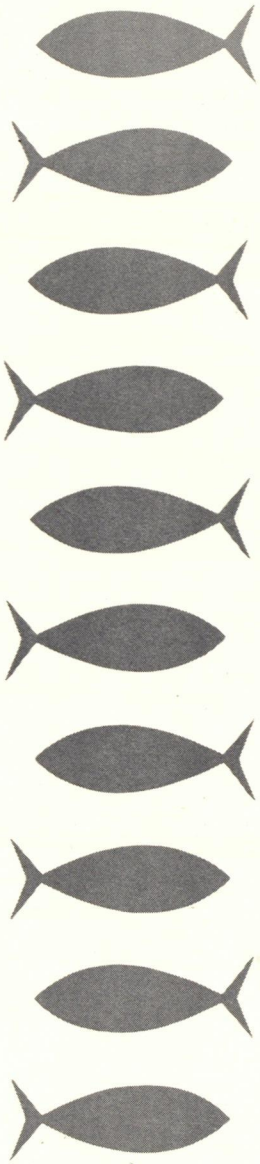
Southwest FISHERIES SCIENCE CENTER

HONOLULU LA JOLLA MONTEREY TIBURON

REPORT OF ACTIVITIES Fourth Quarter 1995



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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

1996 AMLR Field Season

During the last months of 1995, the Antarctic Ecosystem Research Group (AERG) made preparations for the Antarctic Marine Living Resources (AMLR) Program's 1996 field season in the Antarctic. Under the AMLR program, shipboard research is conducted during each austral summer (January through March) in the vicinity of Elephant Island, part of the South Shetland Islands. This research supports the U.S. commitment to the Convention for the Conservation of Antarctic Marine Living Resources, one of several international agreements that make up the Antarctic Treaty System. The main objective of the convention is to manage and conserve living resources in the oceans surrounding Antarctica. The convention stipulates that the harvest of Antarctic organisms will be managed so as to maintain the integrity of the entire ecosystem.

The keystone of the Antarctic pelagic ecosystem is Antarctic krill, *Euphausia superba*. These small, shrimp-like crustaceans are the main food source for many animals, including penguins, seals, whales, and others. Krill are harvested by a multination commercial fishery, part of which is located in the Elephant Island area. Many penguin and fur seal breeding colonies are also located in this area, causing concern that the krill fishery could adversely impact these breeding krill predators. The AMLR field program is designed to describe the functional relationships between the krill, their predators, and key environmental variables in the Elephant Island area.

During past cruises, shipboard mapping of the waters around Elephant Island has revealed that several water masses converge in the area, forming a hydrographic front along the shelfbreak north of the island. High densities of phytoplankton and krill are associated with the position of the frontal zone, although the seasonal timing of their appearance can vary by several weeks. This year's field program will continue descriptive surveys of the pelagic ecosystem in the Elephant Island area.

In previous seasons, the shipboard research was conducted from aboard the NOAA ship *Surveyor*; however, due to the recent decommissioning of the *Surveyor*, this year's cruise will be conducted aboard the chartered Russian research vessel *Yuzhmorgeologiya*. (J. Rosenberg, 619-546-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

Population Genetics Models of Some Pelagic Fish Stocks of the California Current System

The genetics of a population are inextricably linked to the species' life-history and demographic characteristics because only successfully reproducing individuals contribute to the genetic patterns observed. The study of genetic patterns and creation of models with varying life-history parameters can reveal something about past patterns of recruitment and the effects of various harvest strategies on future genetic variability.

Most of the existing population genetic models consider populations at equilibrium and thus, they are not appropriate to study the genetics of pelagic fish stocks (northern anchovy, *Engraulis mordax*, and Pacific sardine, *Sardinops sagax*) of the California Current System (CCS). These stocks undergo vast fluctuations in numbers in response to individual, locational, seasonal, yearly, and decadal variations in reproductive success. It is generally accepted that anchovy and sardine populations are subject to similar fluctuations, but sardine displays levels of genetic variability much lower than those displayed by anchovy. This report describes efforts to create a model of genetic variability in pelagic fish stocks that will allow the effects of different mortality patterns to be tested.

The amount of genetic variability maintained by a population is determined by its "effective population size," N_e, which is defined as the average number of individuals in a population which are assumed to contribute genes to the succeeding generation. Fluctuations in population numbers (among many other factors) might play a very important role in determining the effective population size of a species. As mentioned before, pelagic fish stocks exhibit striking fluctuations in population size, caused by great natural variability in recruitment. This natural variability in recruitment is likely to have an important effect on the genetic variability maintained by pelagic fish populations and might lead to temporal changes in their genetic constitution.

Besides environmental changes (that lead to recruitment fluctuations), another factor that influ-

ences a fish population's N_e is life history. The very high fecundities and high mortalities of early life stages characteristic of clupeoid fish can lead to large variance in the number of offspring that individuals contribute to the next generation of reproducing adults. Thus, a small minority of individuals are capable of replacing the entire population each generation by a sweepstakes-chance matching of reproductive activity with oceanographic conditions conductive to spawning, fertilization, larval survival, and successful recruitment.

Another factor to consider in the case of pelagic fish populations is fishing mortality, which is likely to decrease N_e by increasing the mortality of those age classes that contribute the most to the production of new offspring. The interaction among all the different factors that determine the genetic variability maintained by pelagic fish populations is quite complex and almost impossible to understand without the help of a realistic population genetic model.

A computer simulation model was developed to study the way these factors interact to determine the effective population size of pelagic fish populations inhabiting the CCS. The simulation model consists of a demographic and a genetic component. The demographic component is based on an age-classified matrix model which assumes that all elements of the Leslie matrix are constant over time except $s_{0;t}$, the survival of eggs at time t-1 to age class 1 at time t. The assumption that only $s_{0;t}$ is subject to temporal changes is a simplification; clearly, all elements of the Leslie matrix might vary. It is widely recognized, however, that the overwhelming source of variation, at least in pelagic fish populations, lies in the survival of eggs. The genetic component is based on a coalescence theory approach. The variance in reproductive success among individual fish was introduced by assuming that, each year, there is a fraction (ρ) of the fish population that produces a small number of eggs and a fraction ($1-\rho$) that produces a large number of eggs. Thus, at any given time, the fish population can be divided into a less successful and a more successful group (group 1 and group 2). This differential success in reproduction is independent of the genetic constitution of the individuals and is solely determined by the environmental conditions experienced by the individuals before and during reproduction. That is, a given fish might belong to group 1 in one year but to group 2 in another year.

The simulation model and demographic data can be used to estimate the effective population size of sardine and anchovy populations. Although these demographic data cannot be considered accurate enough to provide valid estimates of effective population sizes, the differences between sardine and anchovy vital rates that they reflect can be considered real. The ongoing research does not attempt to give accurate estimates of effective population numbers; instead it focuses on determining the most important factors that control the amount of genetic variability maintained by pelagic fish populations.

In unexploited populations, the sardine is predicted to have higher mortality than the anchovy during the first year of life. This higher mortality is compensated by the lower adult mortality, longer life (13 years for sardine versus 7 years for anchovy), and greater reproductive output of sardine. The first step of the analysis was to determine to what extent differences in life history between sardine and anchovy alone can lead to differences in the amount of genetic variability maintained. To achieve this goal, a deterministic version of the model in which egg survival was constant was considered. Figure 1 shows the equilibrium N_e as a function of ρ, the proportion of fish that fail to reproduce in any given year. N_e is larger for anchovy than for sardine due to the fact that the generation time of anchovy (1.738 years) is lower than that of sardine (2.996 years). Because it takes less time for an individual anchovy to contribute genes to the succeeding generation, the proportion of individuals that contribute genes to the succeeding generation is higher in the anchovy population. As expected, N_e for both species decreases as ρ increases, because the number of

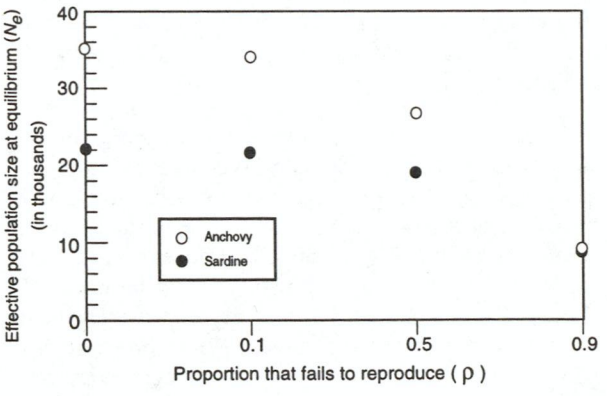

Figure 1. Effective population size at equilibrium for different values of ρ. Sardine and anchovy populations were allowed to grow until reaching the same maximum population size. After reaching the maximum population size, the survival from egg to 1 year old was adjusted to achieve stationarity (constant population size).

individuals that contribute offspring to the next cohort decreases. Note, however, that the decrease is more pronounced for anchovy populations and that for $\rho = 0.9$, both species have the same effective population size. This result is due to the fact that, on average, sardines live almost twice as long as anchovies. Although for both species each year most individual fish fail to contribute offspring to the next cohort, sardine individuals have almost twice as many years as anchovy to reproduce. Therefore, the likelihood that an individual fish will succeed in contributing genes to the succeeding generation is much higher in the sardine than in the anchovy population.

