DEPARTMENT OF COMMERCE · UNITED STATES OF AMERICA

Southwest
FISHERIES SCIENCE CENTER

HONOLULU | LA JOLLA | MONTEREY | TIBURON

REPORT OF ACTIVITIES   March-April 1991

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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

1990-91 AMLR Research Cruise Completed

Following a mid-cruise port call, the NOAA Ship *Surveyor* departed Punta Arenas, Chile on February 16, 1991, to begin Leg II of the Antarctic Marine Living Resources (AMLR) program's annual research cruise at the tip of the Antarctic peninsula. While in transit across the Drake Passage, a series of temperature-depth measurements was conducted utilizing expendable bathythermographs (XBT's) at the request of Chile's Servicio Hidrográfico y Oceanográfico de la Armada (SHOA). The ship arrived at Seal Island, a small island off the coast of Elephant Island, on February 19 to deliver fresh provisions and mail to a field team stationed there since early December 1990.

After leaving Seal Island, the ship transited to the waters north of Elephant Island to begin a small-scale, 4-day survey to characterize physical oceanography, phytoplankton biomass and productivity, and distribution and condition of krill in the area. Physical oceanography and phytoplankton data were collected from conductivity-temperature-depth (CTD)/Rosette samplers deployed at each of the survey's 22 stations. In addition, environmental data for use in physical oceanography studies were collected using the *Surveyor's* continuous weather/navigation system. Krill distribution was assessed using two hydroacoustic systems deployed simultaneously. In order to collect animals to assess krill condition, bongo and Isaacs-Kidd Midwater Trawl (IKMT) nets were deployed.

Following the small-scale survey, directed sampling for krill eggs and larvae, using the multiple opening closing net environmental sampling system (MOCNESS), was conducted over deep water to the northeast of Elephant Island.

A large-scale survey in the waters around Elephant Island, Clarence Island, and the eastern end of King George Island was conducted from February 26 to March 6. The survey covered 1100 transect miles, and again physical oceanography, phytoplankton, and krill biomass and condition data were collected. Following completion the sensors of the hydroacoustic systems were calibrated.

Additional acoustic transects and net-sampling stations were conducted in Bransfield Strait, and a second acoustic calibration was performed at Deception Island. The *Surveyor* returned to the north side of Elephant Island on March 8, where MOCNESS sampling was directed at a persistent area of high krill density along the shelf break east of Seal Island. After recovering the Seal Island field team on March 11, two CTD transects were conducted across the shelf break north of Elephant Island. IKMT tows, conducted during the second CTD transect, caught reproductively active krill. A very fine-scale survey grid (1 mile by 1 mile with 0.2 mile transect spacing) was occupied at the inshore end of the transect; high resolution observations of the distribution of krill and foraging behavior of birds were obtained. The *Surveyor* departed the Elephant Island study area and arrived in Punta Arenas on March 17, bringing to a close the 1990-91 field season. (J. Rosenberg, FTS 893-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

COASTAL EASTERN PACIFIC POPULATION BIOLOGY OF FISHES

Physiology-Genetics Program

Russ Vetter, Eric Lynn and Ngai Chin Lai (former NRC fellow) completed a very successful cruise that constituted the third leg of the 1991 Groundfish Survey aboard the *David Starr Jordan*. Trawl samples were collected from the north side of Monterey Bay at 100-meter depth increments from 100 meters down to 1400 meters. The main purposes of the survey were to provide comparative abundance data for submersible and ROV studies, conducted by John Butler and NRC fellow Waldo Wakefield, and to systematically investigate the oxygen minimum zone (OMZ) as an environmental factor that may influence the distribution, tissue composition, and maximum growth potential of some groundfish species. The OMZ was located between 600 and 700 meters with oxygen concentrations dropping to 0.1 ml/l. Fish samples were collected from shallow, well-oxygenated waters, samples from the heart of the oxygen minimum zone, and from deeper water where oxygen levels are higher again.

Researchers are investigating the possibility that the extremely low oxygen levels in the OMZ may contribute to the jellied condition of adult Dover sole and deepsea sole, and may restrict the movements of deep-sea fishes such as the grenadiers up-slope and the movements of rockfish and shallow-water flatfish such as rex sole, down-slope.

Preliminary examination of the data obtained onboard ship indicates that the Dover sole, sablefish and *Sebastolobus* spp. (that dominate the OMZ fish fauna) have specialized hemoglobins able to extract oxygen at the low environmental concentrations prevalent in the OMZ. Tissue samples were collected from fish at all depths and will be used for molecular genetic studies and further examination of the adaptations to the OMZ.

If inhabiting the OMZ requires specific adaptations that include or exclude certain species, this will effect our assessments of how the slope community as a whole will respond to differential exploitation of certain species or trawling depths. (R. Vetter, FTS 893-7125)

COASTAL AND PACIFIC FISHERIES RESOURCES INVESTIGATIONS

Cooperative U.S.-Soviet Cruise Takes Spawning Jack Mackerel and Captures Pacific Sardine and Chub Mackerel Far From Shore

The Soviet fishery research trawler, *Novodrutsk*, arrived in Seattle on April 21, 1991, after completing the jack mackerel portion of the cooperative research program with the Alaska Fisheries Science Center. Fishery Biologist Dimitry Abramenkoff, from the Southwest Fisheries Science Center in La Jolla, California, worked with Soviet scientists M. Stepanenko and Y. Yermakov of the Pacific Research Institute of Fisheries and Oceanography (TINRO) in Vladivostok, U.S.S.R. A month long survey off southern California produced interesting results. Prior to the mackerel cruise, scientists from the SWFSC Tiburon Laboratory also participated on the *Novodrutsk* cruise to gather information on shortbelly rockfish (*Sebastes jordani*), with help from the Soviets.

Thirty-one out of the 36 pelagic trawls attempted yielded jack mackerel, *Trachurus symmetricus*, with an incidental catch of substantial amounts of chub mackerel, *Scomber japonicus*, and Pacific sardine, *Sardinops sagax* (Table 2, opposite page). The total weight of the catch in the positive trawls ranged from 0.2 tons to 63 tons for the three species. The other fish species of minor incidence in the catch are listed in Table 1. The by-catch of Pacific sardine and chub mackerel was particularly interesting because they were caught far offshore, about 200 nautical miles from the southern California coastline (Figure 1).

Table 1. List of other fish species taken in the trawls aboard the R/V *Novodrutsk* as identified by the Soviet researchers.

Bathylagus pacificus
Brama japonica
Ceratoscopelus townsendi
Ceratoscopelus warmingi
Cololabis saira
Diplophos taenia
Gonichthys tenuiculus
Lampadena urophaos
Lampanictus nobilis
Lampris guttatus
Lestidiops ringens
Mola mola
Nansenia candida
Prionace glauca
Scombrolabrax heterolepis
Symbolophorus calidorniensis
Tactostoma macropus
Tetragonurus cuvieri
Trachipterus altivelis
Trachipterus fukuzakii
Trichiurus nitens
Vinciguerria nimbaria

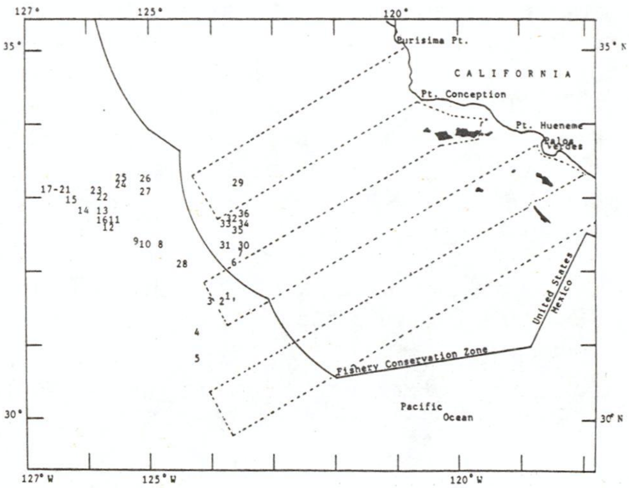

Figure 1. Location of the jack mackerel survey. Numbers indicate location and the identification number of the trawl hauls listed in Table 2. The dotted line shows the standard CalCOFI sampling pattern from line 76.7 in the north to line 93.3 in the south.

Table 2. Estimated number and catch weight of jack mackerel, chub mackerel, and Pacific sardine taken in trawls during the Soviet-U.S.A. cooperative research cruise aboard the Soviet vessel R/V *Novodrutsk* from March 23 to April 9, 1991.

Trawl	Date		Time	Trawl	Total Number and Weight per Trawl					
				Duration	Jack Mackerel		Chub Mackerel		Pacific Sardine	
#	Mo	Day	PST	(Hours)	N	Kg	N	Kg	N	Kg
1	03	23	1420	0.50	537	300	0	0	0	0
2	03	23	1902	1.50	6,250	3,500	800	400	400	60
3	03	23	2256	2.17	52,000	29,000	163	100	0	0
4	03	24	1856	1.90	0	0	0	0	0	0
5	03	24	0202	0.50	0	0	0	0	0	0
6	03	25	1921	0.65	No est	203	1	0.4	0	0
7	03	25	2200	3.25	190	180	30	15	14	2.5
8	03	26	1300	1.42	1,110	850	80	360	160	35
9	03	26	1905	3.58	7,400	5,470	5,550	2,500	140	32
10	03	27	0130	2.00	3,370	3,000	1,600	1,000	0	0
11	03	27	1920	4.50	3,500	3,000	13,900	5,500	2,150	450
12	03	28	0325	3.67	4,227	3,500	1,300	500	10	2.5
13	03	28	1816	4.68	12,684	6,000	64,606	23,000	4,000	1,000
14	03	29	0300	4.83	23,263	12,888	47,234	16,296	3,871	813
15	03	29	1815	4.83	12,667	9,500	45,450	20,000	1,904	400
16	03	30	0110	6.42	28,805	23,160	13,310	5,790	142	30
17	03	30	1842	2.05	17,500	14,000	98,862	43,500	9,524	2,000
18	03	30	2235	3.58	24,615	16,000	165,780	63,000	4,280	900
19	03	31	1900	2.00	15,380	12,000	7,100	2,700	0	0
20	03	31	2310	3.17	17,790	15,300	5,642	2,370	0	0
21	04	01	0505	3.00	0	0	0	0	0	0
22	04	01	1830	2.50	17,850	15,000	9,780	4,500	40	12
23	04	01	2350	6.00	22,500	16,380	8,874	3,452	112	28
24	04	02	1845	2.08	25,850	21,200	21,800	8,500	715	150
25	04	02	2335	3.25	0	0	0	0	0	0
26	04	03	0435	2.25	5,448	4,206	2,105	760	25	5
27	04	03	1925	5.75	5,358	3,660	3,440	2,150	10	2.5
28	04	05	1935	5.33	3,154	3,000	7,247	3,950	0	0
29	04	06	1030	2.17	1,350	1,750	350	250	0	0
30	04	06	1915	1.75	0	0	0	0	0	0
31	04	06	2345	3.50	3,604	4,440	11,631	7,560	0	0
32	04	07	1835	4.42	6,400	7,000	31,034	18,000	4	1
33	04	08	0230	3.50	7,799	6,980	5,808	3,020	0	0
34	04	08	1945	3.25	1,670	1,500	6,740	3,500	15	3
35	04	09	0215	3.08	1,461	1,210	1,312	720	0	0
36	04	09	1910	8.67	5,239	3,940	12,311	5,860	712	190
	Total			117.7 h	248,117 kg		249,253.4 kg		6116.5 kg	

Jack mackerel (up to 100 specimens) were measured and sexed from each trawl. The size of jack mackerel ranged from a 25-cm reproductively inactive female to a 62-cm active male. Most of the jack mackerel were between 39 cm and 43 cm fork length. Gonads and otoliths from 593 jack mackerel were preserved. The majority of the jack mackerel were mature: males had running milt and females had advanced yolked oocytes. Some females with hydrated oocytes were collected, indicating that spawning was occurring at that time.

The pelagic trawl used to sample jack mackerel had a vertical opening of 75-80 meters and the horizontal opening was also 75-80 meters. Thirty-three trawl hauls were made at night and only three were set during daylight hours. The ship's speed during trawling was from 4.2 to 5.5 knots. Trawling depth ranged from 50-105 meters; duration of trawling ranged from 50 minutes to 8 hours and 40 minutes. Surface water temperature ranged from 13.5°C to 14.7°C. (D. Abramenkoff, FTS 893-7126; B. Macewicz, FTS 893-7106)

SURVEY SYSTEMS DEVELOPMENT AND EVALUATION

Habitat Specific Stock Assessment Methodology for West Coast Groundfish

John Butler, Waldo Wakefield, and Pete Adams participated in a 2-week cruise (April 17-May 2) aboard the DSVSS *Laney Chouest* in Monterey Bay, California. The DSVSS *Chouest* is the support ship for the U.S. Navy Deep Submergence Vehicle (DSV) *Turtle*. The cruise is part of an ongoing project sponsored by the National Undersea Research Program (NURP) to develop habitat-specific stock assessment methodology for west coast groundfish. This project is being conducted in collaboration with Bruce Robison and Chuck Baxter from the Monterey Bay Aquarium Research Institute (MBARI), which has made available a state of the art remotely operated vehicle (ROV) and support ship, R/V *Point Lobos* for use in this project. The objective of this study is to compare trawl catches with video line transects on trawlable habitat and to extend the video surveys to untrawlable habitat. Monterey Bay is ideally suited for this study due to its proximity to both trawlable and untrawlable habitat (Figure 2).

