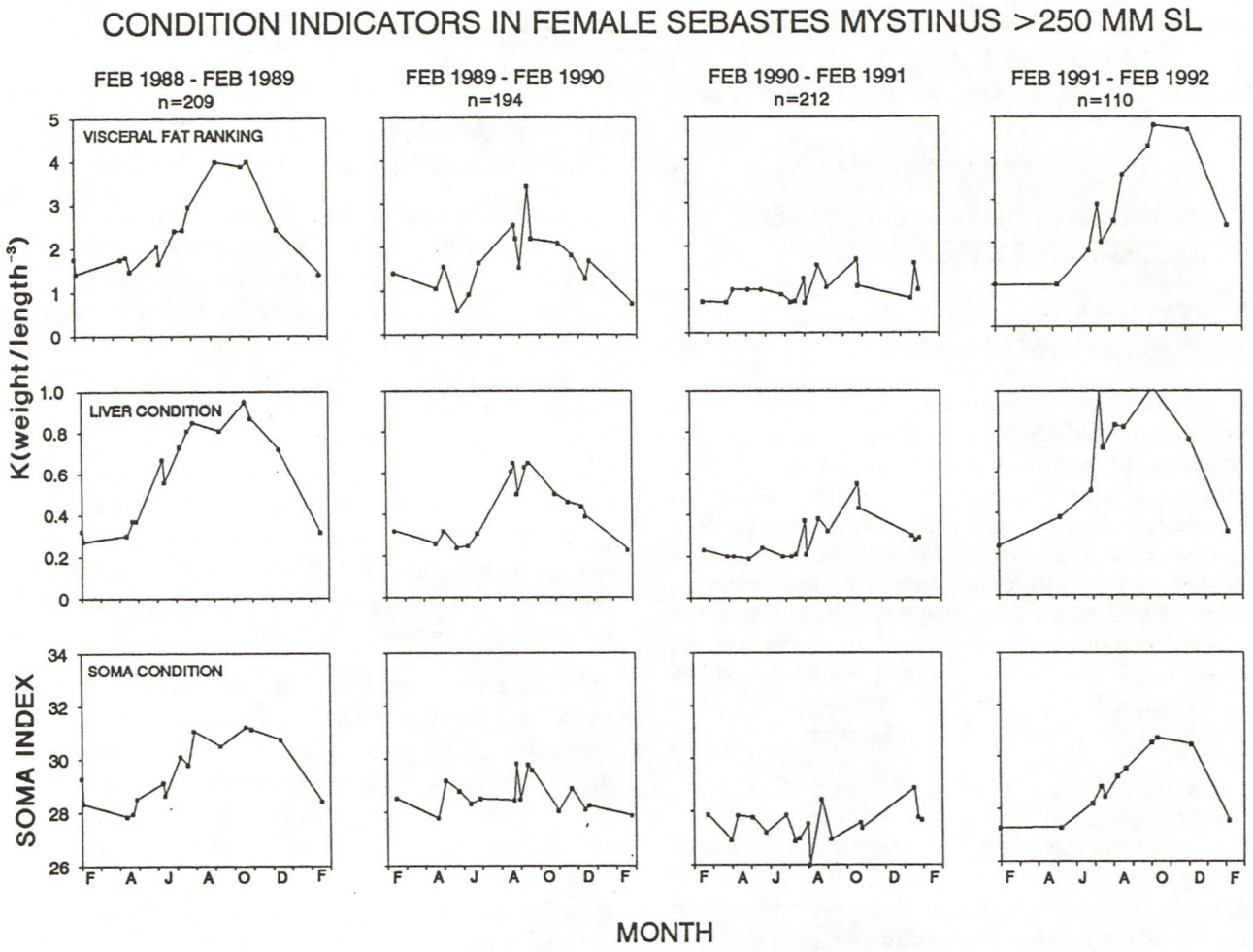

Figure 2. Physical condition indicators in female *Sebastes Mystinus* based on visceral fat ranking, liver condition, and soma condition for the period February 1988 - February 1992.

Fishery Bulletin 86:715-743), and for the first time during this study, these were the major foods.