As mentioned before, existing studies indicate that, as opposed to northern anchovy, Pacific sardine have low levels of genetic variation. One of the explanations advanced for this difference in genetic variability is that, as opposed to northern anchovy, which seems to have been present in the CCS for millions of years, Pacific sardine may have evolved much more recently, some 10,000 years ago, and be far from reaching genetic equilibrium and its maximum genetic variability. Figure 2 shows N_e for both species before reaching genetic equilibrium. In both cases, it takes around 100,000 years to reach genetic equilibrium and at t = 10,000 the effective population size is less than half that present at equilibrium. Thus, the low levels of genetic variability present in the existing sardine population might be due to its recent arrival to the CCS.

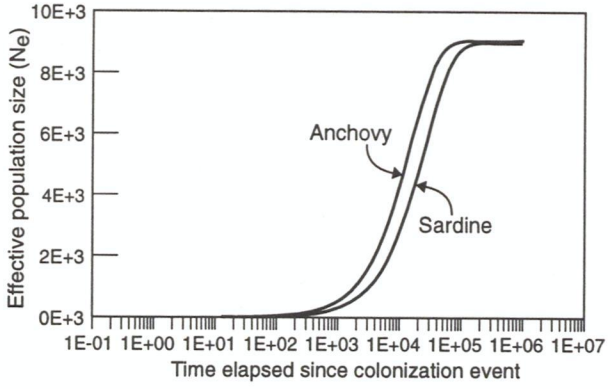

Figure 2. Changes in effective population size that occur before sardine and anchovy populations reach equilibrium.

The present results constitute the first step of the ongoing research. At present, the researchers are investigating the effect of different patterns of stochastic variation in the survival of eggs and will later consider the effect of fishing on the level of genetic variability maintained by these pelagic fishes. Understanding the way different factors interact to determine the genetic constitution of pelagic fish populations will allow researchers to address broader questions about pelagic fishes, such as their responses to global climate change. (O. E. Gaggiotti, [619] 677-9705; e-mail: ogaggiot@sgilj.ucsd.edu)

MARINE MAMMAL DIVISION

La Jolla, California

Marine Mammal Division Participates in International Conference

The Marine Mammal Division participated in the Eleventh Biennial Conference on the Biology of Marine Mammals held December 14-19, 1995, in Orlando, Florida. This premier meeting for marine mammal scientists and managers, which allows scientists to exchange ideas with researchers from around the world, was hosted by Sea World and the Hubbs-Sea World Institute. Division scientists made several presentations and poster presentations and were also responsible for reviewing an unusually large number of abstracts before the meeting. In addition, Barbara Taylor and Barbara Curry, biologists from the division's Population Identity Program, co-chaired a session on population genetics.

Presentations by Marine Mammal Division scientists are briefly described below. Abstracts for the entire conference are available through the conference sponsor, The Society For Marine Mammalogy, Marine Mammal Science, P.O. Box 1897, Lawrence, KS 66044-8897. (J. Sisson, [619] 546-7064)

Status of Okhotsk-Korean Gray Whales Off Sakhalin Island: New Threats from Oil and Gas Development

Marine Mammal Division Chief Robert Brownell co-authored a talk with A. Berzin from the Pacific Research Institute of Fisheries and Oceanography (TNRIO) in Russia, S.A. Burdin from the Kamchatka Institute of Ecology and Nature Management in Russia, and A.M. Minakuchi from Cetus Company in Japan. This cooperative research effort was initiated to determine the status of the Okhotsk-Korean or western population of gray whales, *Eschrichtius*

robustus, in the Okhotsk Sea, which until recently was considered by many to be extinct.

Information on this population has been scarce. Whaling catch statistics show that catches were made until 1966 in coastal Korean waters. In 1967, four gray whales were observed in the Okhotsk Sea. Between 1979 and 1989, there were various reports of gray whales observed in the Okhotsk Sea. These sightings were made mainly off Sakhalin Island. The largest group reported was 34 whales in September 1989. From these opportunistic sightings and whaling data, the estimated size of the population is thought to be about 200-250 whales.

In 1994, the cooperative effort was started to create a photographic catalogue of these animals. So far, 15 different individuals have been identified. This information will be used to better quantify population estimates and to determine the status of the population. New plans to develop oil and gas reserves in the region where these whales are thought to summer and feed pose new threats (from potential oil spills to harassment by increased vessel traffic) to one of the world's most endangered whale populations. (R. Brownell, [619] 546-7165)

DOLPHIN STOCK ASSESSMENT PROGRAM

Status of Dolphin Stocks Affected by the Tuna Purse Seine Fishery in the Eastern Tropical Pacific: A 36-year Summary

Since the eastern tropical Pacific purse seine tuna fishery began in the late 1950s, an estimated 6.3 million dolphins have been taken as bycatch. Spotted (*Stenella attenuata)*, spinner (*S. longirostris)*, and common (*Delphinus delphis*) dolphins account for over 95% of the mortality. Tim Gerrodette, leader of the Dolphin Stock Assessment Program, and Paul Wade, National Marine Mammal Laboratory, combined estimates of mortality over the 36 years of the fishery, relative abundance from observers on tuna boats over 20 years, and absolute abundance estimates from 20 research cruises over 17 years. A Bayesian model was used to estimate the status and trends of seven stocks (management units) of these three species.

Application of the Bayesian model led scientists to conclude that all seven stocks have declined since the fishery began. Two stocks, northeastern offshore spotted dolphins and eastern spinner dolphins, have apparently declined to approximately one-fourth of their pre-fishery abundance and are declared "depleted" under the U.S. Marine Mammal Protection Act.

At present, the annual incidental mortality in this fishery is less than 0.2% of population size for all dolphin stocks. In theory, with such a low mortality rate, dolphin populations should be able to recover to their former abundance. However, this assumes (1) mortality will remain at a low level for the next 30 years, (2) there is no unreported kill, (3) effects of injuries are negligible to the growth of the population, (4) effects of fishing activities are negligible to the growth of the population, and (5) ecosystem changes have not caused changes in natural mortality. (T. Gerrodette, [619] 546-7131)

Cetacean Sighting Cruises in the Colombian Caribbean Sea and the Colombian Pacific Ocean

Tim Gerrodette also contributed to a cooperative project with Daniel Palacios, currently with the Whale Conservation Institute, and S. Beltrán, P. Rodríguez, and B. Brennan from Fundacion Omacha, Colombia. Cetacean sightings data were analyzed from 19 cruises within the jurisdictional waters of the Colombian Caribbean Sea (CCS) and the Colombian Pacific Ocean (CPO). Two cruises in the southern CCS were carried out in May 1988 and April 1994, and one cruise around the San Andrés, Providencia and the Cays archipelago in August 1990. Species identified were sperm whale, *Physeter macrocephalus*; false killer whale, *Pseudorca crassidens*; pantropical spotted dolphin, *Stenella attenuata*; Atlantic spotted dolphin, *S. frontalis*; and bottlenose dolphin, *Tursiops truncatus*. Sightings of sperm whales and false killer whales are the first records of these species for the CCS.

In offshore and coastal waters of the CPO, 16 cruises were carried out in September-November 1986-90, May-July 1988, September-November 1992, February 1993, September-October 1993, and April 1994. Species recorded include Bryde's whale, *Balaenoptera edeni*; humpback whale, *Megaptera novaeangliae*; Dward sperm whale, *Kogia simus*; sperm whale, *Physeter macrocephalus*; Cuvier's beaked whale, *Ziphius cavirostris*; Blainville's beaked whale, *Mesoplodon densirostris*; melon-headed whale, *Peponocephala electra*; pilot whale, *Globicephala macrorhynchus*; killer whale, *Orcinus orca*; false killer whale, *Pseudorca crassidens*; striped dolphin, *Stenella coeruleoalba*; spotted dolphin, *S. attenuata*; common dolphin, *Delphinus delphis*; bottlenose dolphin, *Tursiops truncatus*; Risso's dolphin, *Grampus griseus*; and rough-toothed dolphin, *Steno bredanensis*. Sightings of Blainville's beaked whale constitute

the first record of this species for the CPO and for Colombia. (T. Gerrodette, [619] 546-7131)

COASTAL MARINE MAMMAL PROGRAM

Abundance of Blue and Humpback Whales in California: A Comparison of Mark-Recapture and Line-Transect Estimates

Jay Barlow, leader of the Coastal Marine Mammal Program, and John Calambokidis, Cascadia Research Collective, joined efforts to compare two methods of estimating abundance of blue and humpback whales in California. Relatively distinct populations of blue and humpback whales feed in the waters off California during summer and fall each year. Photo-identification studies of these populations have been conducted since 1986, and ship line-transect surveys were conducted in 1979-80, 1991, and 1993. The abundance of blue and humpback whales is estimated from these data using independent mark-recapture (from photo-identification) and line-transect methods. The best estimates from the 1991-93 mark-recapture studies are 2,017 (CV=0.38) blue whales and 597 (CV=0.07) humpback whales. The comparable estimates from the 1991-93 line-transect surveys are 1,773 (CV=0.31) blue whales and 381 (CV=0.36) humpback whales.