Visual and video transects of trawlable habitat on the north canyon slope and untrawlable habitat on the south canyon wall were made with the Navy's DSV *Turtle*. These transects complement similar transects made in shallower water (200-400 m) with the MBARI ROV. Trawling was conducted on the north canyon slope at the same time by Russ Vetter on the R/V *David Starr Jordan* at sites from 100 m to 1,400 m depth. Due to technical difficulties with the submersible, we were not able to obtain complete video and visual transects for all depth strata, especially on the north canyon slope. Additional ROV and submersible transects and trawling are scheduled for this summer and fall to insure that all depth strata have been sampled. Comparative data on visual counts and NMFS trawl catches in trawlable areas are pending analyses.

Prior to this cruise, few first hand observations of steep canyon habitat existed. They observed the south canyon wall which was comprised of a mixture of rock faces and sediment covered slopes. For example, in our transect, ascending from 800 to 600 m over a distance of a kilometer, sediment coverage averaged 70 percent in an area where the slope varied from 45° to 90°. Fish fauna was dominated by thornyheads (*Sebastolobus* spp.) (Table 3). Within this area of mixed sediment and exposed rock substrate, thornyheads were only observed on the sediment-covered sea floor. Other commercially important species observed within the 800 to 600 m depth section of canyon wall were Dover sole and sablefish. A preliminary comparison with trawl catch data available for the canyon slope and video data from the canyon wall indicate fewer thornyheads and more Dover sole at the same depth on the north canyon slope than on the canyon wall (Table 3). These preliminary results indicate that

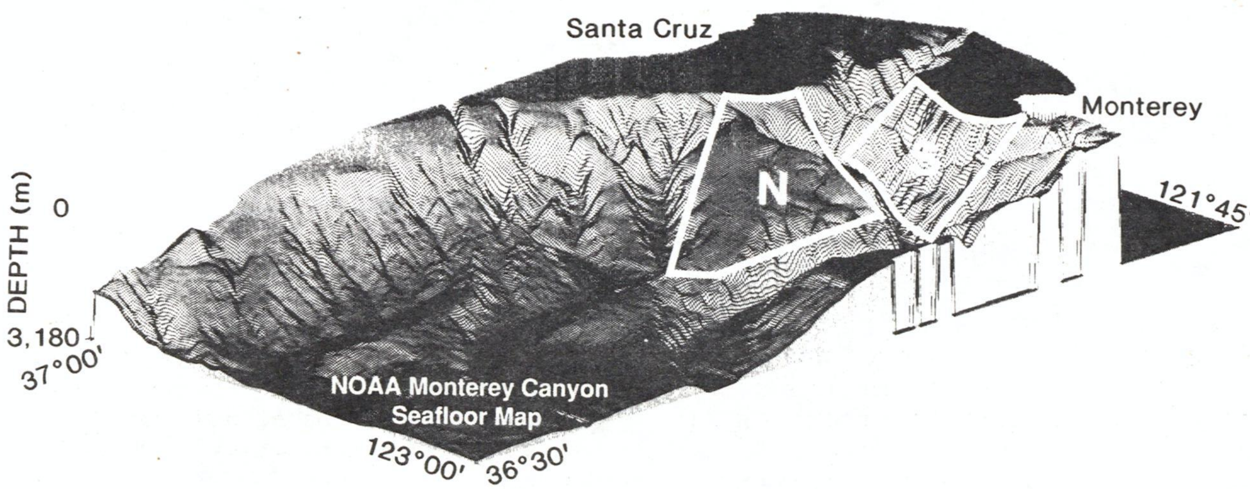

Figure 2. Bathymetric chart of study area in Monterey Bay, California, depicting sampling areas for trawlable (N) and untrawlable (S) habitat on the north and south sides of Monterey Canyon. This figure adapted from NOAA, National Ocean Service Chart "Monterey Canyon (Map Nos. N365121W and N365122W), Bathymetric Map," vertical exaggeration 6:1.

Table 3. Percent abundance of fishes along video transects on untrawlable canyon wall and from trawl catches along the trawlable north canyon slope (water depth = 600-800 m) in Monterey Bay, April 1991.

	Percent Abundance	
	Canyon wall (Video)	Canyon slope (Trawl)
Thorneyheads	86.5	40.8
Dover sole	2.4	50.8
Deep sea sole	4.8	<0.1
Sablefish	2.4	2.5
Hagfish	2.4	0.2
Zoarcid	1.5	0.6
Other	<0.1	5.1

the canyon wall habitat may be a refuge for thornyheads. (J. Butler, FTS 893-7149; W. Wakefield, FTS 893-7104; P. Adams, FTS 556-0565)

Age determination of *Sebastolobus altivilis*

Fishery Biologist John Butler and Biological Technician Kathy Dahlin have analyzed the otoliths of 224 *Sebastolobus altivilis* collected by the R/V *Miller Freeman*. The sample consisted of fish from 70 to 320 mm total length and the ages ranged from 3 to 46 years. Size at age did not differ between sexes, and data from both sexes were pooled to estimate a growth curve (Figure 3). The von Bertalanffy growth curve was fitted using nonlinear techniques. Parameters were L_∞=325.4, K=0.064, and t_0=0.00. All parameters were estimated using the simplex method and it is interesting to note that t_0 was actually zero.

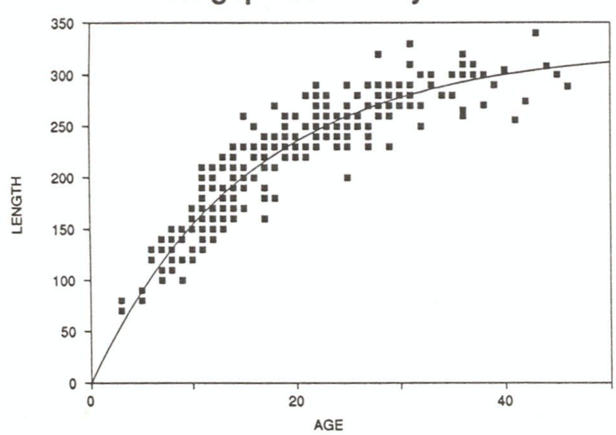

Figure 3. Relation between total length of longspine thornyhead and age determined from analysis of sectioned otoliths. The age has not been verified with an independent method.

Age of first maturity for males was 13 years and age of 50 percent maturity was 16.5 years. The age of first maturity for females was 13 years and the age of 50 percent maturity was 15 years. (J. Butler, FTS 893-7149)

COMMERCIAL AND RECREATIONAL FISHERIES RESEARCH FOR MANAGEMENT

Opportunity Costs in the Southern California Anchovy Reduction Fishery

Cindy Thomson and Larry Jacobson have completed a paper entitled "Opportunity costs and the decision to fish for northern anchovy." The paper focuses on socioeconomic reasons for the decline of the southern California reduction fishery for northern anchovy during recent years.

Thomson and Jacobson's analysis indicates that recent declines in the anchovy reduction fishery were due to low exvessel prices, opportunity costs for traditional Italian-American fishermen, and socioeconomic conditions rather than biological or regulatory factors. In the context of the analysis, opportunity cost is the minimum income required to motivate a traditional fisherman to participate in the fishery. In other words, opportunity cost is the amount of income a traditional fisherman might obtain by employment outside of the fishery or the value a fisherman places on leisure time. Opportunity cost is not an out-of-pocket expenditure but a measure of opportunities foregone in the course of making economic (including employment) decisions. The concept of opportunity cost reflects the reality that limited time and resources allow people to pursue an economic opportunity only at the "cost" of foregoing others.

Most costs incurred in fishing (fuel, insurance premiums, etc.) are tangible and readily quantified, but opportunity cost is more difficult to measure. Estimates of opportunity cost are usually based on information (or assumptions) regarding employment opportunities as well as personal preferences and attitudes. Recent conditions in the wetfish fishery have, however, provided a unique opportunity to estimate opportunity cost for traditional crew members in the anchovy fishery and to illustrate its role in their decision to fish. Opportunity cost plays an important role in the decision to fish since fishermen will participate in the fishery only when earnings from fishing exceed opportunity costs.

Crew members employed in the southern California wetfish fleet, as mentioned above, have traditionally been Italian-American. In recent years, however, young Italian-Americans have found careers outside the fishery and participation by older Italian-Americans has waned as employment of non-traditional fishermen of Hispanic descent has increased. Historical data and interviews with boat owners indicate that exvessel prices of at least \$50 mt^{-1} are required to make crew shares high enough to meet opportunity costs and motivate traditional crew members to fish for anchovy. Non-traditional crew members, in contrast, will fish for anchovy at lower exvessel prices. The anchovy fishery appears to have declined in recent years, despite the availability of nontraditional crew members, because boat owners are reluctant to fish with an exclusively nontraditional crew who tend to be less skilled and have a higher turnover rate than traditional fishermen.

Thomson and Jacobson developed a simple bioeconomic model that links earnings by crew and boat owners to anchovy biomass, exvessel prices, and the price of fuel. They use the model to predict a range of hourly earnings corresponding to an exvessel price of \$50 mt^{-1} and interpret this range as an estimate of the opportunity cost of anchovy fishing for traditional fishermen. As indicated above, the analysis suggests that the decline in the anchovy fishery has been due to exvessel prices and crew shares too low to meet the opportunity costs of traditional fishermen. (C. Thomson, FTS 893-7116; L. Jacobson, FTS 893-7117)

FISHERY-MARINE MAMMAL INTERACTIONS DIVISION

La Jolla, California

COASTAL MARINE MAMMAL PROGRAM

Completion of Spring Aerial Survey for Dolphins and Whales Along the California Coast

The Coastal Marine Mammal Program has completed the first in a series of aerial surveys of cetaceans along the California coast. The surveys have been initiated to obtain minimum abundance estimates for cetaceans which will be used in conjunction with data on incidental mortality for the 1992 assessment of the status of marine mammal populations in California. The recently established gillnet observer program has started generating information on marine mammal mortality in coastal fisheries. However, it will not be possible to judge the impact of this mortality without abundance estimates for the species which are caught. It is likely that future management of cetaceans will be based on a percentage quota applied to the minimum abundance estimate (a minimum count or the lower 95th percentile of a statistically-based population estimate). Currently, abundance estimates are available for some of the more common species, but the estimates are over 10 years old, and statistical confidence limits are only available for one species.

To obtain minimum population estimates for cetaceans along the California coast during 'winter' or 'cold water' conditions, aerial surveys were conducted between March 11 and April 9, 1991. Climatic atlases of the California coast show March/April to have, on average, the coldest sea surface temperatures. Additional ship surveys are planned for fall 1991 during 'summer' or 'warm water' conditions. Standard line transect methods were employed using the NOAA Twin Otter aircraft as a survey platform.

The survey was funded based on a proposal submitted to the NMFS Office of Protected Species in July 1990. The primary objective is to obtain minimum winter population estimates for the common cetacean species in California waters. A secondary objective is to establish a baseline for detecting changes in marine mammal abundance through time (seasonal and inter-annual). The final objective is to add to the body of information on the distribution and seasonal movement of cetaceans along the coast of California.

The study area extends beyond the continental shelf edge along the California coast, to roughly the 3000-4000 m depth isobath. It was selected to encompass all of the known driftnet fishing areas, based on effort data for California Department of Fish and Game (CDF&G) statistical blocks. The transects are laid out in two overlapping grids which cover the study area approximately uniformly (Figure 1). To assure at least coarse coverage of all areas, an attempt was made to complete the first grid before surveying the second. Due to unusually stormy weather in March and April, it was only possible to complete approximately 95% of the first grid and 25% of the second.

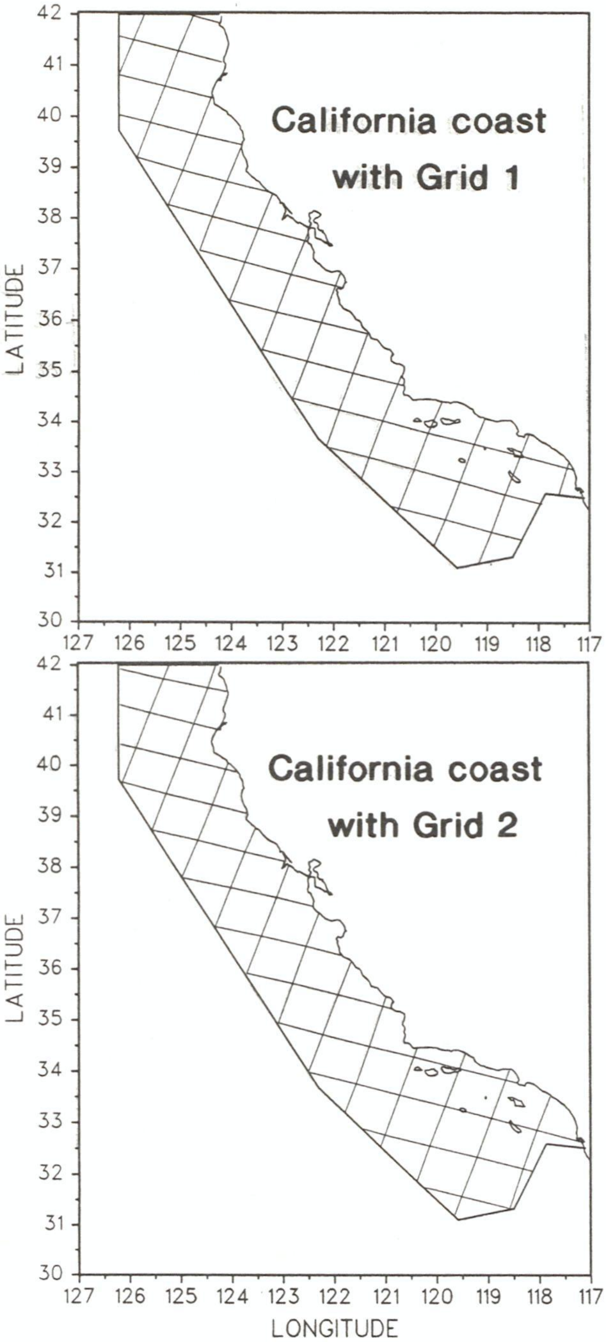

Figure 1. Proposed transect lines for aerial surveys of cetaceans in California. Grid 1 (Figure A) was considered highest priority. Grid 2 (Figure B) was of secondary priority, and surveys were begun on this grid after Grid 1 was essentially complete.