That the improved feeding resulted in healthier fish was indicated by the three measures that have been used to assess physical condition (Figure 2). The visceral fat ranking is a subjective visual assessment on a relative scale, 0 to 5, whereas the liver condition and soma condition (with soma defined as body less viscera and gonads) are represented by Fulton's Condition Factor (K = weight/length^3). It remains to be determined, however, whether the improved physical condition indicated by these measures will translate into a greater number of recruits later this year. (E. Hobson [415] 435-3140)

INFORMATION TECHNOLOGY SERVICES

La Jolla Hosts National Data Management Committee Meeting

Southwest Regional Data Base Administrator (RDBA) Dorothy Roll chaired the National Data Management Committee (NDMC) meeting held at the La Jolla Laboratory from February 11 to 13, 1992. Attending the sessions were Michael Fraser, Craig Felber, Derek Favila, Mark Holliday, Richard Schween, and contractor Dick Conn (National Marine Fisheries Service [NMFS] Headquarters), Joan Palmer and RDBA Eugene Heyerdahl (Northeast

Center), Ted Rodgers (Alaska Fisheries Center), and Ken Zinneger for RDBA MaryAnne Treadway (Southeast Center).

Jerry Hornof (Southwest Region) and Frank Ralston (La Jolla/Information Technology Service [ITS]) were invited to participate in the first day's morning discussions on the issues of security, the conversion of cc:MAIL from 3COM mail, Local Area Network (LAN), Wide Area Network (WAN), and Fisheries plans for the FTS 2000 and INTERNET link. Observing the morning sessions were Richard Charter (Coastal Fisheries Resources Division), Al Coan (Pelagic Fisheries Resources Division), Rob Bistodeau, Matt Bones, and Susan Jacobson (La Jolla/ITS).

The remaining closed sessions of the meeting were devoted to the group's discussions on the following topics: progress of the technical review process of the IT-95 proposals, the upcoming request to the regional sites for their IT-95 transition plans, an overview of the NOAA Earth System Data and Information Management (ESDIM) program, the reasons for the NMFS Marine Ecological Data System (MEDS) program under ESDIM, the distribution of funds for the MEDS planning, and the call for the data survey/inventory at all Fisheries sites. It was decided that the data survey should meet two objectives: 1) provide the inventory needed to rank the data bases for conversion to the IT-95 system, and 2) populate the NOAA-wide data directory required by NOAA for formulating their data management strategy for the 1990s and beyond.

A full day's session was spent on the overview of ESDIM and MEDS. The ESDIM program was started in FY 1991 as a NOAA-wide effort to revitalize data management throughout its agencies in order to respond to present and future world-wide demands for science-quality data bases. Ecosystems-based management of the living marine resources, one of NOAA's top ten goals, fits into one of the NMFS strategic goals, which addresses ecosystems and improvement of forecasts. MEDS, a specific program under ESDIM, is strongly endorsed by Dr. William Fox, Administrative Assistant for Fisheries. To meet the goals of MEDS, he has directed F/RE2, Data Management Division, under the guidance of NMFS Chief Scientist, Mike Sissenwine, to develop the strategic plans to design and implement a data-management system supporting ecosystems-based management of the living marine resources.

To develop ideas for the MEDS planning, the F/RE2 Acting Director Fraser initiated a brainstorming session on Vision Thinking: how NMFS would be collecting and managing fisheries information in the year 2002. The group separated into two working teams: Team 1 took the perspective of the "end user" and Team 2 the perspective of "end-to-end data management." After an hour's work session, the teams reconvened and discussed each other's findings. The two groups discovered that they shared many of following views: (1) more complex and non-traditional fisheries questions might focus on global economics, food supply, and aquaculture instead of on wild harvest; (2) planning of a research project might address data-management requirements at the onset and be influenced by new sampling techniques; (3) research and management might be conducted by teams composed of a mix of single-disciplined experts; (4) analysis of massive quantities of information might utilize sophisticated tools such as artificial intelligence expert systems and visualization/animation; (5) fisheries might be managed at the global rather than the regional level; and (6) policies might focus on ecosystems management of multi-species rather than on single species.

Before adjourning on the third day, the group discussed the responsibilities of the NDMC. This discussion was prompted by some apparent misunderstanding at Headquarters and at the field sites on the decision to adopt cc:MAIL as the NMFS electronic mail service. It was emphasized that the NDMC does not make decisions but rather, given an issue by NMFS top managers, the committee considers how best to resolve the issue and agrees upon recommendations for implementation. Decisions based on the recommendations are made by the top-level managers. To preclude misunderstandings in the future, the group agreed to provide a formal report to the Directors on recommendations reached by consensus during the NDMC meetings. (D. Roll [619] 546-7057)

PUBLICATIONS

Published

Bakun, A., and C.S. Nelson. 1991. The seasonal cycle of wind-stress curl in subtropical eastern boundary current regions. Journal of Physical Oceanography, Vol. 21, No. 12.