Although each estimate is affected by different types of biases, the resulting abundances are not significantly different between methods for these two species. This study shows the value of using independent methods to corroborate each other. It shows that, in some cases, mark-recapture methods can give a much more precise estimate of abundance than line-transect methods as is apparent for the humpback whale estimates above. (J. Barlow, [619] 546-7178)

The Abundance of California Coastal Bottlenose Dolphins Estimated from Replicate Aerial Surveys

Fishery Biologist Jim Carretta presented a poster that he and Wildlife Biologist Karin Forney prepared showing the results of their aerial survey data. Aerial surveys were conducted year-round on 22 dates between 1990 and 1994 to determine the minimum abundance of coastal bottlenose dolphins, *Tursiops truncatus*, in southern California. Six of the surveys were replicate flights designed to estimate the fraction missed on a single overflight. Five of these surveys used two aircraft flown one hour apart and the sixth used one aircraft surveying northbound and southbound legs several hours apart.

A simple mark-recapture model was employed to analyze the aerial survey data; the geographic location of dolphin groups and group sizes as markers were used along with expected rates of travel to determine exclusiveness of sightings between flights. Dolphins were considered "recaptured" when it was determined that both flights detected the same animals. The Chapman modification of the Peterson mark-recapture estimate was used to determine that during single aircraft flights, observers missed an average of 33.3% (95% CI=15.2%-44.1%) of all dolphins.

Survey counts for single flights made during different months ranged from 38 to 215 dolphins and indicate intra-annual variability in abundance off southern California. This is consistent with the results obtained by independent researchers since 1982 and indicates movement of bottlenose dolphins from this population northward into central California and southward into Mexican waters. The best estimate of total population size is 322 dolphins (95% CI 282-359), based on the maximum count of 215 dolphins observed in October 1991 and corrected for the estimated proportion missed. Although this estimate is similar to historical photographic mark-recapture estimates, differences in methodology and uncertainties regarding shifts in the population's range prevent direct comparisons or trend analyses. (J. Carretta, [619] 546-7181)

Counts of California Sea Lion, *Zalophus californianus*, Pups at San Nicolas Island, California: Comparison of Ground Counts and Aerial Photograph Counts

California sea lion pups are censused annually at San Nicolas Island, California, by biologists on the ground or with large-format aerial color photographs taken with a camera that eliminates distortion due to the forward movement of the aircraft. Fishery Biologist Mark Lowry examined single counts of pups from photographs and ground counts obtained at various areas of the island with paired-sample *t*-tests. The standard deviation of the differences (*Sd*) between the counts from the paired-sample *t*-test was used to measure precision of counts by each method. Simultaneous counts by biologists on the ground (*Sd* = 73.72) and counts from ground surveys made one week apart (*Sd* = 89.63) are less precise than repeated counts from large-format aerial color photographs by one person (*Sd* = 28.51) or photographic counts from three

aerial photographic surveys conducted within a one-week period (Sd = 45.07). Researchers using a paired-sample t-test comparison of ground counts against photographic counts found no significant difference between the two methods (p = 0.076), but counts from the various areas of the island can be very different between each method (Sd = 183.92). Biologists on the ground have difficulty counting large groups of pups and underestimate the number of pups when encountered with obstructed views. Although the totals of the counts for the island are close between ground and aerial photographic surveys, the trend depicted by each method is different during the 3-year period of this study. (M. Lowry, [619] 546-7174)

The Distribution of Marine Mammals Along the Aleutian Islands in 1994 - Where Have All the Blue Whales Gone?

Karin Forney, Robert Brownell, and Oceanographer Paul Fiedler presented results of a 1994 ship survey conducted south of the Aleutian Islands. This survey was designed to assess the current distribution and abundance of large whales in this historical whaling area. Line-transect methods were applied along a set of zigzag transects extending approximately 200 nmi (370 km) southward of the Aleutian Islands between 180° and 153° W longitude. Physical and biological oceanographic data were collected throughout the survey. Sea surface temperatures were slightly warmer (0.5-1.5 °C warmer) than the long-term August average east of 165° W and were within ±0.5 °C of the long-term average west of this longitude.

Eight species of cetacean were identified: Dall's porpoise, *Phocoenoides dalli* (151); humpback whale, *Megaptera novaeangliae* (57); killer whale, *Orcinus orca* (16); sperm whale, *Physeter macrocephalus* (12); minke whale, *Balaenoptera acutorostrata* (5); fin whale, *B. physalus* (4); Baird's beaked whale, *Berardius bairdii* (1); and Cuvier's beaked whale, *Ziphius cavirostris* (1). Humpback whales were the most abundant large cetacean species, with areas of concentration located primarily in deep offshore waters east of 165° W longitude, where sea surface temperatures were warmest (12-14 °C). Killer whales were seen in deep offshore waters throughout the study area. Three of the four fin whale sightings were made in shelf waters between Kodiak Island and the Shumagin Islands.

No blue whales, *Balaenoptera musculus*, were sighted, despite the historical importance of this region as a summer feeding area. The absence of blue whales raises important questions regarding the extent of historical whaling activity and the structure of blue whale stocks in the North Pacific. (K. Forney, [619] 546-7171)

The Importance of Proper Survey Design: A Case Study Using Harbor Porpoise Aerial Survey Data

Scott Benson, a marine mammal observer currently studying at Moss Landing Marine Laboratories in Santa Cruz, California, presented the results of a study he co-authored with Karin Forney and James Harvey, Moss Landing. The study showed that proper allocation of sampling effort is important to a successful survey program. Nonetheless, many sampling designs do not explicitly take allocation of samples into account. In this case study, aerial survey data for harbor porpoise, *Phocoena phocoena*, collected from 1986 to 1993 off central California were used to examine the effects of stratified sampling and sample allocation on the precision of an index of abundance. The first 3 years of the data set were used as a pilot study from which population parameters were estimated for 2 geographic strata (north and south). Four allocation techniques were evaluated by performing bootstrap simulations on the pilot data and the 1989-93 data. The optimally stratified and density-weighted designs consistently had higher precision than area-weighted or equal allocation methods. The optimal allocation model was used to determine that a sample size of 40 survey passes, 33 in the north stratum and 7 in the south stratum, would be needed to achieve 10% precision. (K. Forney, [619] 546-7171)

POPULATION IDENTITY PROGRAM - BIOLOGICAL ASSESSMENT

Prey of the Northern Right Whale Dolphin in California Coastal Waters

Fishery Biologists Kelly Robertson and Michael Henshaw identified 30 prey species in 18 northern right whale dolphin stomachs collected off the coast of California between San Francisco and the Mexican border. Observers aboard driftnet vessels collected the samples from incidental kills between 1991 and 1993. Prey were identified from fish otoliths (17 species) and cephalopod beaks (13 species) recovered from the stomachs. Average stomach fullness was 80.5%, and 23.4% of the otoliths and beaks used for species identification were extracted from recently ingested prey. Habitat for 22 of the 30 prey species has been characterized as mesopelagic. This includes lanternfishes (family

Myctophidae) which were the most numerous prey and accounted for 51.8% of all prey ingested. However, freshly ingested prey did not include lanternfish but was comprised of other predominantly mesopelagic species: Pacific hake, barracudinas, boreal clubhook squid, gonate squid, and enope squid. The scientists used published equations for converting otolith and beak measurements to prey size to estimate that the average size of fish was 10.6 cm (SE=12.1), and the average size of squid was 5.4 cm (SE=1.9). These are small prey compared to animals taken in the 50-cm average stretch mesh size used in the driftnet fishery. In fact, none of the prey species found in the sample have been reported taken in the driftnet fishery. (K. Robertson, [619] 546-7182)

POPULATION IDENTITY PROGRAM - GENETICS

Probabilities of Population and Dispersal Rates Inferred from Genetic Distance Data for Marine Mammals

Wildlife Biologist Susan Chivers and Fishery Biologist Barbara Taylor are studying the interpretation of genetic evidence of population distinctness in terms of annual dispersal rates between populations in order to meet the management objectives of the Marine Mammal Protection Act. An individual-based model is used to translate from genetic distance data to estimates of dispersal rates. This approach does not require that statistical power be estimated to interpret results, but it does depend on capturing the genetic variability of a population in equilibrium to establish initial conditions for the model. The scientists used mtDNA genotypes sequenced from individual harbor porpoise in their model and asked the question, What is the probability of observing the detected level of genetic distinctness at different hypothetical dispersal rates? The probability is estimated using the shift in distributions of Φ_{st} (calculated from an analysis of molecular variance) from the beginning to the end of model simulations for each dispersal rate.