The following cetaceans were sighted during the surveys: common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), northern right whale dolphin (*Lissodelphis borealis*), Risso's dolphin (*Grampus griseus*), Dall's porpoise (*Phocoenoides dalli*), harbor porpoise (*Phocoena phocoena*), killer whale (*Orcinus orca*), Cuvier's beaked whale (*Ziphius cavirostris*), mesoplodont beaked whales (*Mesoplodon* sp.), minke whale (*Balaenoptera acutorostrata*), humpback whale (*Megaptera novaeangliae*), gray whale (*Eschrichtius robustus*), and sperm whale (*Physeter macrocephalus*).

Pinniped sightings were recorded at distances greater than 10 km from the coast; identified species include California sea lion (*Zalophus californianus*), harbor seal (*Phoca vitulina*), elephant seal (*Mirounga gustirostris*), and northern fur seal (*Callorhinus ursinus*). Sea otters (*Enhydra lutris*) and leatherback turtles (*Dermochelys oriacea*) were also sighted on a few occasions.

Aerial photographs of cetacean schools were taken with a medium-large format camera when weather conditions allowed. These photographs will be used to assist in species/stock identification and to obtain photogrammetric data. Analysis of the sighting data will enable us to generate minimum winter abundance estimates for most of the small cetaceans and for beaked whales as a group. Confidence limits on the mean abundance estimates are likely to be high with data only from a single survey, and future surveys are planned to improve our estimates. (K. Forney, FTS 893-7171; J. Barlow, FTS 893-7178)

Harbor Porpoise Radio Tagging

On the morning of April 5, the first stranded harbor porpoise was returned to the wild after having been rehabilitated (nursed back to health) in captivity. Not only was this recovery-release a first, but the porpoise was also fitted with a radio tag prior to release, making this the first opportunity to radio-track harbor porpoise on the U.S. West Coast.

Last fall, a young female harbor porpoise became stranded near Santa Cruz, California. This porpoise (dubbed "DC") was approximately 3 months old at that time and appeared severely emaciated. She was cared for by UC Santa Cruz personnel until being transferred to the animal care facility at Marine World Africa U.S.A. in Vallejo, California. Under the care of the California Marine Mammal Center and with the help of Marine World vet Lourie Gage, the porpoise's condition improved and was soon actively swimming around her tank. By winter it was decided that she was healthy enough to be released back into the wild. The survival rate of stranded cetaceans is typically very low. This was the first harbor porpoise to have survived long enough to be released.

Marc Webber of the California Marine Mammal Center (formerly of the SWFSC) contacted Jay Barlow (SWFSC) about the possibility of attaching a radio tag to "DC" before her release in order to keep track of her movements. This proved to be an outstanding opportunity to learn about the feasibility of tracking a harbor porpoise in California waters. First, the tag attachment was designed around a miniature (15 g) radio transmitter made by Advanced Telemetry Systems. To reduce drag, Barlow designed the tag so that the radio was attached behind the dorsal fin, out of the current flow. Next, the tag was tested in a controlled situation when the porpoise was still in captivity. After 3 days, no evidence was seen of the tag affecting the behavior of the porpoise or causing damage to the dorsal fin.

Finally came the time for the release. The porpoise was flown by helicopter from Vallejo to Moss Landing, California. Chuck Haugen, of the California Department of Fish and Game (CDF&G), piloted the release vessel, a 23' Boston whaler. The porpoise was transported by boat from Moss Landing harbor to a point 2 miles offshore of Sunset State Beach. This area of Monterey Bay is known as being prime harbor porpoise habitat. Several harbor porpoise were seen in the immediate vicinity. "DC" was released and swam off strongly.

Dr. Jim Harvey and Tom Kekeffer, Moss Landing Marine Laboratory, were present in another boat and were able to track the porpoise using radio receiver equipment. Jay Barlow and some of Jim Harvey's students tracked the porpoise from shore using a second set of radio receivers. Harvey's students continued the tracking around the clock for the next 3 days. Doyle Hanan (CDF&G) conducted an aerial tracking experiment and was easily able to find the porpoise.

Unfortunately, 3 days after her release, "DC" was seen floundering in the surf. Howard Reinhart, UC Santa Cruz, was able to guide her towards the beach and recapture her by hand. "DC" was transported back to the dolphin tanks at the Long Marine Laboratory where her health was evaluated. She had apparently lost 8 pounds in her 3-day adventure in the wild and had eaten a few kelp cysts and other floating debris. She had not been successful at feeding in the wild. Attempts are being made now to find a permanent home for "DC" in captivity.

Despite the failure of the rehabilitation and release, much was learned from the attempt. If this is to be tried again, considerable effort will have to be put into training the porpoise to capture live food in a natural setting ("DC" had shown some ability to capture fish before release, but did not learn to depend on this for survival). Much was also learned from the radio tracking. Harbor porpoise can be tracked by land, sea, and air. The practical range was about 1 mile by boat and about 2 miles from coastal cliffs or aircraft. Continuous tracking from shore was not practical in this area because porpoise commonly travel more than 2 miles from the coast. It was relatively easy, however, to relocate the porpoise after its signal had been lost.

Additional attempts are planned to radio-tag wild harbor porpoise in order to gather information on diurnal and seasonal movement patterns. Having now settled many of the questions about the logistics of tracking, the primary remaining obstacle is capture methodology. Two summers ago a team of SWFSC and CDF&G researchers attempted to capture harbor porpoise using an anchovy purse seine in Monterey Bay. That vessel proved to be too slow and difficult to maneuver. Additional work is planned on methods to safely live-capture harbor porpoise in open waters for tag-release experiments. (J. Barlow, FTS 893-7178)

DOLPHIN ECOLOGY PROGRAM

Seasonal Variability of Eastern Tropical Pacific Surface Waters

As fisheries scientists well know, changes caused by environmental variability must be taken into account when monitoring the effects of man on natural systems (e.g. fishing mortality or incidental kill). Studies of the distribution and variability of dolphin stocks affected by the tuna purse seine fishery in the eastern tropical Pacific Ocean (Monitoring of Porpoise Stocks, MOPS) have needed a comprehensive review of the climatological distributions and variability of physical oceanographic variables in the surface waters of the ETP. This region is subject to great variability caused by the El Niño-Southern Oscillation (ENSO), with profound biological consequences. However, oceanic tropical marine ecosystems have been characterized as exhibiting little or no seasonal variation, probably due to the paucity of observations.

Oceanographer Paul Fiedler has recently completed an analysis of seasonal variability in historical hydrocast, bathythermograph, CTD, ship drift, and wind stress data obtained from NODC and other sources. Annual and seasonal climatologies, and seasonal deviations from the annual climatology, of surface temperature, surface salinity, thermocline (20°C isotherm) depth, thermocline strength, surface dynamic height (0/500 db), surface current velocity, surface current divergence, surface wind velocity, surface wind stress, surface wind divergence, and Ekman pumping velocity were mapped and will be published in a NOAA Technical Report NMFS.

An analysis of surface temperature, thermocline depth, and surface wind stress data quantified seasonal and interannual variability. Seasonal and interannual variability of surface temperature and thermocline depth were estimated after averaging each variable in bins of 2 degrees latitude x 5 degrees longitude and 2-month intervals from 1960 through 1987. Seasonal and interannual standard deviations were calculated as the standard deviations of bimonthly binned values after subtracting the yearly or bimonthly means for the bins. Seasonal and interannual standard deviations of wind stress were calculated from the 1961-1989 monthly 2 x 2-degree grids averaged in bimonths. Standard deviations of the x- and y-components were calculated separately and summed, so that they represent variability of both the magnitude and direction of wind stress.

The results show that the magnitude of seasonal variability is comparable to interannual variability, within a factor of two or less, but that there is considerable spatial variation between water masses in the ETP. Surface temperature variability is very low (<1°C) in tropical surface water (3-17°N) and southern subtropical surface water (south of 10°S), both seasonally and interannually (Figure 2). Seasonal and interannual variability are high (1-2.5°C) in equatorial surface water (10°S-3°N) and the Peru Current, and off Baja California. High seasonal variability also occurs in northern subtropical surface water north of Hawaii. Interannual variability exceeds seasonal variability in tropical surface water and in equatorial surface water west of 120°W, where variability on both time scales is low and mean surface temperature is high. Seasonal variability exceeds interannual variability both in coastal Peru and California Current water and in subtropical surface waters.

Thermocline depth variability is greatest, both seasonally and interannually, in subtropical surface water north of 20°N (Figure 3). Interannual variability is low in tropical surface water and higher in equatorial surface water. Seasonal variability is low in a band along 17°N. There are three zonal bands in seasonal variability to the

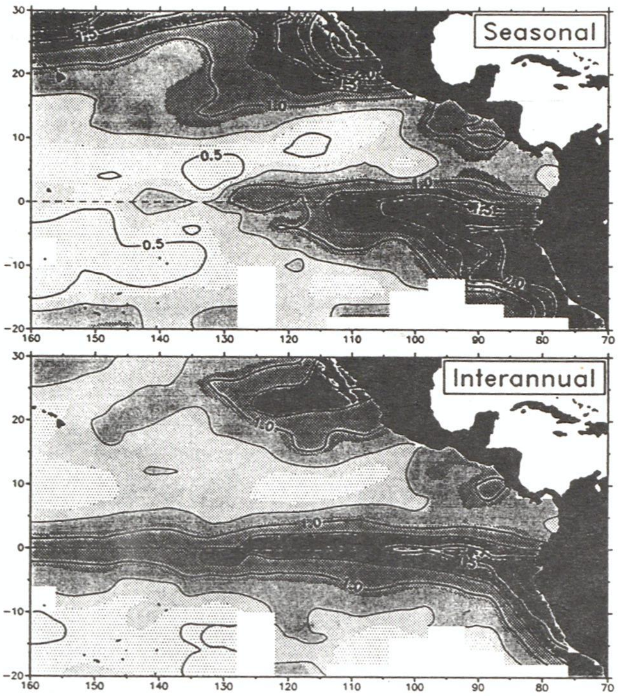

Figure 2. Surface temperature variability (standard deviation, °C) between bimonths (seasonal) and between years (interannual).

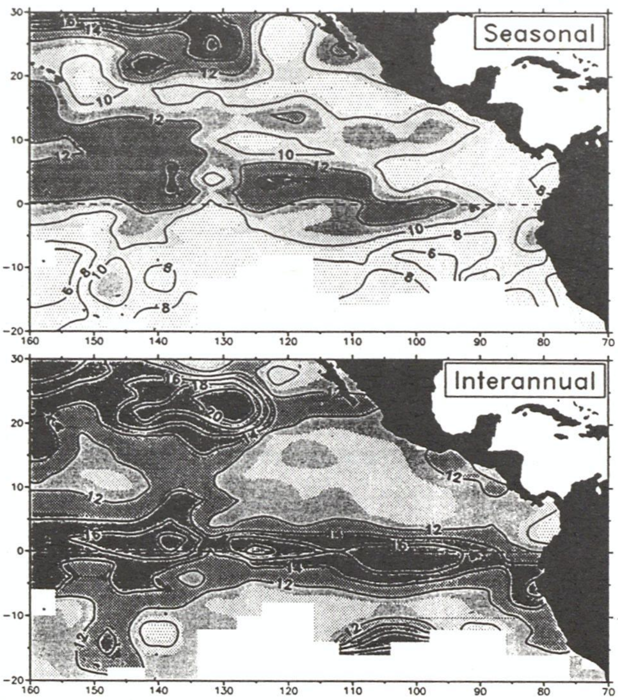

Figure 3. Thermocline depth variability (standard deviation, m) between bimonths (seasonal) and between years (interannual).

south of this band, most obvious to the east of 130°W: a local maximum along 12°N, a minimum along 8°N, and a maximum along 4°N. This pattern reflects the seasonal variation in the slope of the thermocline beneath the North Equatorial Countercurrent.

Wind stress variability tends to increase from east to west (Figure 4), as does mean wind stress. Seasonal variability is very high along 10°N west of 110°W, due to seasonal movement of the intertropical convergence zone. Seasonal variability is also relatively high between the equator and 10°N, east of 100°W. Seasonal and interannual variability of wind stress along the equator is low compared to variability at tropical and subtropical latitudes. This suggests that the relatively high variability of surface temperature and thermocline depth along the equator is not forced by local winds.