Historical surface marine-wind reports have been processed to define characteristic seasonal distribu-

tions of wind-stress curl over the four major eastern boundary current regions of the World Ocean (i.e., the California, Canary, Benguela, and Peru/Humboldt system) on smaller scales than previously available. Interregional comparisons show that these "classical" coastal upwelling systems are characterized by cyclonic wind-stress curl near the continental boundaries and anticyclonic curl offshore, in association with predominantly equatorward (upwelling favorable) alongshore wind stress. The cross-shore profile of alongshore stress typically has an offshore maximum located some 200 to 300 km from the coast. The decay of the wind stress toward the coast defines a region of cyclonic wind-stress curl, where coastal upwelling is enhanced by curl-induced oceanic upwelling (Ekman pumping). During summer in the respective hemispheres, the region of cyclonic curl expands poleward in each boundary current system. Particularly intense cyclone curl occurs adjacent to capes during summer coastal-upwelling maxima. During fall and winter when the upwelling system weakens, the latitudinal extent of cyclone curl adjacent to the coast contracts, and the most intense cyclonic curl is usually associated with coastal bights.

Bakun, A., and R.H. Parrish. 1991. Comparative studies of coastal pelagic fish reproductive habitats: the anchovy, *Engraulis anchoita*, of the southwestern Atlantic. ICES J. Mar. Sci. 48:343-361.

A framework of comparative climatology of reproductive habitats of coastal pelagic fishes is extended to the anchovy inhabiting the shelf-sea ecosystem off Argentina, Uruguay, and southern Brazil. Maritime weather reports are summarized to yield distributions of wind stress, cloud cover, insolation, sea-surface temperature, wind-mixing index, and Ekman transport. These distributions are considered together with other known aspects of the oceanography of the region and with seasonal and geographical aspects of reproductive activity. Over its extensive range, *Engraulis anchoita* spawns successfully within three different configurations of environmental processes affecting transport, water column stability, and trophic enrichment. One of these, incorporating a coastal indentation downstream from a coastal upwelling center, is very similar to the most common configuration characterizing spawning grounds of eastern ocean anchovy populations. The second, featuring interleaving water masses and upwelling at the continental shelf break, exhibits similarities to the reproductive habitat of the South African anchovy. The third, involving tidal mixing fronts, has been previously noted primarily in connection with herring of higher-latitude, shallow-shelf sea systems. The study adds support to the idea that similar fish populations in different regions must solve similar basic environmental problems and that various experiences of environmental effects in different populations, when viewed from a properly posed conceptual framework, can add up to a useful accumulation of insight.

Dailey, M.D., M.L. Fast, and George H. Balazs. 1991. *Carettacola hawaiiensis* n. sp. (Trematoda:Spirorchidae) from the green turtle, *Chelonia mydas*, in Hawaii. J. Parasitol. 77:906-909.

Carettacola hawaiiensis n. sp. (Tremadoda:Spirorchidae) is described from the hepatic vessels of the green turtle, *Chelonia mydas* (L.), in Hawaii. The new species differs from any previously described species of *Carettacola* in size, placement of vitellaria, and shape and placement of Laurer's canal. The genus *Haemoxenicon* (Martin and Bamberger 1952) becomes a synonym of *Carettacola* (Manter and Larson 1950). *Haemoxenicon stunkardi* (Martin and Bamgerger 1952) is transferred to the genus *Carettacola* (Manter and Larson 1950) and becomes *Carettocola stunkardi* n. comb. An emended generic diagnosis for *Carettacola* is given along with a key to the species.

Hobson, E.S. 1991. Trophic relationships of fishes specialized to feed on zooplankters above coral reefs. *In* P.F. Sale (editor), The ecology of fishes on coral reefs, p. 69-95. Academic Press.

Fishes specialized to feed on zooplankters are major components of coral-reef communities and understanding their trophic relations is essential to understanding the dynamics of tropical reef systems. These relations differ sharply from day to night. Fishes that consume zooplankters by day are characterized by modifications of head and jaws, including dentition, that permit even relatively large individuals to take tiny organisms in midwater, whereas fishes that consume zooplankters at night tend to be large-mouthed species with specialized means to detect and capture the larger organisms that are in the water column only after dark. Other features of their anatomy and behavior, including distributions, can be interpreted as adaptive during interactions with predators or prey. Planktivory above tropical reefs during the day is based largely on the vulnerability of open-water organisms in situations outside their evolutionary experience.