A case was considered in which a manager has set the critical, or maximum, dispersal rate for maintaining population distinctness at 1% per year. For an average initial Φ_{st} of 0.07, the probability that dispersal rates were ≤1% per year was 0.34, 0.66, and 0.68 for population abundances 300, 1,000, and 5,000, respectively. Managers can use these probabilities to assess the costs of different management schemes after setting a critical dispersal rate to meet management objectives. (S. Chivers, [619] 546-7093)

Power Analysis of Genetic Data to Define Population Structure

Barbara Taylor, Susan Chivers, and Andrew Dizon, leader of the Population Identity Program, investigated statistical methods using genetic distance data to make decisions about managing groups of animals together or separately.

For genetic studies, scientists often present genetic results about population subdivision hypotheses as *P*-values and evaluate the significance of a test for a single type I error ($\alpha = 0.05$). Negative results are often interpreted to mean that populations should be managed together. The manager cannot address the question, If these 'populations' were mixing at 1% per year, what is the probability that this research would have detected it? This represents the statistical power of the test (1-β, where β is the type II error).

Marine mammal examples were used to show the need to (1) define a specific alternative hypothesis about required dispersal, (2) translate dispersal into genetic measures via a model, and (3) present results for a range of errors (both α and β). Management objectives set by the Marine Mammal Protection Act define the alternative hypothesis. The results agreed with analytical results: the statistical power to detect differences was found to be low when abundance exceeded the low hundreds and dispersal was moderate (a few individuals per year). (B. Taylor, [619] 546-5620)

Phylogenetic Relationships of the Closely Related Sei and Bryde's Whales: A Possible Third Species?

Like many other cetaceans, the Bryde's whale, *Balaenoptera edeni*, taxon seems composed of several morphologically and ecologically differentiated populations that are thought to be genetically isolated to some degree. Andrew Dizon presented the results of a review he, Christie Lux, Sean Costa, Richard LeDuc, and Robert Brownell completed. Their molecular analysis, based on the maternally inherited mitochondrial DNA genome (hypervariable region I of the control region), suggests that one of the morphotypes examined may be a separate species.

This result is based on a maximum parsimony phylogeny from 22 Bryde's and 12 sei whale (*B. borealis*) sequences (some from old bones and forensic samples), and includes blue (*B. musculus*) and fin (*B. physalus*) whales as outgroup taxa. Three sequences (one morphologically verified from skull

measurements as a so-called pygmy Bryde's type) cluster basally in the phylogeny relative to the other ingroup taxa. This finding, as well as earlier allozyme results, implies separate species status. Curiously, in both these results and the earlier ones, the standard-form Bryde's whale is more closely related to its congener, the sei whale, than it is to its ostensible conspecific, the pygmy Bryde's whale. (A. Dizon, [619] 546-7089)

Mitochondrial Systematics of the Delphinidae

Current dolphin taxonomy is largely based on past morphological systematic studies, and to date, molecular studies on delphinids have been limited in scope. To provide an independent phylogeny and perhaps clarify some unresolved relationships, Richard LeDuc, Andrew Dizon and Senior Scientist William Perrin constructed a more comprehensive molecular phylogeny. The scientists sequenced the entire cytochrome *B* gene (1140 bp) of 45 dolphins representing all genera and all but four species of extant delphinids. Seven non-delphinid cetacean species were also sequenced as outgroups. Phylogenies were constructed using parsimony, maximum likelihood, and neighbor-joining methods.

The results strongly indicate the need for several taxonomic revisions. For example, the genus *Stenella* is an artificial assemblage, with some species more closely related to *Delphinus* or *Tursiops* than to their congeners. Also shown to be paraphyletic is the genus *Lagenorhynchus*. The sister species *L. obliquidens* and *L. obscurus* show close affinity to *Cephalorhynchus* and *Lissodelphis* and require a generic name change. The type species for the genus *Lagenorhynchus albirostris* is far removed from its congeners in our phylogeny. *Lagenorhynchus acutus* also did not show any close affinities, although *L. australis* and *L. cruciger* were unavailable for analysis. At the subfamily level, Lissodelphinae and Cephalorhynchinae compose a tight clade that includes *L. obscurus* and *L. obliquidens* and should be combined. Because none of the *Lagenorhynchus* spp. fell inside the Delphininae, they should be removed from that subfamily. *Grampus* is shown to be part of the subfamily Globicephalinae, nested in the clade that includes Globicephala, Pseudorca, Feresa, and *Peponocephala*. (R. LeDuc, [619] 546-7095)

Population Structure of Bottlenose Dolphins, *Tursiops truncatus*

While most authors have provisionally accepted that there is a single species of bottlenose dolphin, *Tursiops truncatus*, phylogenetic relationships among populations with both allopatric and sympatric distributions have not been defined, and taxonomic work is required for clarification of the many nominal species (including the inshore *T. aduncus*). Furthermore, it is not clear whether variations among populations reflect genuine phylogenetic separations or merely the ecological plasticity of a widely distributed single species.

Population Identity Program scientists Barbara Curry, Richard LeDuc, and Andrew Dizon (working with R.G. Milinkovitch of Liege University, Belgium, and J. Smith of Rhodes University, South Africa) completed a direct sequencing of the mtDNA control region in 99 bottlenose dolphin samples. This combined effort was employed to examine population structure in bottlenose dolphins from the Pacific, Atlantic, and Indian Oceans.

Results support the existence of multiple inshore stocks that are genetically isolated from offshore animals, including those in their own ocean basins, but did not indicate isolation between offshore stocks from different ocean basins. Genetic differences between bottlenose dolphin populations from the inshore northern Gulf of Mexico to the east coast of the United States and all other individuals sampled suggest that they represent separate species. (B. Curry, [619] 546-7094)

Molecular Investigation and Management of Harbor Seal Populations in Alaska

The decline in numbers of Pacific harbor seals, *Phoca vitulina richardsi*, in some areas of Alaska raises concerns over the definition of management units. To address this issue, San Diego State graduate student Robin Westlake (working with Greg O'Corry-Crowe, Barbara Taylor, and Andrew Dizon from the SWFSC) is using polymerase chain reaction amplification and automated sequence analysis of mtDNA ($tRNA^{pro}$ gene and d-loop, 434 bp) to study the population structure from the three designated potential biological removal management units within Alaska: (1) Bering Sea, (2) Gulf of Alaska, and (3) Southeast Alaska. A preliminary investigation of 103 animals showed no significant substructuring (analysis of molecular variance, alpha = 0.05). Samples were highly polymorphic and a total of 54 haplotypes were detected.

These results could indicate that either the sampled population is panmictic or the population is genetically subdivided. Unfortunately, the analysis has insufficient resolving power, due to the limited sample size, choice of genetic loci, or a small effect size.

Genetic differentiation depends on dispersal and abundance. Both high abundance and high dispersal contribute to increased homoginity. The high abundance of harbor seals in Alaska would therefore result in little genetic differentiation even with low dispersal. Although a few dispersers per year may be insufficient to warrant managing Alaska areas as one unit, it may be sufficient dispersal within this large population to effectively homogenize the populations genetically. (R. Westlake, [619] 546-7001)

PHOTOGRAMMETRY PROGRAM

Measurements of California Gray Whale Day/Night Migration Patterns with Infrared Sensors

Independent contractor Meghan Donahue, Fishery Biologist Wayne Perryman, and National Marine Mammal Laboratory Biologist Jeffrey Laake used data collected with infrared sensors from the U.S. military to test the assumption that diel (day/night) variation does not occur in the migration patterns of California gray whales passing Granite Canyon, California. It was assumed that if day and night migration rates differ, population estimates based on visual counts will be biased.

The standard composite video output from the sensors was recorded on two-hour VHS videotapes. Each videotape was reviewed independently by at least two technicians who recorded pod size and the time of each respiration. Mean distance offshore for each pod was determined by the angle of declination from the horizon to the pod.