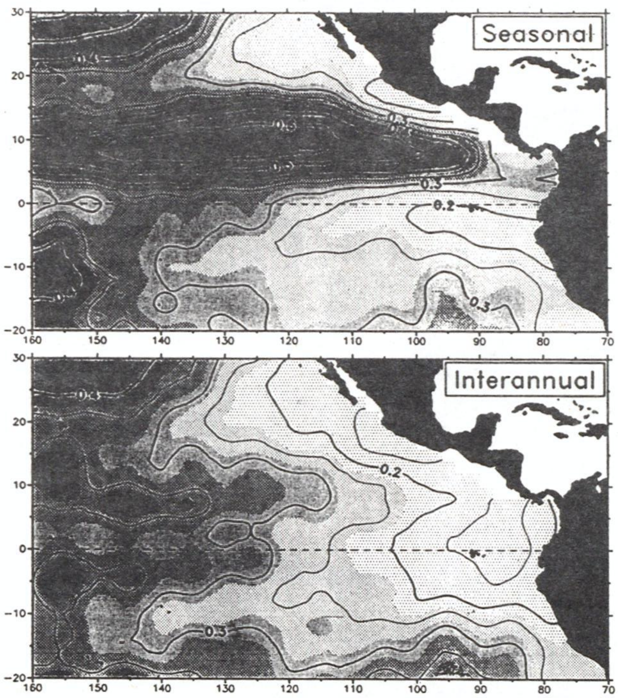

Figure 4. Wind stress variability (standard deviation, dynes cm^{-2}) between bimonths (seasonal) and between years (interannual).

The seasonal/interannual variability comparisons were presented as a poster at the Second Scientific Meeting of The Oceanography Society, March 24-28, in St. Petersburg, Florida. These results will be used in habitat analyses of dolphin stocks, which have shown that habitats are loosely related to surface water masses. Differences in variability within habitats corresponding to Tropical and Equatorial Surface Water may have implications for stocks facing variability caused by natural or anthropogenic climate change. (P. Fiedler, FTS 893-7016)

DOLPHIN STOCK ASSESSMENT PROGRAM

New Analysis of 5 Years of ETP Dolphin Data

In 1990, the SWFSC completed the fifth of an annual series of large-scale Monitoring of Porpoise Stocks (MOPS) surveys in the eastern tropical Pacific (ETP). Tim Gerrodette and Paul Wade have analyzed the 1990 data using line-transect analysis under the stratified survey design originally set up by Rennie Holt. Because the analysis of the 1990 data differs from previous approaches, data from 1986-89 were also reanalyzed using the same methods. Results have been submitted as a paper to the 1991 meeting of the International Whaling Commission in Iceland.

In the past, management of the tuna-dolphin problem was based on detecting possible reductions in ETP dolphin population sizes over time due to the tuna purse-seine fishery, and for this purpose relative estimates of population size were sufficient. The previous analyses of MOPS data were designed with this in mind, and attempted to produce estimates of relative abundance with minimum variance. However, it seems likely that some system of quotas on incidental dolphin mortality will be instituted on an international basis in the near future. Because of this, there will be a need for absolute estimates of population size. The new approach being taken by Gerrodette and Wade will ultimately lead to such estimates, although a considerable amount of further work remains to be done. Until that work is complete, the annual estimate for each stock of dolphins is still reported as a relative index.

Figures 5-8 show estimates of relative abundance for nine stocks of four ETP dolphin species that are impacted by the tuna purse-seine fishery. These are provisional estimates subject to change with further analysis. The estimates of relative abundance shown in Figures 5-8 are highly variable, and it is difficult to discern any common pattern. No overall declining trend was detected during the 5-year study period, as might be expected if mortality due to the tuna purse-seine fishery in the ETP were

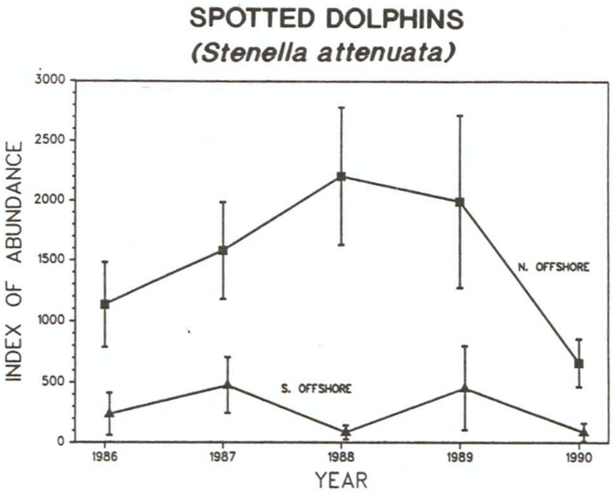

Figure 5. Relative estimates of abundance for two stocks of spotted dolphins (*Stenella attenuata*) in the eastern tropical Pacific, 1986-90. Error bars are one standard error.

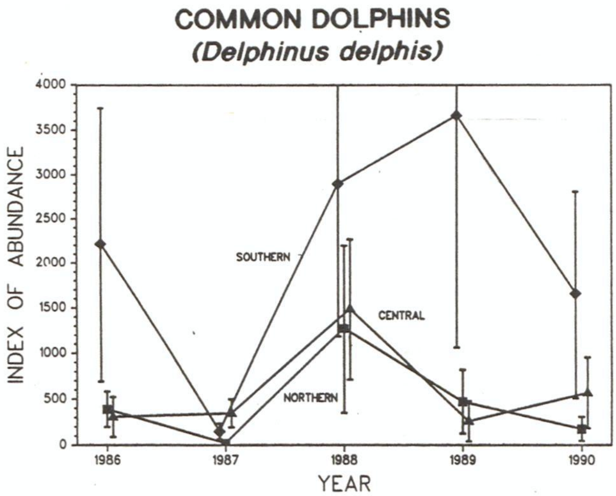

Figure 7. Relative estimates of abundance for three stocks of common dolphins (*Delphinus delphis*) in the eastern tropical Pacific, 1986-90. Error bars are one standard error.

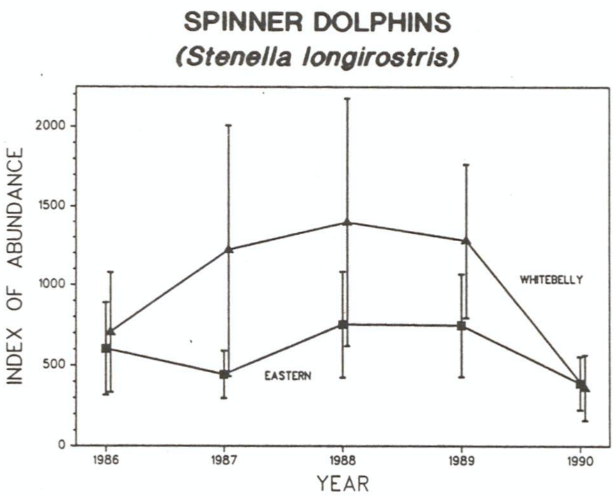

Figure 6. Relative estimates of abundance for two stocks of spinner dolphins (*Stenella longirostris*) in the eastern tropical Pacific, 1986-90. Error bars are one standard error.

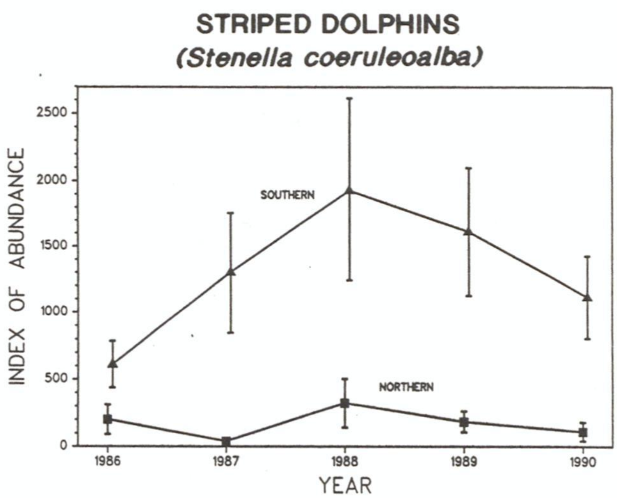

Figure 8. Relative estimates of abundance for two stocks of striped dolphins (*Stenella coeruleoalba*) in the eastern tropical Pacific, 1986-90. Error bars are one standard error.

having a strong impact on the populations. However, the data also do not warrant a final conclusion that no impact is occurring, because the statistical power of detecting even a large decline during a 5-year period given the observed variability of the estimates is low. Thus, data collected to date neither confirm nor deny a negative impact of the tuna purse-seine fishery on these dolphin populations. Monitoring of ETP dolphin populations will continue on a less frequent basis, and additional future surveys will increase the power to detect trends in dolphin population size. (T. Gerrodette, FTS 893-7131)

BIOLOGY ASSESSMENT PROGRAM

Aerial Photographs Provide Data for Stock Identifications

Lengths of dolphins from aerial photographs taken during the first 4 years of the MOPS cruises are providing data for stock identifications and a fishery-independent source of life history data other than that drawn from animals killed in purse seines. Samples of schools of common dolphins (*Delphinus delphus*) from areas of three geographi-

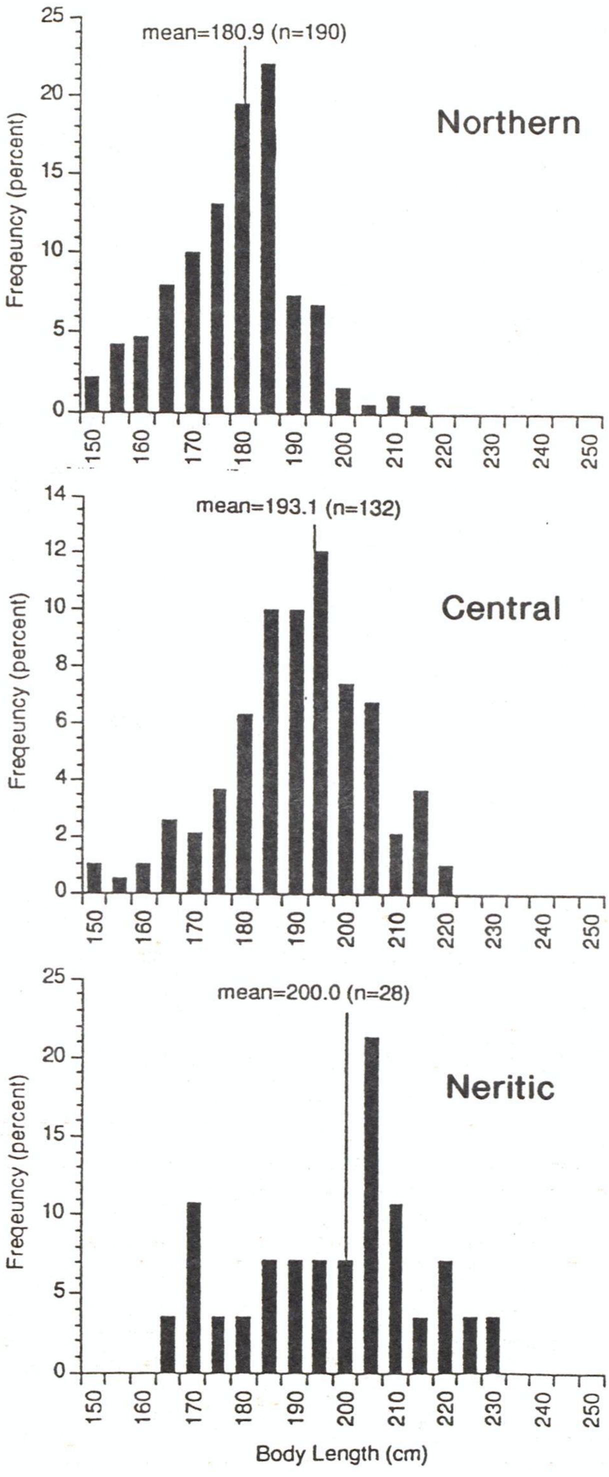

Figure 9. Percent frequency of lengths of common dolphins derived from aerial photographs for two geographically defined stocks (northern and central) and for the neritic stock which overlaps geographically with the northern stock.

cally delineated stocks were measured on analytical plotters at NOAA's Photogrammetry Center in Rockville, Maryland. The length samples showed clear differences in adult length (Figure 9) and further work is underway to detect other possible indications of stock discreetness.

In addition, a sample of cow-calf pairs of eastern spinner dolphins (*Stenella longirostris*) located within 100 nm of the coast of Mexico were measured on the same analytical hardware for comparison with published life history data. If we can assume that animals swimming closely alongside calves (animals less that 132 cm) are adult females, then the length distribution for these females can be compared with the maturity data in the life history data base. From our sample of 79 cows (Figure 10), we

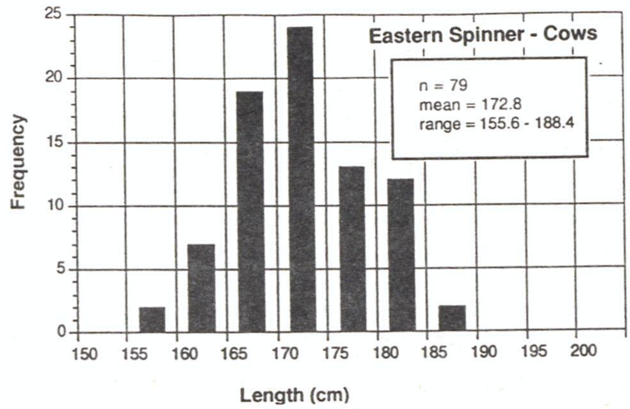

Figure 10. Length frequency distribution for adult female spinner dolphins (animals paired with calves) measured from aerial photographs.

presumed that females with calves ranged from 155 to 188 cm, with an average of 173 cm. This compares closely with Perrin et al. (1985) whose published figures for a sample of 697 mature females ranged from 152 to 193 cm with a mean of 171 cm. For the aerial photographic sample of 56 measurable animals less that 132 cm (Figure 11), (length of eastern spinner calves at one year), we back-projected the birth date of each calf using the technique published by Barlow (1984). The resulting distribution of projected birthdates showed a single broad peak in reproduction in the late spring and early summer. A similar peak was found when Barlow's (1984)life history samples were used. Further work is underway to compare kill-based information with remotely sensed data to see if the biases suspected in the life history data can be detected.