Kope, R.G. 1991. Current analytic concerns with harvest-rate management. *In* T.J. Hassler (editor), Proceedings of the 1990 Northeast Pacific Chinook and Coho Salmon Workshop, p. 45-55. California Cooperative Fishery Research Unit, Humboldt State University, Arcata, California.

Concerns with the implementation of harvest-rate management can be lumped into two broad categories: strategic concerns--problems with the planning of a harvest rate management strategy, and tactical concerns--problems with actually carrying the strategy out. Strategic concerns are relevant for all management strategies while tactical concerns are more specific to harvest-rate management. Strategic concerns include specification of a production function (stock-recruit relationship), estimation of stock productivity, and the problem of optimizing the harvest from fisheries that exploit both natural and hatchery

fish. Harvest-rate management was initiated for chinook salmon, *Oncorhynchus tshawytscha*, stocks of the Klamath River basin largely because of these strategic concerns. Implementation of harvest-rate management has brought tactical concerns to the forefront. These include variability in the ocean distribution of Klamath basin stocks, unpredictability of the fishing industry response to attempts at managing harvest rates, and the imprecision of forecasts of the Klamath basin stocks. The future of harvest-rate management will depend on the extent to which fisheries scientists are able to find solutions to these problems and the acceptability of the solutions to the management bodies and user groups.

Mason, J.E. 1991. Variations in the catch of jack mackerel in the southern California purse seine fishery. CalCOFI Rep. 32:143-151.

Jack mackerel landings from southern California sampled by the California Department of Fish and Game show a high degree of variability in recruitment success. The period from 1947 to 1983 is examined for variations in landings due to changes in fishing effort of the multispecies purse seine fishery. Fishing effort for jack mackerel has been affected by the availability of alternative species such as Pacific sardine and Pacific mackerel and by economic factors including cannery capacity and the price of imported mackerel. Significant variations in recruitment success are apparent. Above-average recruitment for jack mackerel and Pacific mackerel, both pelagic species in southern California waters, often occurs in the same years.

The age composition of jack mackerel landings has changed noticeably during this period. Before 1965, fish three years old or older contributed significantly to the fishery, but after 1965 the fishery was dominated by one- and two-year old fish. The seasonal nature of the multispecies fishery and the decreased contribution of older fish from the fall fishery are reflected in this change in age composition. Other factors include economic effects, the frequency of relatively strong year classes, shifts in the areas fished, and possible changes in fish behavior.

Schwing, F.B., D.M. Husby, N. Garfield, and D.E. Tracy. 1991. Mesoscale oceanic response to wind events off central California in spring 1989; CTD and surveys AVHRR imagery. CalCOFI Rep. 32:47-62.

Analysis of hydrographic data obtained during juvenile groundfish surveys, in relation to local wind forcing and AVHRR sea-surface temperature imagery, reveals that the oceanic region off central California between Point Reyes and Point Sur in spring 1989 was characterized by complex circulation patterns and considerable temporal and mesoscale variability. The "spring transition" to upwelling-favorable winds is most clearly evidenced by large, rapid decreases in SST (up to 4-5 degrees C) measured at four meteorological buoys. Daily averaged winds are spatially coherent and oscillate between upwelling-favorable and relaxation conditions at 3-10 day intervals.

Persistent upwelling centers near Point Reyes and Point Año Nuevo were characterized by relatively cool, salty (8-10 degrees C, 33.6-34.0 psu) water in the upper 50 m, which is derived from offshore water at depths of 50-100 m. Water-mass analysis reveals that upwelled water is advected equatorward from its source. Some upwelled water is transported into shallow coastal areas and warmed. Alongshelf fronts between relatively warm, low-salinity (greater than 13 degrees C, less than 33.5 psu) offshore water and cool, higher-salinity upwelled water are advected onshore in response to wind relaxation or reversal events; frontal gradients intensify at these times. AVHRR imagery verifies the spatial patterns and complex mesoscale variability of the near-surface patterns observed in the CTD survey data. Eddylike hydrographic features are noted with horizontal scales on the order of the station spacing (10 km). How the complex circulation patterns and intense mesoscale spatial and temporal variability affect the survival and subsequent recruitment of juvenile groundfish is discussed.

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Schneider, D.C., D.C. Duffy, A.D. MacCall, and D.W. Anderson. Seabird-fisheries interactions: Evaluation with dimensionless ratios. For book: *Wildlife 2001: Populations*, Elsevier Science Publishers.

Watson, W. Spatial and temporal distributions of larval Pacific sardine, *Sardinops sagax*, in shallow coastal waters between Oceanside and San Onofre, California: 1978-1986. For consideration for publication in CalCOFI reports.

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