No significant differences in pod sizes or surfacing intervals were found between day and night. Mean distance from shore was significantly shorter at night in 1993/94 (t-test, p=0.01), but this was not the case in 1994/95 (t-test, p=0.57). In addition, the researchers used logs of pods per tape and whales per tape to compare day and night migration rates. For the 1993/94 field season, a significantly larger number of pods per tape were seen at night (paired t-test, p=0.05). For the 1994/95 data set, there were no significant differences between day and night. When data were lumped over years, the number of pods per tape was significantly higher at night (t=2.09; p=0.05), but the number of whales per tape did not differ significantly (t=1.25; p=0.22). The 1995/96 field season should provide a better understanding of gray whale migration patterns that can be used to improve their population abundance estimates. (W. Perryman, [619] 546-7014)

Aerial Photogrammetry and Photo-identification of Blue Whales *(Balaenoptera musculus)* at the California Channel Islands—1994

Photogrammetrists James Gilpatrick, Wayne Perryman, and Morgan Lynn used large-format vertical aerial photography to identify individual blue whales and compare lengths from photographs taken at the California Channel Islands in 1994 with known blue whale lengths in other oceans. To date, 74 individual blue whales have been identified based on color patterns, scars, or both. Evidence from geographic distributional data indicates that the whales found in California may be separate from other blue whale stocks. These photographs will provide morphological evidence for any stock differentiation between blue whale stocks. Morphometric data (derived photogrammetrically) for California whales were tested against length data available for blue whales taken in fisheries in the Antarctic, Indian, and North Pacific Oceans.

Results from analysis of variance (ANOVA) of total lengths (TL, for whales ≥ 20 m) revealed significant differences ($p < 0.001$) between sampled geographic areas. Post hoc tests showed California and pygmy blue whales (*B. m. brevicauda*, from the Indian Ocean) were similar in TL (Scheffe's test, p=0.80) and both were significantly smaller than whales from the other geographic areas. Because pygmy blue whales have been described as having a shorter tail section than "regular" or full-sized blue whales, the scientists tested for differences in the distance from dorsal fin to fluke notch (DRSFN-FLKNTCH) and used data available from California, pygmy, and Antarctic whales. ANOVA showed significant differences between whale groups ($p < 0.0001$). Scheffe's tests indicated no difference in DRSFN-FLKNTCH between California and pygmy blue whales ($p = 0.33$). Location of dorsal fin was found to be more posterior for California and pygmy blue whales when compared with Antarctic whales ($p < 0.0001$).

TL data for California whales, when stratified, showed a lack of juvenile-sized whales off San Nicholas Island in August. Temporal and spatial aspects of segregation merit further investigation to reveal any similarities with patterns described for other rorqual populations. Size of weaning for

calves (approximately 16 m) was found to be similar to that noted for blue whales from Antarctica.

These results support previous distributional and photo-identification studies which indicate that blue whales found seasonally between Baja California, Mexico, and central California are a discrete geographic population in the northeastern Pacific. Preliminary analyses indicate that California whales are similar in length to pygmy blue whales from the Indian Ocean. (J. Gilpatrick, [619] 546-7195)

DOLPHIN ECOLOGY PROGRAM

Survey Completed of Indian Ocean Cetaceans

Ecologist Lisa Balance and Wildlife Biologist Robert Pitman conducted a cetacean survey in the western tropical Indian Ocean (mainly the Arabian Sea from Sri Lanka to Somalia and from Oman to the Seychelles Islands) aboard an oceanographic research vessel during 105 sea days from March 21 to July 25, 1995. The scientists used mounted 25X binoculars and line-transect methodology and recorded 589 sightings of 21 species of whales and dolphins. The most commonly identified species were sperm whales, *Physeter macrocephalus* (99), and spinner dolphins, *Stenella longirostris* (65). Significant findings included the following:

(1) Blue whales, *Balaenoptera musculus* (17 sightings), were highly localized during this study, being recorded only between the Maldives Islands and the tip of India.

(2) Dwarf sperm whales, *Kogia simus*, (21 sightings) were observed widely in the open ocean while pygmy sperm whales, *K. breviceps*, (2 sightings) were almost entirely absent from pelagic waters, suggesting habitat partitioning between these species similar to that observed in the eastern tropical Pacific and Gulf of Mexico.

(3) Bottlenose whales, *Hyperoodon* cf. *planifrons*, (3 sightings) were recorded in the central Arabian Sea at 7° N latitude, the first confirmed sightings of this species north of the equator in the Indian Ocean.

(4) Mixed aggregations of spinner and spotted, *S. attenuata*, dolphins with yellowfin tuna were recorded for the first time in waters other than the eastern tropical Pacific Ocean.

(5) *Delphinus* cf. *tropicalis* was common off the coast of Oman (16 sightings) and readily distinguishable in the field from both *D. delphis* and the recently recognized *D. capensis*, providing, perhaps, further evidence that this is in fact a separate species.

These data, along with data collected on sea bird and flying fish communities and marine turtle distribution, have been summarized in a NOAA Technical Memorandum. (L. Ballance, [619] 546-7173)

Whale Habitat and Prey off Southern California

A Whale Habitat and Prey Survey (WHAPS95) was conducted off southern California during August 1995 to study the distribution and activities of blue and other large whales, to survey the distribution of krill, and to quantify habitat variability affecting both whales and their prey. Paul Fiedler presented a poster which provided some of the preliminary results of the survey. The presentation was co-authored by Ecologist Stephen Reilly, Oceanographer Valerie Philbrick, Fishery Biologist Roger Hewitt, Ocean Acoustics Engineer David Demer, and Fishery Biologist Susan Smith. A total of 580 cetacean sightings were made, including 146 blue whale, 62 fin whales, and 81 humpback whale sightings. Most blue whales were found in cold, productive upwelled water advected south of Point Conception. They were aggregated in this water near San Miguel and Santa Rosa Islands, where they fed on dense, subsurface layers of the large euphausiid *Thysanoessa spinifera* which extended off the shelf edge. These krill patches on the Channel Island feeding grounds are a resource exploited during summer-fall by the world's largest stock of blue whales. (P. Fiedler, [619] 546-7016)

HONOLULU LABORATORY

Honolulu, Hawaii

PROTECTED SPECIES INVESTIGATION

Preliminary Results of the 1995 Hawaiian Monk Seal Field Season

During 1995, long-term field camps were established at the six main breeding islands of the Hawaiian monk seal, *Monachus schauinslandi*—Kure Atoll, Midway Atoll, Pearl and Hermes Reef, Lisianski Island, Laysan Island, and French Frigate Shoals.

Primary activities at the camps included pup tagging; population monitoring; collecting, rehabilitating, and releasing seals; and collecting scats for prey species determination. The primary indicators of the status of these main populations are the number of pups born and the mean beach counts (Fig. 1). As illustrated in Figure 1, the mean beach counts for these breeding sites totaled 383. Brief highlights of field activities are provided below.

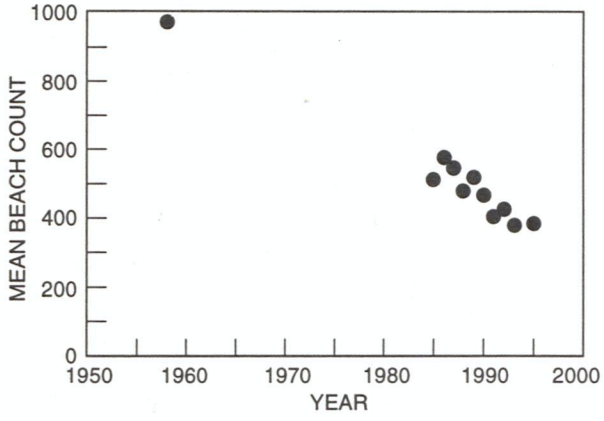

Figure 1. Annual total of mean beach counts of the Hawaiian monk seal at its six main reproductive sites, showing the extent of decline since the late 1950s.

Kure Atoll

A field camp was established at Kure Atoll during May 14-July 13, under the supervision of Lucy Keith, cooperating scientist, Joint Institute of Marine and Atmospheric Research (JIMAR), University of Hawaii. In addition to population monitoring, activities included the release of yearling seals that had been collected as underdeveloped pups in 1994 and the identification and enumeration of the population of seals at Kure Atoll by applied bleach marks, tags, and distinctive scars. Twelve atoll-wide counts were conducted, resulting in a mean(±*s*) of 42.3(±4.4) seals (excluding pups). Eleven pups were born (6 male, 5 female). A total of 102 individuals were identified by existing or newly applied tags, applied bleach marks, natural marks, and scars. Seven yearling seals were released, and all were resighted throughout the duration of the field effort. Two seals were observed entangled in marine debris; a weaned pup was released from a piece of net, and a nursing pup entangled in the debris freed itself unaided. Potentially hazardous debris items totaling 313 pieces were inventoried and destroyed. Fifty-seven scat and spew samples were collected.