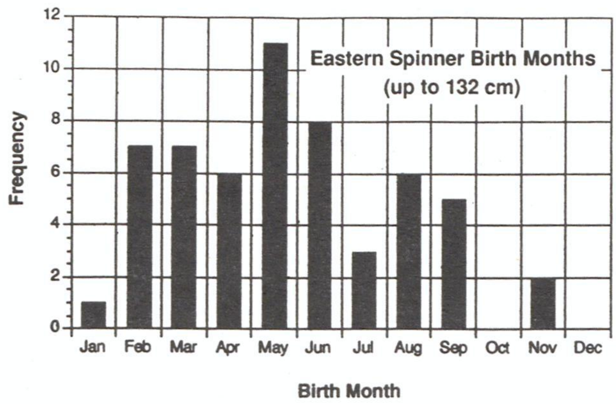

Figure 11. Distribution of back-calculated birth dates for spinner calves measured on aerial photographs.

(W. Perryman, FTS 893-7014).

HONOLULU LABORATORY

Honolulu, Hawaii

MARINE MAMMALS AND ENDANGERED SPECIES PROGRAM

Research Plan Completed for Marine Turtle Fibropapilloma Disease Problem

"Research plan for marine turtle fibropapilloma" (NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-156), edited by George H. Balazs and Samuel G. Pooley, was published in March 1991. The objective of this research plan is to identify a sequence of activities to determine the cause of fibropapilloma and ultimately to develop solutions and effective strategies for containment of the disease. Fibropapilloma is a disease in which lobulated tumors develop on a marine turtle's skin, scales, scutes, eyes and surrounding tissues, oral cavities, and viscera (Figure 1). In the past few years, this disease has increased to epidemic proportions in populations of green turtles, *Chelonia mydas*, in areas as far apart as Florida and Hawaii. The disease represents a significant threat to the survival of this protected marine turtle species and is cited as the top priority research issue in the draft Hawaiian Sea Turtle Recovery Plan.

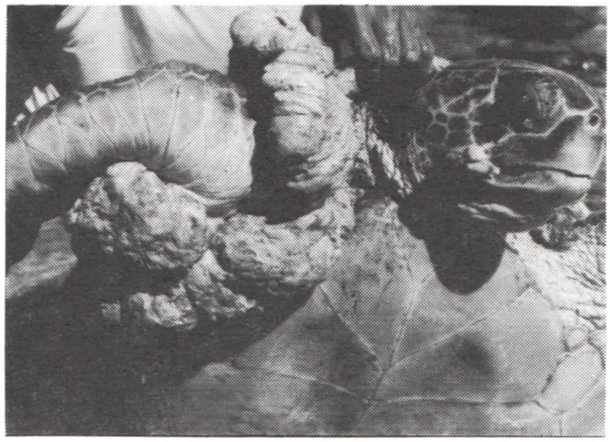

Figure 1. A Hawaiian green turtle afflicted with fibropapilloma.

The research plan was developed during the Marine Turtle Fibropapilloma Disease Workshop that was held in December 1990, and sponsored by the Honolulu Laboratory. Scientists from across the country met to discuss their research and to propose activities that could identify a solution to the disease. Using an interactive planning methodology, the workshop was a first step in developing a comprehensive research strategy on marine turtle fibropapilloma. No formal organization of the researchers studying this disease exists, but individual researchers and their agencies are using the research plan as a framework for research coordination. The research plan recommends a 5-year schedule of activities. with an estimated cost of $2.7 million ($510,000 in the first year). Implementing any resulting solutions to contain or prevent the disease would require additional funding.

The most promising avenues of investigation are the isolation and identification of either a virus or parasite in association with the disease. Most of the research to date has been on incriminating a virus by using some of the latest technology in attempting to identify the etiologic agent. Additional research has occurred on the impact of trematode parasites. Some other possible causes are pollutants, changes in natural environments or habitats, and weakened immune systems. A full epidemiological investigation of the disease also is required. However, work on studying the transmission mechanisms is extremely difficult because so little is known of the complete life cycle of marine turtles and because experimental work on threatened and endangered species has been extremely limited.

Intermediate disease management programs may be initiated before the exact causal mechanism is discovered: rehabilitation of afflicted turtles through removal of tumors, vaccination of turtles, treatment of turtles with anthelmintics, or removal of afflicted turtles from their populations. Treatment of wild populations is presently difficult, but progress on practical inoculation schemes is under way.

The research plan identifies the research activities and funding requirements necessary to make substantial progress toward finding the cause of this disease. However, sources of funding are not identified in the research plan, and efforts must begin immediately to develop the required funding sources. (G. Balazs (808) 943-1240)

FISHERY MANAGEMENT RESEARCH PROGRAM

Pelagic Fisheries Information Compiled for Fishery Management Council

Industry Economist Samuel G. Pooley and Operations Research Analyst Stacey S. Yoshimoto recently completed a preliminary compilation of the Fishery Management Research Program's 1990 market monitoring data results for Hawaii pelagic fishery catch and effort. Pooley and Yoshimoto considered monthly catch-per-trip data and their relationship with longline landings for 1987-90. This compilation is designed to identify trends in catch-per-trip by troll and handline vessels in Hawaii. The results will be used by the Western Pacific Regional Fishery Management Council (WPRFMC) in preparing amendments to the Pelagic Fishery Management Plan.

Pooley and Yoshimoto found a strong correlation between results from their sample of Oahu-based trollers and handliners and earlier work by Fishery Biologist Christofer H. Boggs, who used the State of Hawaii's data on commercial landings by trollers.

Pooley also revised an earlier market analysis of Hawaii yellowfin tuna for the WPRFMC concerning the relationship between longline landings and the prices of yellowfin tuna, *Thunnus albacares*. Pooley found no long-term trend in average monthly yellowfin tuna prices in 1987-90 for longliners or for trollers and handliners based in Oahu or the other main Hawaiian Islands (MHI). A strong seasonal signal was identified based on the peak market season (December-April). (S. Pooley (808) 943-1216)

Observers Continue Trips to the Northwestern Hawaiian Islands

Five observer trips were conducted in February-April 1991 aboard commercial longline and bottomfish vessels planning to operate in the Northwestern Hawaiian Islands (NWHI). Observers included Robert A. Dollar and Ingo Fleming of the Honolulu Laboratory's Fishery Management Research Program, and Wes Armstrong and Bill Irwin of the La Jolla Laboratory. Data from these trips are being compiled for reports on marine mammal interactions and fishing operations of the two fleets.

The observations are being conducted to obtain information on potential interactions between fishing vessels and endangered species, such as the Hawaiian monk seal, *Monachus schauinslandi*. The WPRFMC's recommendation to close the 50-mile area around most of the NWHI will mean an end (approximately April 15) to the longline part of the observer program, but observers will still be required for bottomfish boats operating in the NWHI. These observers will now be fielded by the NMFS Pacific Area Office. (S. Pooley (808) 943-1216)

Lobster Fishery Statistics Compiled for 1990

Biological Technician Kevin C. Landgraf recently compiled data for the NWHI lobster fishery for 1990. Fourteen vessels fished during the year, making a total of 45 trips. Trip activity was 36% higher than in 1989. Total fishing effort for 1990 was 1.18 million trap-hauls, up 10% from 1989. Total catch was 590,700 legal spiny lobster, *Panulirus marginatus*, and 183,700 legal slipper lobster, *Scyllarides squammosus*. Legal catch (number of legal-sized lobsters) per-unit-effort (trap-hauls) declined for spiny (0.50) and slipper lobsters (0.16) in 1990, compared to 1989. Slipper lobster continued to be caught only incidentally in 1990. Gardner Pinnacles was the area of highest fishing intensity and catch during the year. Market demand for spiny lobster remained high, with the ex-vessel price for 4- to 6-ounce frozen tails averaging $15 per pound in 1990. A more complete assessment of the fishery will be contained in the annual report due to be available in April 1991. (S. Pooley (808) 943-1216)

Hawaii's Total Commercial Landings Are Estimated for 1990

The Fishery Management Research Program is responsible for monitoring Hawaii's commercial fishery through a variety of logbook and shoreside monitoring programs (Table 1).

Table 1. Preliminary estimates of total commercial landings in Hawaii for 1990.

Fishery	Millions of pounds landed (round weight)	Value (in millions US$)
Longline	13.1	28.8
NWHI bottomfish	0.4	1.1
MHI bottomfish	0.8	3.3
MHI pelagic fish	4.5	7.0
Aku	1.0	1.8
NWHI lobster	0.9	4.9
Other	1.7	3.5
Total	22.5	50.4

NWHI = Northwestern Hawaiian Islands.

MHI = Main Hawaiian Islands.

MHI pelagic fish = billfish, sharks, mahimahi, ono (wahoo), and tuna landings by troll and handline vessels.

Aku = pole-and-line skipjack tuna fleet.

These figures are preliminary since additional data sources are being polled from a number of new market locations. Total landings in 1990 were the same as in 1989, although revenue was up 2% (less than the rate of inflation). The tremendous growth in the longline fleet over the past 3 years has led to rapidly increased landings, with 1990 having increased over 1989 by 35%. Landings of MHI pelagic species fell marginally (7%). Both fisheries had increased landings of yellowfin tuna. The aku boat fleet had a particularly bad year, with landings down 65%. The MHI bottomfish fishery also had a substantial decline (down 30%). The Honolulu Laboratory's Insular and Pelagic Resources Investigation programs will be evaluating these trends, and the analyses will be considered by the WPRFMC Plan Monitoring Teams.

Estimates of 1989 landings were revised upward slightly, with total landings increased to 22.5 million pounds ($47.2 million). The revision was based on a new estimation procedure which incorporated annual information from neighbor island locations directly into the estimation procedure for landings of pelagic species in the MHI. (S. Pooley (808) 943-1216)

ECOLOGICAL PHYSIOLOGY PROGRAM

Manuscript Completed on Responses of Tunas to Low Ambient Oxygen

A manuscript entitled "Cardiovascular responses of skipjack tuna (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*) to acute hypoxia," by Peter G. Bushnell (currently a postdoctoral fellow in the Department of Zoology, University of British Columbia, and formerly a graduate student in the Physiology Department, John A. Burns School of Medicine, University of Hawaii) and Richard W. Brill (fishery biologist, Honolulu Laboratory), has been completed and submitted to the Journal of Comparative Physiology. This is the third in the series of papers resulting from a multi-year study designed to determine tuna reactions and tolerances to low ambient oxygen. The overall objective of the work is to allow prediction of movements, distributions, and gear vulnerability of tunas as they relate to specific oceanographic conditions.

Responses to acute reductions in ambient oxygen (i.e., hypoxia) were measured in (≈1-3 kg body weight) skipjack tuna and yellowfin tuna. Fish, prevented from swimming by a spinal injection of lydocaine, were placed in front of a seawater delivery pipe and could thus set their own ventilation volumes. Heart rate, dorsal and ventral aortic blood pressures, and cardiac output were continuously monitored. Water and blood samples were taken and oxygen levels determined in fluids afferent and efferent to the gills. From these data, various measures of the effectiveness of oxygen transfer, as well as branchial and systemic vascular resistance, were determined during normoxia (i.e., fully oxygen-saturated seawater, inhalant water pO_2 >150 mm Hg) and three levels of hypoxia (inhalant water $pO_2 \approx$ 130, 90, and 50 mm Hg).

Despite high ventilation volumes (4-6 $L \cdot min^{-1} \cdot kg^{-1}$), tunas were able to extract approximately 50% of the oxygen from the inhalant water, partly because high cardiac outputs (115-132 $mL \cdot min^{-1} \cdot kg^{-1}$) result in ventilation-perfusion conductance ratios (0.75-1.1) close to the theoretically ideal value of 1.0. Tunas, therefore, have oxygen transfer factors ($mL\ O_2 \cdot min^{-1} \cdot mm\ Hg^{-1} \cdot kg^{-1}$) that are 10-50 times greater than those of other fishes. The efficacy of oxygen transfer from water was found to be high (≈65%) in tunas and to match that measured in teleosts with ventilation volumes an order of magnitude lower.

The high oxygen transfer factors of tunas are made possible partly by large gill surface areas. Large gill surface areas, however, appear to carry a considerable osmoregulatory cost, as the metabolic rate of gills accounts for up to 70% of the total metabolism in these spinally blocked (i.e., non-swimming) fish. High rates of gill oxygen consumption, in turn, seem to reduce the efficiency of oxygen transfer to the blood, which is relatively low in tunas (≈75%) compared with rainbow trout, *Oncorhynchus mykiss* (91%).

In response to hypoxia, skipjack and yellowfin tunas made a variety of cardiorespiratory adjustments apparently aimed at maintaining oxygen consumption. Most of the responses were similar to those previously reported in other fishes. However, hypoxic bradycardia was not accompanied by equivalent increases in stroke volume, and cardiac output fell as heart rate decreased. In both tuna species, oxygen consumption eventually was maintained by drawing on substantial venous oxygen reserves. This occurred at a higher pO_2 (90 mm Hg) in skipjack tuna than in yellowfin tuna. The need to draw on venous oxygen reserves would make it difficult to meet the oxygen demand of increasing swimming speed, which is a common response to hypoxia in both species. Because yellowfin tuna can maintain oxygen consumption at a seawater pO_2 of 90 mm Hg without drawing on venous oxygen reserves, it was concluded that they could probably survive indefinitely at this level of hypoxia. (R. Brill (808) 943-1234)

Manuscript Completed on Etiology of Burnt Tuna

Another recently completed manuscript "Anatomical and biochemical definitions of burnt tuna: evidence of calpain proteolysis," was coauthored by Cheryl L. Watson (currently a postdoctoral fellow, Brown University, and formerly a graduate student, John A. Burns School of Medicine, University of Hawaii), Henry A. Morrow (John A. Burns School of Medicine, University of Hawaii), and Richard W. Brill (fishery biologist, Honolulu Laboratory).