Midway Atoll

Field studies were conducted at Midway Atoll during March 31-April 28 under the direction of Lee Eberhardt, contractor to the Marine Mammal Research Program, and during August 4-18 under the direction of Wildlife Biologist William Gilmartin. Activities at Midway focused on the tagging of pups and other untagged seals and identification of the population. Six pups were born, the highest documented total from Midway. All pups were tagged (two were tagged by U.S. Fish and Wildlife Service personnel), as were an additional 10 seals. A preliminary population estimate for the number of seals at Midway is 41 individuals.

Pearl and Hermes Reef

Field studies were conducted at Pearl and Hermes Reef from July 16 to August 31 under the direction of Fishery Biologist John Henderson. Camps were erected at Southeast and North Islands, ensuring coverage of the entire atoll. Research objectives included population monitoring and identification of the entire population by applied bleach marks or known scar profiles of individual seals. Ten censuses of all islets in the atoll were conducted. The mean beach count (excluding pups) was 81.7(±13.1) seals. A total of 27 pups were born (16 male, 11 female). Twenty-three juveniles were newly tagged, and tags were replaced on 13 other seals. A preliminary population estimate for seals using Pearl and Hermes Reef in 1995 is 225, representing an increase of about 50 animals from the last population estimate derived in 1991. One seal was disentangled from marine debris, and entanglement scars had appeared on 2 seals since the previous field camp season in 1993. Bones from 2 seals were found, 1 of which had been entangled in marine debris. Hazardous debris items totaling 678 pieces were inventoried and destroyed. Sixty-four scat and spew samples were collected for identification of prey items.

Lisianski Island

Field studies of the Hawaiian monk seal at Lisianski Island were conducted from April 19 to July 14 under the direction of Heather Johnston, cooperating scientist, JIMAR. Research objectives specific to this population included identification of all seals and documentation of adult male behavior. Fourteen censuses were conducted, and the

mean(±s) count (excluding pups) was 66.7(±7.0). Because Lisianski Island was visited for only a single day in 1994, beach count and population composition data were not obtained for comparison with the current year. However, mean beach counts from 1995 are similar to mean counts recorded in 1992 and 1993 (70.5[±9.3] and 64.0[±10.4], respectively). A total of 218 seals were identified. The male-to-female sex ratio of 1.6:1.0 continues the downward trend of recent years (2.0:1.0 in 1992 and 1.7:1.0 in 1993). Twenty-two pups were born (10 females, 10 males, 2 unknown), compared with 23 and 17 pups in 1992 and 1993. Three seals died during the 1995 field season, and two others disappeared and are assumed dead. Two emaciated juvenile males died, and another emaciated juvenile male disappeared after receiving a shark-inflicted injury. A prematurely weaned male pup disappeared, and a nursing male pup died of undetermined causes. In addition, a prematurely weaned pup in deteriorating condition at the end of the field season probably did not survive. Although mobbing events were not observed, two mating-related injuries were seen on adult females. Six seals were entangled; 2 adult females escaped by themselves, and 4 pups (3 weaned females and a nursing male) were released by observers. The remains of a subadult seal and 2 pups that had died of unknown causes since the 1994 field season were also found.

Laysan Island

Field studies were conducted at Laysan Island during April 21-July 18 under the direction of Wildlife Biologist Brenda Becker. In addition to population monitoring, scientists worked to identify the entire population and monitor behavior of adult seals as part of continuing research on the occurrence of mobbing. The mean(±s) of 13 beach counts was 69.5(±10.0), excluding pups, which is similar to totals of the past 5 years. The total number of animals in the population (excluding pups) was 209, 11 fewer than counted in 1994. This decrease in number was largely due to the translocation of 21 adult males to the main Hawaiian Islands in 1994; none of these males were resighted in the Northwestern Hawaiian Islands in 1995. The total Laysan population included 68 adult males and 70 adult females (ca. 1.0:1.0).

Forty-three pups were born (23 female, 18 male, 2 unknown), the third highest number of births recorded since 1977. The birth rate was 61% for adult-sized females. Thirty-seven of the pups were tagged; one was still nursing at the end of the season. Five neonate pups (2 male, 2 female, one unknown) were known to have died of unknown causes. Two yearling females disappeared and are assumed dead; one had received injuries from a mobbing event, and the other was severely emaciated.

Two seals were entangled in marine debris; one disentangled itself, and the other was released uninjured by field staff. All marine debris capable of entangling an animal was inventoried and destroyed. Of 17 seals that had been oiled from a spill in 1993, 12 were sighted in 1995. Of the 5 not sighted, 1 was not seen in 1994 and 1 (adult male) had been translocated to the main Hawaiian Islands from Laysan Island in 1994.

French Frigate Shoals

A field camp at French Frigate Shoals was established during May 8-September 3 and during October 25-November 18 under the direction of Mitchell Craig, JIMAR cooperating scientist. In addition to population monitoring, activities included collection of underdeveloped pups for rehabilitation at facilities on Oahu and instrumentation of seals with satellite transmitters, time-depth recorders, and video cameras. Ten atoll-wide censuses were conducted, resulting in a mean(±s) spring-summer beach count of 123.9(±14.3) seals, excluding pups, approximately 35 fewer than in 1994. The 73 births were 38 fewer than in 1994. Of 56 pups that survived to weaning, 55 were tagged. Tags were replaced on 103 seals which had lost or broken tags. Twelve undersized female weaned pups were collected for rehabilitation and subsequent release. Twenty-four seals were found dead, 12 of which were prematurely weaned pups or stillbirths. Three male seals were instrumented with both satellite and radio transmitters in November and were tracked for 3 weeks to determine the satellite tag position error. (J. Henderson, [808] 943-1225; and T. Johanos-Kam, [808] 943-1271)

ECOSYSTEM AND ENVIRONMENT INVESTIGATION

Video Cameras Provide First Insight into Hawaiian Monk Seal Foraging Ecology

During November 1995, eight adult male Hawaiian monk seals, *Monachus schauinslandi*, at French Frigate Shoals in the Northwestern Hawaiian Islands were fitted with video recording instruments. These "crittercams" were provided by National Geographic Television and were evaluated by

Honolulu Laboratory researchers as a data collection instrument to assess the seals' foraging strategies. The video cameras were set to record images and sounds at periodic intervals (for example, 3 minutes every 30 minutes) during the times the seals were at sea. Depth profiles of the seals' movements were recorded continuously throughout the deployment. All of the cameras deployed were retrieved in good condition.

Preliminary examination of the resulting videotapes and depth data indicated that the seals foraged at depths ranging from 10 to 90 meters but always targeted benthic-associated fauna. Prey items identified included reef fish and octopus. Foraging activity included opportunistic searching of the shallow bottom as the seals moved between haulout sites and periods of intense diving and searching of 60- to 90-meter habitat on the slopes of the atoll. Some of this deep habitat contained numerous rocks which one seal was observed to routinely flip over in order to get to the animals hidden underneath. Supplementary information, such as aggression between adult and juvenile seals, was also apparent in the videotapes.

This work has provided researchers with unique insights into the foraging strategies of adult monk seals and has distinguished National Geographic's "crittercam" as a valuable tool for studying monk seal foraging behavior. Additional studies are planned for August 1996. (F. Parrish, [808] 943-1254)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

Expert Consultation on Indian Ocean Tunas Held in Colombo

The 6th Expert Consultation on Indian Ocean Tunas was held in Colombo, Sri Lanka, September 25–29, 1995. Attending the consultation were 51 scientists from national institutions of 20 countries and representatives from international tuna commissions and the Food and Agriculture Organization (FAO). The consultation was organized by the FAO Indo-Pacific Tuna Development and Management Programme to review progress of research, developments in the fisheries, and the status of the stocks of Indian Ocean tuna and tuna-like species. Gary Sakagawa, chief of the Pelagic Fisheries Resources Division, attended and served as moderator for a session involving status of the stocks. Although data for assessing the status of the stocks were either not available in usable form or inadequate for assessment of the current condition of the stocks, the meeting, nonetheless, was successful in promoting information exchange among researchers, updating information on the fisheries, and identifying research needs for performing stock assessments.

The consultation noted, among other things, that there is an urgency to complete an up-to-date stock assessment because the tuna fisheries in the Indian Ocean are expanding. Since 1982, total catch of tuna and tuna-like species has steadily increased— doubling every five years—with growth and expansion of coastal and high-seas fisheries. In 1993, the total catch was approximately 981,300 mt, of which 690,300 mt (70%) was principal tuna species (yellowfin, bigeye, albacore, southern bluefin, and skipjack) and the rest neritic tuna species, seerfishes, and billfishes. Increased catches of yellowfin tuna and skipjack tuna are the primary causes for this upward trend. Southern bluefin tuna catches, on the other hand, have fallen markedly (34,700 mt in 1983 to 4,300 mt in 1993) during the period, and catches are being severely restricted for conservation purposes.

Most available catch-per-unit of effort (CPUE) indices, which are standard measures of fishery performance, indicated an increasing or stable trend over recent years. This implies no or little effect on stock condition due to increased catches; however, the consultation voiced caution in drawing such a conclusion. It was noted that technological innovations and new fishing practices introduced into many of the fisheries have likely increased the efficiency of a unit of fishing effort over the years. Such improvements in fishing efficiency so far have not been accounted for in computing CPUE indices. It was recommended that analyses be undertaken to adjust CPUE indices for improvements in fishing efficiency, and that this be a priority in an up-to-date assessment of stock condition. (G. Sakagawa, [619] 546-7073)

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

47th International Tuna Conference Call for Papers

The first announcement and call for papers for the 47th International Tuna Conference was mailed in October. The conference is planned for May 20-23, 1996, at the University of California Conference

Center at Lake Arrowhead, California. Sponsors are the U.S. National Marine Fisheries Service and the Inter-American Tropical Tuna Commission. Norman Bartoo, Alan Jackson, and Rand Rasmussen of the SWFSC are the co-chairs for the conference.

The theme for the 47th Tuna Conference is "Sustaining Tuna Fisheries--Issues and Answers." This theme is designed to address questions such as: How can the world's tuna resources continue to support an increasingly industrialized and multinational fishery into the 21st century? Stock enhancement and aquaculture--a solution to overfishing? Fisheries monitoring and stock assessment requirements of the new FAO agreement on straddling fish stocks and highly migratory fish stocks--are the data good enough? Management of fishery inputs versus outputs--are we up to the challenge? The burgeoning developing world--can the resource meet the potential demand of these new and emerging markets?

Deadline for receipt of abstracts is April 1, 1996. Twenty minutes is to be allocated for each presentation with an additional five minutes for questions. There will be an author-attended poster session for poster papers. The conference provides scholarships in support of students presenting papers. For additional information, contact Rand Rasmussen at (619) 564-7184 or by e-mail at rand@tuna.ucsd.edu. (N. Bartoo, [619] 546-7073)

Albacore Data Collected at Sea

SWFSC Biologist John Childers sailed with the 42-foot albacore troll vessel *Triggerfish* to collect fishery and biological data on the late-season nearshore albacore fishery. The *Triggerfish* operated along the west coast from Ilwaco, Washington, to Point Conception, California, within 100 miles of shore and logged only eight fishing days between September 14 and 28; the remaining time was lost to weather. The average catch was 30 fish per day fishing with fish averaging about 12.5 lbs and 65 cm fork length. (N. Bartoo, [619] 546-7073)

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

1995 U.S. Western Pacific Purse Seine Fishery

To date, landings data have been received from 42 U.S. purse seiners that fished in the western tropical Pacific under the South Pacific Tuna Treaty in 1995. Provisional landings from these vessels are 140,300 mt of skipjack tuna and 32,100 mt of yellowfin and bigeye tunas (Fig. 1). While some landings data still have not been received at the time of this writing, 1995 skipjack tuna landings are within 4% of those in 1994 and combined yellowfin and bigeye tuna landings are 47% lower. When all the data are processed, 1995 landings are expected to be close to those in 1994. Updated landings and results of sampling of catches and vessel logbooks will be available in the next SWFSC quarterly report. (D. Prescott, [619] 546-7080)

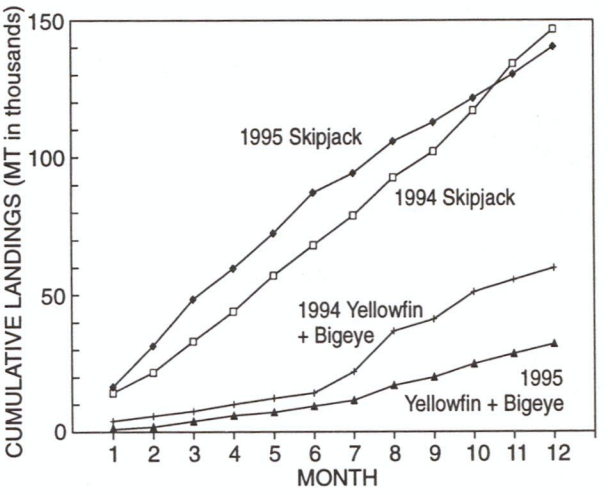

Figure 1. Cumulative tuna landings, by month, for the U.S. western tropical Pacific purse seine fishery, 1994 and 1995 (preliminary).

TIBURON LABORATORY

Tiburon, California

COASTAL FISH COMMUNITIES INVESTIGATION

Workshop on Sampling Methods for Surveys of Coho Salmon

To improve surveys of salmonid occurrences in coastal streams of northern and central California, the Coastal Fish Communities Investigation conducted a workshop that included managers and researchers from state and federal agencies, universities, and industry. The workshop was organized

by Pete Adams, leader of the Tiburon Laboratory's coho salmon project, and was held at the NMFS Southwest Region's facility in Santa Rosa, California, on December 5-6, 1995.

The purpose of the workshop, which focused on current research, was to establish a protocol for assessing salmonid abundance and distribution. Each of the wide variety of methods now in use was described, with subsequent discussion examining the strengths and weaknesses of each. Current efforts to assess juveniles include visual counts, electrofishing, and traps; adults are being assessed by counts of individuals and redds. Lengthy discussion of relative merits in presence/absence data produced a consensus that while presence is a useful statistic, absence is essentially impossible to determine. It was concluded that there is need for a standard protocol for determining absence and that studies should incorporate a 3-year time frame that would include all segments of the population.

The workshop succeeded in establishing lines of communication among the many and diverse workers in the field. Priorities were set regarding species and streams to be studied, and groundwork was established for a coastwide database that would make generally available the great body of information now being collected. (T. Laidig and K. Silberberg, [415] 435-3149, ext. 223)

INFORMATION TECHNOLOGY SERVICES

ITS Chief Retires

Rob Bistodeau has taken over management of Information Technology Services (ITS) in La Jolla from Dorothy Roll, who retired from federal service in December. As chief of ITS, Roll transformed the Center's computer operations into a sophisticated, cost-effective computer system supporting the many complex database, communication, and computation needs of Center scientists and administrative personnel. She also devoted much effort to national computer issues and planning, including the ITS-95 project.

During the quarter, ITS staff assisted the Coastal Division's California Cooperative Fisheries Investigation (CalCOFI) data management group in moving their data processing from the mainframe Vax computer timeshared through the University of California San Diego to the Center's SGI work stations. In addition to providing routine troubleshooting, backup, maintenance, and other administrative services for the newly acquired workstation, called "cfrdsgi," ITS staff also supplied programming support to convert data processing programs from Vax to SGI-operable versions for CalCOFI cruise planning and processing and for Aerial Marine Resources Monitoring System (AMRMS) sight and effort processing. During the conversion process, "cfrdsgi" functions were expanded and more software, more users, and access to more printers were acquired.

ITS plans to continue to support the Coastal Division's programming needs, including the development of Oracle forms for data entry, moving a preliminary version of the CalCOFI database to the center-owned SGI's Oracle for testing, conversion of utility programs from Basic to Fortran, and inclusion of AMRMS data into an Oracle database. (S. Jacobson, [619] 546-7060)

PUBLICATIONS

Published

Barlow, J., R. L. Brownell, Jr., D. P. DeMaster, D. A. Forney, M. S. Lowry, S. Osmek, T. J. Ragen, R. R. Reeves, and R. J. Small. 1995. U.S. Pacific marine mammal stock assessments. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-219, 162 p.

Under the 1994 amendments to the Marine Mammal Protection Act, the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) are required to produce stock assessment reports for all marine mammal stocks in waters within the U.S. Exclusive Economic Zone. This document contains the stock assessment reports for the U.S. Pacific marine mammal stocks under NMFS jurisdiction; reports for species under the management jurisdiction of the USFWS are not included. A separate report containing background, guidelines for preparation, and a summary of all stock assessment reports is available from the NMFS Office of Protected Resources. Individual stock assessment reports will be updated as new information becomes available and as changes to marine mammal stocks and fisheries occur; therefore, each stock assessment report is intended to be a stand alone document.