The white muscle of yellowfin tuna, bigeye tuna (*T. obesus*), and southern bluefin tuna (*T. maccoyii*), is subject to a form of deterioration known commercially as "burnt tuna." Previous investigators have theorized that burnt tuna is either due to generalized proteolysis caused by lactic acidosis and high muscle temperatures, or to a more specific proteolysis caused by a calcium-activated neutral proteinase (calpain). The study by Watson, Morrow, and Brill uses transmission electron microscopy (TEM) and sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) to quantify cellular differences between the white muscle of burnt and unburnt tuna and to determine whether the observed differences are consistent with generalized myofibrillar deterioration or the specific destruction of non-contractile myofibrillar proteins known to be caused by calpain.

Electron micrographs indicated a significant loss of Z-disc integrity and an increase in intracellular edema in burnt tuna; electrophoresis established that a specific doublet of proteins (molecular weights, 42 and 46 kD) was lost. Both methodologies show that burnt tuna is a specific and limited proteolysis of myofibrillar structural proteins characteristic of calpain proteolysis. Proteolysis in isolated myofibrils incubated in calpain was greatest at pH 7.5 and was selective for intermediate molecular weight proteins.

These data strongly suggest that burnt tuna is a calpain-mediated proteolysis that progresses fastest when the muscle is at physiologic pH. The paper hypothesized that tuna with minimal white muscle glycogen reserves are likely to be more susceptible to the problem. (R. Brill (808) 943-1234)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

Study on Condition Factors of Pelagic Fishes Completed

It is presently popular to attribute the variability in the size of fish stocks to conditions affecting the early life history stages (i.e. the recruitment process); however, processes affecting the population rates of the adults (particularly those associated with fecundity, or natural mortality) have not been excluded as candidates for causality at the inter-year time scale and they are prime candidates at the inter-decadal time scale. Presently, long-term information on the variability of the natural mortality rates or fecundity of California's major pelagic fishes is not available.

Fishery Biologist Richard Parrish has recently completed an analysis of the condition factors of mackerel, jack mackerel, and northern anchovy.

Condition factor (i.e. the relative weight of a fish in relation to its length) is one of the few biological indicators for which extensive time series are available to assess long-term variations in the adult component of fish stocks. Variation in the condition factor of fishes is primarily the result of an interplay between food availability, the physiology of the fish, and physical environmental conditions. Food availability is expected to be dependent upon the geographical location of the habitat, environmental conditions and consumption (which is related to population density). The physiology of individual fish is expected to be influenced by their age, sex, and reproductive state as well as by environmental conditions. Thus time series of condition factors are an indicator of the physiological state or 'health' of a fish stock; however, condition factors do not, by themselves, indicate why the 'health' of the stock is changing. The analyses carried out were intended to identify environmental factors associated with the variation in condition factors of the three species.

Four time series of condition factors were utilized in the study. The data for three of these (mackerel, jack mackerel, and northern anchovy landed at San Pedro) were supplied by the California Department of Fish and Game and data for the fourth (northern anchovy landed at Ensenada) was supplied by J. T. Barnes of LMR Fisheries Research, Inc., San Diego. The data bases utilized cover the period of 1966-88 and are quite extensive (44,021 mackerel, 57,242 jack mackerel, 68,304 anchovy at San Pedro, and 152,234 anchovy at Ensenada).

The models used to calculate monthly condition factors for the three San Pedro time series included correction factors for frozen fish, month of capture, and age and separate length-weight equations for males, females, and immature fish. Condition factors for anchovy sampled in Ensenada were calculated using modal lengths from monthly length frequencies and monthly length-weight equations.

The condition factor time series for mackerel and jack mackerel show considerable fluctuation at the decadal time scale and are significantly correlated ($r=0.469$, $df=191$, $p<0.001$); annual condition factors of mackerel and jack mackerel are also significantly correlated ($r=0.668$, $df=21$, $p=0.001$). Both time series have high condition factors during the late 1960s and early 1970s, a sharp transition to low condition factors in the mid 1970s, low values extending until the mid 1980s and a return to high values in the late 1980s. As would be expected, annual condition factors were at a minimum for mackerel and jack mackerel during the 1983-84 El Niño.

The two anchovy time series show runs of high and low condition factors extending for 1 to 2 years, however, two series overlap for only 5 months and therefore it cannot be determined if they are intercorrelated. Neither anchovy time series is significantly correlated with the mackerel or jack mackerel time series; however, anchovies sampled at Ensenada also had minimum condition factors during the El Niño.

A wide range of correlation analyses were made between each condition factor time series and environmental time series. The monthly environmental variables included upwelling indices (6 locations), sea level (3 locations), salinity (2 locations), sea surface temperature (2 locations), and a southern oscillation index. The seasonal cycle of each environmental time series was removed before the analyses were made. In addition, 7 different lags and/or combinations of months were used for each environmental variable. The large number of correlation analyses (98 with each condition factor time series) were used for their value in pattern recognition and it was not intended that they represent statistical tests.

Although there is considerable difference between the overall patterns of variation in condition factors between the anchovy and the mackerel/jack mackerel time series, there is a remarkable and rational similarity in the patterns of correlation of all four condition factor time series with the environmental time series. In all four condition factor time series the largest correlation coefficients (negative) are with sea level at San Diego during the previous 1 to 3 months; and nearly all of the correlations with sea level, at any of the three locations, have negative coefficients. The largest correlations with upwelling are positive; for mackerel and jack mackerel the largest coefficients are with the previous month at 27°N and for anchovy at Ensenada it is with the previous month at 33°N. In all four condition factor time series the largest correlations with temperature are negative coefficients with the current to previous 3 months at Scripps Pier. The great majority of correlations with salinity and the southern oscillation index are positive and there does not appear to be a common pattern of higher correlations with the sea level, upwelling and temperature time series commonly occur at the shorter lags, i.e. within the previous month or the previous 3 months.

Not unexpectedly the observed correlation patterns suggest that the environmental conditions associated with variation in condition factors are those which are also associated with food availability. Higher condition factors are found in association with lower sea level at the coast, increased upwelling in northern Baja California, and lower sea surface temperatures; all of these factors are associated with increased nutrients and productivity. Lower sea level is associated with increased southerly flow of the California Current, increased upwelling, and lower temperatures. Higher sea level is associated with El Niño events which result in reduced advection of nutrients and food from the north as well as a warmer, deeper upper mixed layer which reduces local nutrient enrichment associated with upwelling.

In spite of the broad patterns of association with the environmental time series the correlation between the condition factors of mackerel and jack mackerel is larger (r=0.469) than that found between the condition factor of either species and any environmental variable (r=0.450). This suggests that the mackerel and the jack mackerel are responding to the same environmental conditions and that each species is a better predictor of the effect of that environment on the other species than are the environmental data series used in this study. (R. Parrish (408) 646-3311)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

1990 Pacific International Billfish Angler Survey Underway

The 1990 Pacific International Billfish Angler Survey is underway. This is the 21st consecutive year of the Survey. The Billfish Angler Survey was started in 1969, and annual surveys have been conducted since to monitor catch-per-unit-effort (CPUE, or catch-per-days-fishing) of billfish anglers in various fishing areas of the Pacific, Indo-Pacific, and Indian Oceans.

Prior to the start of the Survey in 1969, the only comprehensive billfish CPUE data available were from the Japanese longline fishery. Over the years, catch rates for the longline fishery have decreased (i.e., northeastern Pacific) as have catch rates for billfish anglers. The Survey has provided data to determine the magnitude of the decline in billfish angler catch rates.

Longline catch rates for striped marlin around the southern tip of Baja California, Mexico, declined from about 18 fish/1,000 hooks fished to about 9 fish/1,000 hooks fished during the period 1963-1976. Angler catch rates, determined by the annual Billfish Angler Survey, declined from about 0.6 fish/day to 0.3 fish/day during the same period. Angler catch rates increased during 1977-1980 when longlining was prohibited off Mexico. Permits were again issued to longliners starting in 1980. Targeting with longline gear for striped marlin and other billfish species was prohibited in 1990. Figure 1 gives the angler CPUE for striped marlin at several locations in the eastern Pacific.

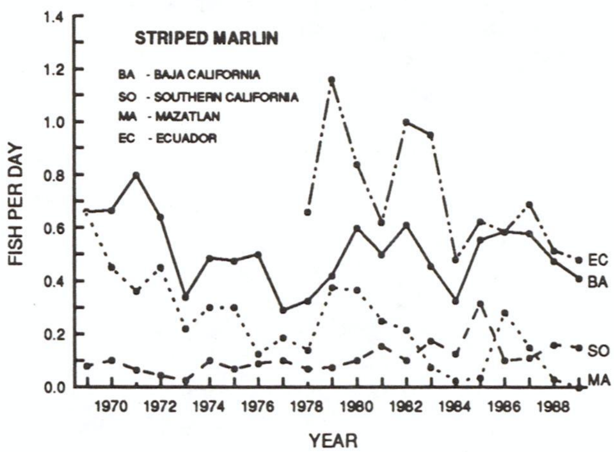

Figure 1. CPUE (number of fish/angler day) for striped marlin and number of angler days (indicated adjacent to CPUE data points) reported fishing in important catch areas in the eastern Pacific, 1969-1989.

Results of the 1989 Billfish Angler Survey indicate that the total number of billfish fishing days in the Pacific, Indo-Pacific, and Indian Oceans, reported by those anglers responding to the survey, was 10,016. Anglers responding to the survey reported catching 5,744 billfish. The catch rate for the Pacific, Indo-Pacific, and Indian Oceans was 0.57 billfish/day. This catch rate is slightly lower than that reported for 1988, 0.58 billfish/angler day.

For southern California, the 1990 CPUE for striped marlin increased slightly from 1988, 0.12 fish/day to 0.16 fish/day. The striped marlin CPUE for Baja California, Mexico, declined from 0.73 fish/day to 0.67 fish/day. (J. Squire, Jr., FTS 893-7072)

Albacore Reproduction Biology Project

A project to determine if frozen samples of albacore ovaries could be used to stage maturity of ovaries has been partially completed by Fishery Biologist Darlene Ramon at the La Jolla Laboratory. She has found that for immature and inactive ovaries, either frozen or formalin preserved samples are suitable for determining the maturity state by gross morphology and by microscopic staging of the oocytes. This result allows for a greater spectrum of sampling because fishing vessels that were previously hesitant to take formalin on board for preservation can preserve the ovaries by freezing. Also, fish that arrive at the canneries can now be used because when they are defrosted during the canning process, the gonads can be removed and refrozen for shipping and analysis.

Samples for this project were obtained from two sources. The Tuna and Billfish Assessment Programme of the South Pacific Commission provided pairs of formalin preserved samples from the longline fishery off New Caledonia. The second source was from observers aboard U.S. troll vessels fishing in the North Pacific region. These were preserved in formalin or frozen.

Two questions were involved in this project of determining the suitability of frozen samples: 1) is there a difference in maturity between the two sides of the ovary of the same fish? 2) is there a difference between frozen and formalin-preserved oocyte diameters?

Albacore display morphological size differences between their right and left gonads. The right side is generally greater in weight than the left in both males and females (Figure 2). Researchers have reported that asymmetric maturation of testes allows for rapid maturation of the more developed smaller gonad for opportunistic spawning.

In order to determine if asymmetric maturation also occurs in females that display asymmetric differences of ovaries, pairs of formalin-preserved ovaries were studied for maturity differences by measuring oocyte diameters. The data were tested statistically, using the Wilcoxon signed-rank test. The result showed no significant difference in maturity between the right or left side of the ovary at the 90% confidence level (n=19, P=0.0883).

The second question, "Is there a difference between frozen and formalin-preserved oocyte diameter?" was dealt with in the same manner as

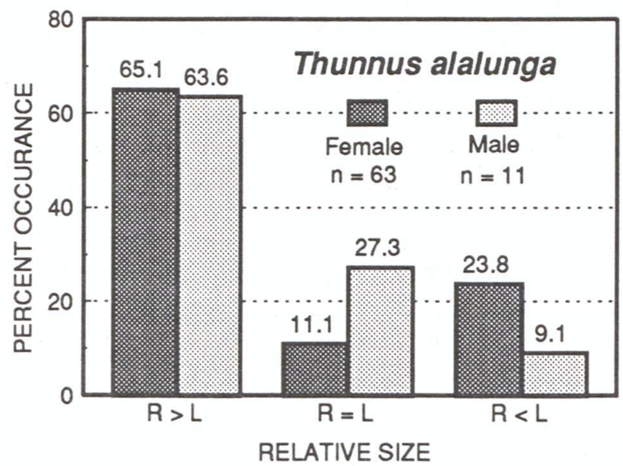

Figure 2. Relative size of left and right gonads, *Thunnus alalunga*.

the first. Ovaries with their right side preserved in formalin and their left side frozen were studied for differences in oocyte diameters to determine if they were affected by preservation method. The data were tested statistically using the Wilcoxon signed-rank test. No significant difference in maturity between the frozen or formalin preserved side of the ovary was detected at the 99% confidence level (n=63, p=0.0001). Therefore, samples preserved in either manner are acceptable for maturity analysis.

Researchers will continue to determine if advance developing or mature ovaries display the same tendencies as immature ovaries. Samples are currently being collected from mature fish in Hawaii and in American Samoa for this portion of the project. (D. Ramon, FTS 893-7074)

PELAGIC ECOSYSTEM MODEL DEVELOPMENT PROGRAM

Estimates of Natural and Fishing Mortality Rates from Tag-recapture Data

In the September-October 1990 Report of Activities of the Southwest Fisheries Science Center, Operations Research Analyst Carlos Salvadó and Fishery Biologist Pierre Kleiber reported on progress in developing a model to analyze tag-recapture data with the Green's function or propagator method. They have since expanded on their results and are estimating natural and fishing mortality rates of migratory fish separately. Their results are as follows:

In the propagator method,

$$g_0(x,t|x_0,t_0) = \frac{c_T(x,t)}{F\ \#_T}$$

is the tag catch rate density (i.e., $c_T(x,t)$) dependent probability of finding a tag at location x at time t given that at an earlier time t_0 it was released at x_0, F is the fishing mortality rate density and $\#_T$ is the number of tag released at (x_0, t_0). It can then be shown that the generalization of Baranov's catch equation for the case of fish that are distributed in space and time is given by

$$< c(x,t) >_{x,t} =$$

$$F \int_{t_0}^{t} d\tau \int_{-\infty}^{\infty} dx \int_{-\infty}^{\infty} dx' g_0(x,\tau|x',t_0) p(x',t_0)$$

$$= F\ \frac{1 - e^{-(M+F)\ (t-t_0)}}{M+F},$$

where $<c(x,t)>_{x,t}$ is the catch rate density integrated over space and time, M is the natural mortality rate density and $p(x,t_0)=c(x,t_0)/F$ is the initial population density.

By computing the tag catch rate independent probability of tag migration from (x_0,t_0) to (x,t) as

$$g(x,t|x_0,t_0) = g_0(x,t|x_0,t_0) +$$

$$(\frac{1}{\#_T}) \int_{t_0}^{t} dt' \int_{-\infty}^{\infty} dx'\ g_0(x,t|x',t') c_T(x',t')$$

$$+ O(\frac{1}{\#_T})^3,$$

where $O(1/\#_T)^3$ means that it is a term of order $(1/\#_T)^3$, the effects of natural and fishing mortality in Baronov's catch equation can be separated by computing

$$\int_{t_0}^{t} d\tau \int_{-\infty}^{\infty} dx\ g(x,\tau|x_0,t_0) =$$

$$\frac{1 - e^{-M\ (t-t_0)}}{M}.$$

The computation can also be generalized to the case of varying M and F, which Salvadó and Kleiber have done, and will be reporting in a manuscript. (C. Salvadó, FTS 893-7052; P. Kleiber, FTS 893-7076)

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

Seychelles Purse Seine Data Updated

Biological Technician Gary Rensink has completed updating the fourth quarter 1990 Seychelles Fishing Authority data from tuna purse seiners fishing in the western Indian Ocean. Data are summarized in LOTUS spreadsheets, and cover the period 1983 to the present.

The number of vessels participating in the purse seine fishery in the western Indian Ocean during the final quarter of 1990 reached a high of 46 in November (16 French, 20 Spanish, 2 Mauritian, 1 Panamanian, 3 Soviet, and 4 Japanese), compared to the high of 49 vessels recorded for the same period last year. A record high of 63 purse seiners participated in the fishery in 1990, compared to 54 vessels in 1989.

Fourth quarter catch rates in 1990 averaged 20 mt/day, significantly higher than those during the same period in 1989 (average 14 mt/day) (Figure 3). Overall, fishing results in 1990 were not as good as those in the past 3 years, due primarily to poor fishing conditions from January to May. Catch rates for 1990 were up 25% for yellowfin (7 mt/day), and down 34% for skipjack (8 mt/day) from those of 1989. Total catch rates for 1990 (15 mt/day) were down for the second straight year from 18 mt/day in 1989 and 22 mt/day in 1988.

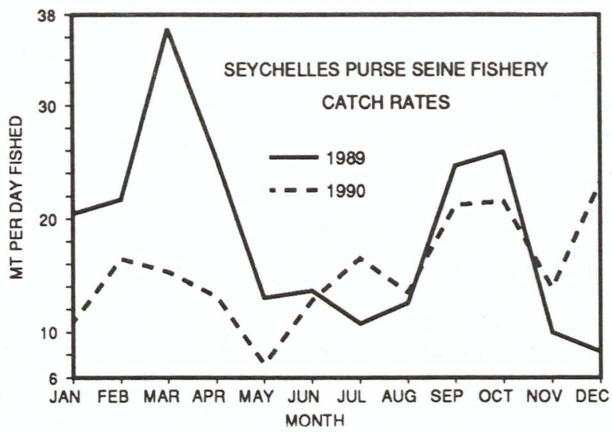

Figure 3. Seychelles purse seine fishery catch rates.

Preliminary estimates of the cumulative catch for 1990 were 193,340 mt, a decrease of 15% below catches recorded for 1989 (Figure 4). The breakdown of tuna catch for the fourth quarter of 1990 was 52% yellowfin and 46% skipjack tuna, com-

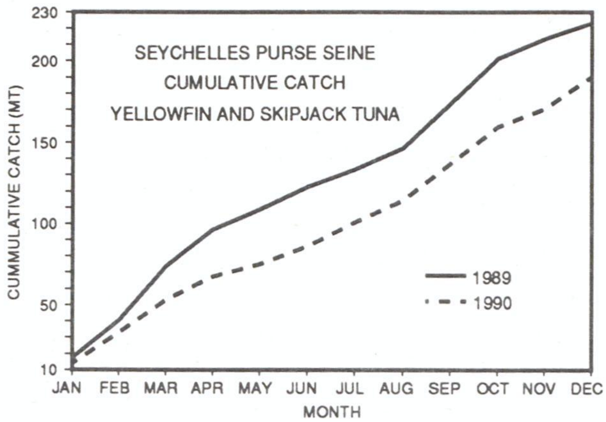

Figure 4. Seychelles purse seine cumulative catch.

pared to 27% yellowfin and 72% skipjack tuna during the same period in 1989. Yellowfin comprised 87% of the catch in December 1990. The breakdown of tuna catch for 1990 was 46% yellowfin and 52% skipjack, compared to 31% yellowfin and 67% skipjack in 1989. (G. Rensink, FTS 893-7192)

TIBURON LABORATORY

Tiburon, California

DIRECTOR'S OFFICE RESEARCH

During March and April, Dr. Alec MacCall presented the following lectures: "Dynamic geography of marine fish populations" to Dr. David Hankin's fisheries class at Humboldt State University, Eureka; "Climate and changes in the California Current Ecosystem" at the meeting on Pacific Climate, Asilomar; and "Biogeographic dynamics of resources" at the National Research Council Marine Board, San Francisco. He also partipated in a program review of the California Department of Fish and Game's [San Francisco] Bay Study, Sacramento, on April 16 and 17.

GROUNDFISH COMMUNITIES INVESTIGATION

Effects of Feeding Conditions on Rockfish Physical Condition and Recruitment Success

Conditions that influence relative success of recruitment in rockfishes, *Sebastes* spp., have been major topics of study for the Groundfish Communities Investigation. One of the questions under study has been whether recruitment of *S. mystinus* is influenced by how well adults of that species feed. That this relationship may exist became apparent during the 1982-83 El Niño, when exceptionally poor recruitment during 1983 followed a year when the adult fish had become emaciated from severe lack of food. Taking a lead from that observation, Fishery Biologists Ted Hobson, Tony Chess and Dan Howard have, since November of 1987, evaluated feeding success and the physical condition of adult female *S. mystinus* and related the results to the number of recruits counted during the following year. So far, too few years have been studied to draw firm conclusions, but results have been interesting.

The evaluation of feeding conditions is based on the study of gut contents and samples of the plankton (*S. mystinus* is a planktivore). The period June to November is considered the critical period, because energy stored as fat during this period is used in producing the next year's recruits (parturition in this species occurs from December to February). Based on our results (Figure 1), there has

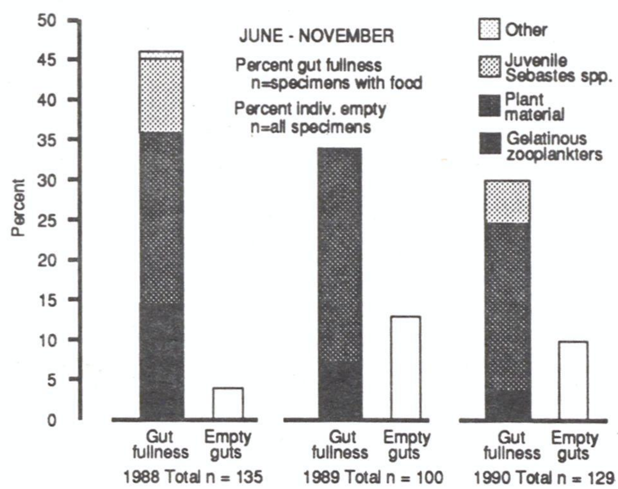

Figure 1. Feeding by female *Sebastes mystinus* (>250 mm SL).

been a progressive decline in feeding conditions over the past 3 years (1988-90). Compared to other years, in fact, feeding conditions have been subpar during all three of these years. This is evident in the relative prominence of algae, an uncertain food source for this species. (Earlier study concluded that *S. mystinus* consumes more algae in the absence of preferred gelatinous zooplankters.) Despite this, it is evident that feeding conditions were better during 1988 than during either 1989 or 1990. (The occurrence of juvenile *Sebastes* spp. among the gut contents during 1988 reflects the relative strength of the 1988 year class, which was among the stronger in recent years. Like a number of other nearshore predators, the planktivorous adult *S. mystinus* feeds significantly on juvenile rockfishes only when these prey are particularly abundant.)

Evaluation of physical condition is based on assessments of selected condition indicators: a visceral fat ranking represents subjective visual estimates of fat content on a relative scale, 0 to 5, whereas liver condition and soma condition (with soma defined here as body less viscera and gonads) are represented by Fulton's Condition Factor (k = weight/standard length^3). It would seem significant that during the 3 years considered here (Figure 2), the condition indicators show a decline that matches the decline in feeding conditions.

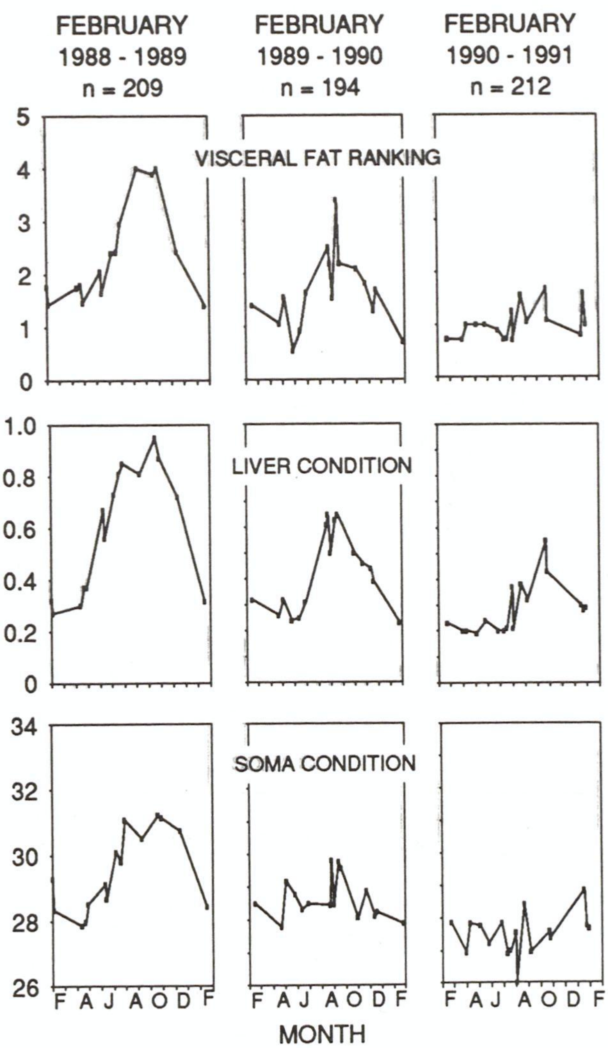

Figure 2. Condition indicators from female *Sebastes mystinus* (>250 mm SL), February 1988 through February 1991.

Even though our results so far can be related to recruitment during just 2 years, 1989 and 1990, they are consistent with the possibility that recruitment success is influenced by poor physical condition that results from poor feeding. Although both of these years produced relatively weak year classes (compared, for example, to 1988 - Figure 3), clearly there were more recruits during 1989 than during 1990. It is noteworthy, therefore, that females which produced the 1989 recruits appear to have fed better and to have been in better condition than females which produced the 1990 recruits. If these relationships continue to hold, the outlook for the 1991 year class would seem bleak, because the females that will have produced this year's recruits did not feed as well as the females of 1990, and were in even worse condition. Whether or not recruitment is in fact influenced by feeding and physical condition of adult females remains problematical, however.

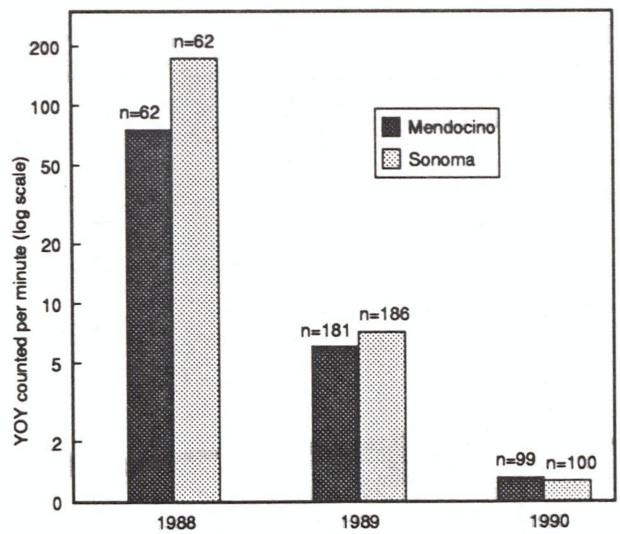

Figure 3. Occurrences of first-year *Sebastes mystinus* during August and September.

We also considered stage and weight of female gonads, but these factors did not show the response to feeding success that has been evident in other aspects of physical condition. Consider, for example, how gonads developed each year from 1988 to 1991 in females of 260-280 mm SL (Figure 4). (We must consider fish of similar size because gonads develop earlier and to a larger relative size in larger fish.) The comparison is based on an index calculated as gonad weight/standard length^3, where

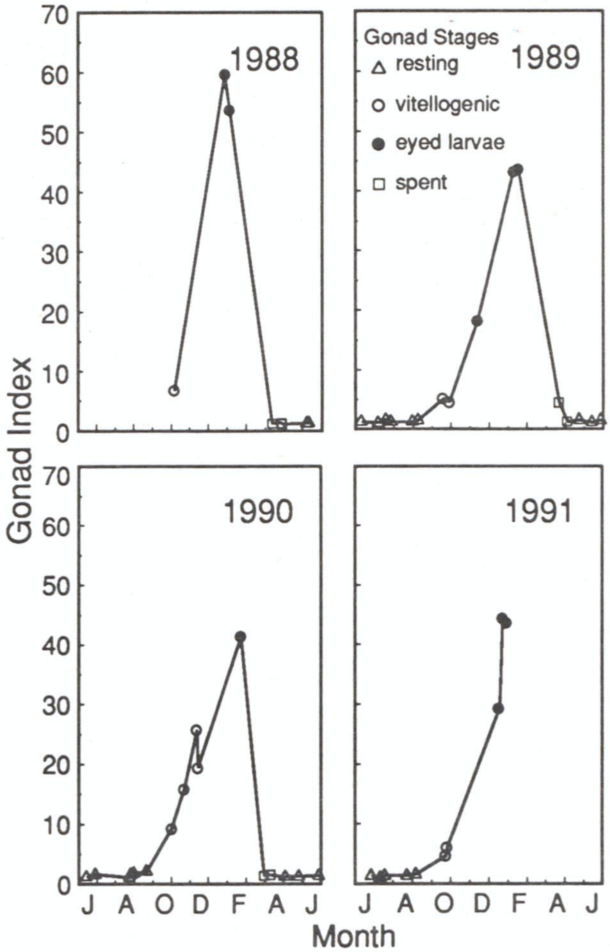

Figure 4. Gonad index from female *Sebastes mystinus.*

each point represents from 1 to 10 fish ($\bar{x}$=3.3) and maximum gonad development each year is at the eyed-larvae stage. Because sampling began in November of 1987, the data include females that would have been among those which produced the strong year-class of 1988. This would seem to offer a better opportunity than with the above to consider the possibility of an influence on recruitment, but the data show no obvious difference in gonad development between these years. The mean index values from females that would have produced the very strong 1988 year class (upper-left panel) were just 10 to 15 units above the others (and the range of variation within each sample tended to exceed this). Furthermore, the highest index value of all came from a female that would have contributed to the very weak 1990 year class. (That extreme outlier was excluded from this analysis.) Although this is a crude measure and the sample is limited, the results caution against a premature suggestion that feeding and physical condition affect recruitment.

The small difference observed in gonad development between 1988 and the other years may be real and enough to have affected recruitment. On the other hand, it is also possible that despite poor feeding the females were able to channel sufficient energy to develop their gonads and that this in fact contributed to the relatively poor physical condition observed during those years. This would be consistent with the contention of Bruce MacFarlane (Groundfish Physiological Ecology Investigation; see page 24 this report) that adult female yellowtail rockfish (*Sebastes flavidus*) use protein from their own tissues as an alternate source of energy to produce larvae during lean years. (E. Hobson, J. Chess, and D. Howard, FTS 556-0565)

GROUNDFISH ANALYSIS INVESTIGATION

Effect of Survey Design on Reliability of Catch-at-Age Analysis

Fishery Biologists James Bence and Joseph Hightower have been working with visiting scientist Ana Gordoa (Institute of Marine Science, Barcelona, Spain) on a simulation study of the reliability of catch-at-age analysis. The simulated assessments were done using the same assumptions and methods as Rick Methot's stock synthesis model. For each trial, 15 years of catch-at-age data were generated for a simulated fishery on widow rockfish. There was assumed to be an annual survey of relative abundance, with one of three selectivity patterns: recruitment (sampling primarily the youngest fish), dome-shaped, or asymptotic. These selectivity patterns could arise due to variations in the depth distribution of survey effort: shallow water for recruitment, intermediate depths for dome-shaped, or all depths for an asymptotic selectivity pattern. The survey estimates of relative abundance were assumed to have a coefficient of variation (CV) of 10, 25, or 50% (representing a range of likely levels of precision). Fishing mortality during the 15-year horizon was assumed to be (on average) one-half or twice the natural mortality rate at the age of full selectivity.

When the fishing mortality rate was low, estimates of recruitment, biomass, and selectivity were often far from the correct values. Estimates were substantially better at the higher fishing mortality rate. Predictably, reliability also increased as survey variability decreased. At both levels of fishing mortality, a survey that concentrated on recruits produced the least reliable estimates of recruitment, biomass, and fishery selectivity. An asymptotic survey produced estimates of final-year biomass that were most often roughly correct (within 20% of the correct value), while the recruitment survey produced the fewest roughly correct estimates. Large errors in estimated final-year biomass generally were associated with errors in estimating the selectivity of the fishery. A manuscript describing this work is undergoing external review. (J. Bence, FTS 556-0565).

GROUNDFISH PHYSIOLOGICAL ECOLOGY INVESTIGATION

Indications of Increased Protein Metabolism during 1990-91 Reproductive Period in Yellowtail Rockfish

Compared to all previous years, female yellowtail rockfish (*Sebastes flavidus*) during 1990-91 had significantly greater concentrations ($P<0.001$) of proteins in their serum during the interval spanning late exogenous vitellogenesis through parturition (Table 1). To assess the component of serum constituents intended for nutrient energy transfer to the ovaries, the mean concentrations in male serum were subtracted from means in serum of females during the same time period. This assumption seems valid since male gonadal development does not occur during this time period (essentially December through February or March), having been completed by the time of copulation (August and September). It is reasonable that differences in nutrient concentrations in the serum of the two sexes during the annual ovarian maturation period reflect utilization for oocyte and embryonic development.

Table 1. Female - specific mean values (i.e., difference between mean values in females and males) of energetic nutrient variables during period of annual reproductive development in *Sebastes flavidus*. Females were in late vitellogenesis to parturition phase of ovary maturation. All values are the difference between means of females and males, except for ovary lipid and protein which are mean values of females for the given reproductive year. Number in parentheses below each year represents the number of females evaluated.

Variable	1987-88 (45)	1989-90 (68)	1990-91 (37)
Serum Protein Variables			
Total protein (g/dl)	0.52	0.11	0.97
Albumin (g/dl)	0.16	0.18	0.54
Vitellogenin (as Ca^{++}, mg/dl)	4.9	3.1	6.0
Serum Energy Lipids			
Triacylglycerols (mg/dl)	143.8	192.7	314.4
Nonesterified fatty acids (Eg/l)	24.2	156.8	96.8
Tissue Variables			
Mesenteric fat index (%)	0.39	0.08	0.18
Ovary lipid (mg/g)	74.9	113.1	140.4
Ovary protein (mg/g)	206.2	181.4	183.7

The predominant form of energy transfer for ovarian development in yellowtail rockfish is triacylglycerols (triglycerides). Concentrations of nonesterified fatty acids in serum are related to the energetic demands of the female to fulfill maintenance functions and do not appear to be involved with ovarian maturation. In previous years, differences between male and female serum concentrations of proteins, including albumin, were relatively small, whereas female triacylglycerol levels were three- to fourfold greater than in males, during the months of ovary enlargement. During 1990-91, although triacylglycerol concentrations were again elevated, albumin, vitellogenin, and total protein concentrations were also greatly increased compared to values in male serum.

The significance of these results is unclear, but this altered nutrient transfer profile may be a consequence of changes in lipid dynamics earlier in the reproductive cycle. Unlike previous years when substantial lipid accumulation and circulation occurred from early summer through fall, during the summer of 1990 there were very low concentrations of lipids in serum, and lipid stores (mesenteries, liver) did not increase, suggesting poor feeding during the usually forage-rich season. Tissue and serum lipid levels did not increase until late in the fall. It may be that metabolic regulatory mechanisms responded to depleted lipids by turning on protein metabolic sequences to provide, or supplement, the energy requirements for ovarian development.

It is known that some fish species, both facultatively and obligatorily, utilize protein as an energy source. If this facultative process is operative in yellowtail rockfish, it would have adaptive significance for ensuring adequate production of larvae, since interannual fluctuations in upwelling intensity and duration cause variable (and uncertain) levels of secondary productivity, the principal foraging trophic level and source of lipids for yellowtail rockfish off California. This facultative process may also operate in other rockfish species and may explain why Ted Hobson, Tony Chess, and Dan Howard (Groundfish Communities Investigation; see p. 21 this report) found no clear connection between feeding conditions and gonad development in adult female blue rockfish (*Sebastes mystinus*). (B. MacFarlane, FTS 556-0565)

Rockfish Gestation Study

One of the problems facing researchers who attempt to estimate spawning biomass of rockfishes by the larval production technique is the lack of information on the rate of gestation, i.e., the time course required for embryonic and larval development leading to an estimate of parturition date. In December 1990, we conducted laboratory experiments that involved monitoring the rate of gestation in four yellowtail rockfish that were transported from Cordell Bank, California, maintained in 2,000-L tanks, and sampled weekly by catheterization for 14 weeks. Three fish were captured with fertilized eggs already present. The developmental progression of their eggs was individually monitored for the duration of the remaining development until larval release. The remaining female entered the laboratory with unfertilized eggs. Within 2 weeks of collection, the eggs matured and fertilization took place. This particular fish was sampled from the day of fertilization until parturition.

Table 2. General developmental sequence for yellowtail rockfish embryos and larvae at 11.0-11.5°C.

Day	Developmental Features
0	Eggs opaque; yolk becomes progressively transparent and granulated.
1	Fertilization; yolk and oil translucent, non-granulated; single oil globule; early formation of germ disc.
2	Well-developed blastodisc (morula to blastula).
4	Advanced gastrula;early appearance of embryonic body.
10	Embryo well-formed; otic and optic vesicles developed; eyes with lens and no retinal pigmentation.
19	Embryos well-pigmented; eyes 90% pigmented; mouth open.
22-25	Hatched.
26	Larval yolksac contents approximately 1/2 consumed.

Table 2 summarizes the general developmental sequence and rate for yellowtail rockfish embryos and larvae. We believe these rates to possibly be advanced because the ambient tank water temperatures (11.0-11.5°C) were warmer than those that occurred at Cordell Bank. The entire gestation period lasted from 28-31 days. This period consisted of embryonic incubation from fertilization to hatching at 22-25 days, and an internal larval incubation lasting 6-9 days. (M. Eldridge, FTS 556-0565)

INFORMATION TECHNOLOGY SERVICES

Molecular 32X Supermicro Computer Shutdown for Last Time

On April 30, 1990, the Molecular 32X at the La Jolla Laboratory was shut down for the last time. The system was originally purchased and installed in early 1983. Throughout its 7 year life span the Molecular primarily supported word processing, data base management, communications, and file sharing applications.

The Molecular 32X system was capable of supporting 32 concurrent users. The system was configured with multiple Z80 CPUs with 64K of RAM running at 4 Megahertz and used a modified version of CP/M for the operating system.

The Molecular 32X became obsolete as more powerful IBM DOS-based PCs became available. Software vendors abandoned the development and support of CP/M software in favor of DOS software. All the files and applications that are still needed have been converted and reside on the 3COM LAN at the La Jolla Laboratory. (R. Bistodeau, FTS 893-7055)

PUBLICATIONS

Published

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Barlow, Jay and Peter Boveng. 1991. Modeling age-specific mortality for marine mammal populations. Mar. Mammal Sci. 7(1):50-65.

A method is presented for estimating age-specific mortality based on minimal information: a model life table and an estimate of longevity. This approach uses expected patterns of mammalian survivorship to define a general model of age-specific mortality rates. One such model life table is based on data for northern fur seals (*Callorhinus ursinus*) using Siler's (1979) 5-parameter competing risk model. Alternative model life tables are based on historical data for human females and on a published model for Old World monkeys. Survival rates for a marine mammal species are then calculated by scaling these models by the longevity of that species. By using a realistic model (instead of assuming constant mortality), one can see more easily the real biological limits to population growth. The mortality estimation procedure is illustrated with examples of spotted dolphins (*Stenella attenuata*) and harbor porpoise (*Phocoena phocoena*).

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Batch fecundity was positively (and allometrically) related to female somatic weight. Fecundities were remarkably similar during four of the five years evaluated. After adjustment for annual differences in female size, fecundities were still significantly lower (by about one-fifth) during 1984, a major El Niño year, compared with the preceding (1979-80) or following (1985-86) pairs of years. Gonadal condition also was uniquely low in 1984. The 1984 declines in fecundity and gonadal condition co-occurred with low somatic condition during 1984, particularly for larger females. Mean size (diameter, dry weight) of eggs was indistinguishable among years. There was a positive relation between egg size and female body size, and a general decline in egg size as the spawning season advanced for females of all size.

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