Bigelow, K. A., and C. H. Boggs. 1995. Hawaii-based swordfish longline vessel distribution and catch from 1991 to 1994: Relation to observed thermal structure and lunar periodicity. [Abstr.] Pelagics Fisheries

Research Program Workshop, East-West Center, Honolulu, Hawaii, November 28–30, 1995.

Bjorndal, K. A., A. B. Bolten, A. L. Coan, Jr., and P. Kleiber. 1995. Estimation of green turtle (*Chelonia mydas*) growth rates from length-frequency analysis. Copeia 1995(1):71–77.

Curran, D., X. He, Q. Yang, and C. H. Boggs. 1995. Performance indices for Hawaii's troll and handline fisheries. [Abstr.] Pelagics Fisheries Research Program Review, Honolulu, Hawaii, November 28–30, 1995.

DeMartini, E., F. A. Parrish, and J. D. Parrish. 1995. Interdecadal changes in reef fish abundance at two pristine Hawaiian atolls. [Abstr.] The 8th International Coral Reef Symposium, June 1996, Panama.

Forney, K. A. 1995. A decline in the abundance of harbor porpoise, *Phocoena phocoena*, in nearshore waters off California, 1986–93. Fish. Bull., U.S. 93(4):741–748.

Hayward, T., D. Cayan, P. Franks, R. Lynn, A. Mantyla, J. McGowan, P. Smith, and F. Schwing. 1995. The state of the California Current 1994–1995; a period of transition. CalCOFI Reports. 36:19–39.

He, X. 1995. Preliminary estimation of shark bycatch in the Hawaii longline fishery. [Abstr.] Pelagic Fisheries Research Program Review, Honolulu, Hawaii, November 28–30, 1995.

He, X., and C. H. Boggs. 1995. Estimating fisheries impacts using commercial fisheries data: Simulation models and time series analysis of Hawaii's tuna fisheries. Second World Fisheries Congress, Australia, August 1966.

He, X., and C. H. Boggs. 1995. Simulation modeling and time series analysis of catch and CPUE in Hawaii's tuna fisheries. Pelagic Fisheries Research Program Review, Honolulu, Hawaii, November 28–30, 1995.

Kirkley, J. E., D. Squires, and I. E. Strand. 1995. Assessing technical efficiency in commercial fisheries: the mid-Atlantic sea scallop fishery. Amer. J. Agr. Econ. 77:686–697.

Despite the extensive effort to research issues of allocative efficiency in fisheries, little empirical analysis of technical efficiency in fisheries exists. This study examines vessel efficiency using a stochastic production frontier based on a sample of sea scallop vessels operating in the Mid-Atlantic between 1987 and 1990. Estimates of technical efficiency are computed and compared with input usage, resource conditions, economic performance, and recently imposed regulations. The analysis suggests that owners and captains only partially compensate for changes in resource conditions through the use of labor and fishing effort, and recent regulations may improve overall technical efficiency in the short run.

Lenarz, W. H., D. VenTresca, W. M. Graham, F. B. Schwing, and F. Chavez. 1995. Explorations of El Niños and associated biological population dynamics off central California. CalCOFI Reports. 36:106–119.

Lynn, R. J., F. B. Schwing, and T. L. Hayward. 1995. The effect of the 1991–93 ENSO on the California Current System. CalCOFI Reports. 36:57–71.

Polovina, J. J. 1995. A climate-induced change in carrying capacity of the coral reef ecosystem in the Northwestern Hawaiian Islands. [Abstr.] The 8th International Coral Reef Symposium, June 1996, Panama.

Ramp, S. R., N. Garfield, C. A. Collins, L. K. Rosenfeld, and F. B. Schwing. 1995. Circulation Studies over the Continental Shelf and Slope near the Farallon Islands, CA, Executive Summary. Technical Report NPS-OC-95-004. 40 p.

Sakagawa, G. T. 1994. Theme 5: Assessment methodologies and fisheries management, pp. 194–196. *In* C. W. Voigtlander (ed.), The state of the world's fisheries resources. Proceedings of the World Fisheries Congress, Plenary Sessions. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Sakagawa, G. T. (ed.) 1995. Assessment methodologies and management. Proceedings of the World Fisheries Congress, Theme 5. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. 195 p.

Sakuma, K. M., F. B. Schwing, H. A. Parker, and S. Ralston. 1995. The physical oceanography off the central California coast during February and May–June, 1991: a summary of CTD data from larval and pelagic juvenile rockfish surveys. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-220. 156 p.

Hydrographic conditions during a 7-day period in February 1991 in the area bounded by Cypress Point (36°30′ N) and Point Reyes (38°10′ N), California, from the coast to approximately 135 km offshore are summarized in a series of horizontal maps and vertical transects. In addition, hydrographic conditions during three periods of approximately ten days each from mid-May through mid-June 1991 in the coastal ocean bounded by Cypress Point and Point Reyes and from the coast to about 75 km offshore are also summarized. A total of 69 conductivity-temperature-depth (CTD) casts were obtained during the R/V *David Starr Jordan* Cruise DSJ9102, while 240 standard casts were taken during Cruise DSJ9105 over the course of three consecutive sweeps of the region. Data products contained in this report include (1) a master list of CTD stations during each cruise; (2) surface meteorological time series from the region's four National Data Buoy Center meteorological buoys; (3) horizontal maps of temperature, salinity, and density at depths of 2, 10, 30, 100, 200, 300, and 500 m; and (4) temperature, salinity, and density along four cross-shelf vertical transects in the survey region.

Sakuma, K. M., F. B. Schwing, H. A. Parker, K. Baltz, and S. Ralston. 1995. The physical oceanography off the central California coast during March and May–June,

1994: a summary of CTD data from larval and pelagic juvenile rockfish surveys. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-221, 202 p.

Hydrographic conditions during a 9-day period in early March 1994 in the area bounded by Cypress Point (36°35′ N) and Bodega Bay (38°20′ N), California, from the coast to approximately 240 km offshore are summarized in a series of horizontal maps and vertical transects. In addition, hydrographic conditions during three periods of approximately ten days each from mid-May through mid-June 1994 in the coastal ocean bounded by Cypress Point and Point Reyes and from the coast to about 75 km offshore, are also summarized. A total of 71 conductivity-temperature-depth (CTD) casts were obtained during the R/V *David Starr Jordan* Cruise DSJ9403, while 235 standard casts were taken during Cruise DSJ9406 over the course of three consecutive sweeps of the region. Data products contained in this report include (1) a master list of CTD stations during each cruise; (2) surface meteorological time series from the region's four National Data Buoy Center meteorological buoys; (3) horizontal maps of sea surface temperatures from advanced very high resolution radiometer satellite images; (4) acoustic Doppler current profiler data; (5) horizontal maps of temperature, salinity, and density at depths of 2, 10, 30, 100, 200, 300, and 500 m; (6) temperature, salinity, and density along four cross-shelf vertical transects; and (7) dynamic height topography (0/500 m and 200/500 m) in the survey region.

Somerton, D. A., and B. S. Kikkawa. 1995. A stock survey technique using the time to capture individual fish on longlines. Can. J. Fish. Aquat. Sci 52:260–267.

Longline catches per unit of effort (CPUE) from research surveys are often assumed to vary in proportion to fish abundance. This assumption, however, may be invalid if the abundance of the target species is high enough to saturate the gear or if the abundance of nontarget species is high enough to exclude the target species from capture. The authors examine a new approach to surveying fish populations with longlines that is based on time-to-capture data measured with small, fish-activated devices attached to every hook. A new measure of relative abundance, λ, is developed that is immune to the effects of gear saturation and interspecific competition for hooks. Two estimators of λ are compared by using capture-time data collected during summer 1987–1991 for pelagic armorhead (*Pseudopentaceros wheeleri*). Both estimators are shown to be unbiased if the underlying assumptions are true and fairly robust to the observed departures from these assumptions.

Squires, D., J. Kirkley, and C. A. Tisdell. 1995. Individual transferable quotas as a fisheries management tool. Rev. Fish. Sci. 3(2):141–169.

Fisheries management faces a new era. Markets, in the form of individual transferable quotas (ITQs) and growing global integration of fish markets, will increasingly provide the organizing and regulatory principle for many fisheries. Whether ITQs and global markets are a panacea or Pandora's box for organizing and managing fisheries is, as yet, unclear, and requires additional experience to fully evaluate. This article reviews the workings and expected benefits of ITQs, the origin and concept of ITQs, the problems they were designed to address, world-wide experience and literature on ITQs, and the problems and prospects for ITQ management. Particular attention is given to the growing importance of markets as the primary organizing principle for many fisheries, including the roles of ITQs and increased global integration of fisheries markets.

Townsend, R. E., and S. G. Pooley. 1995. Distributed governance in fisheries. *In* S. Hanna and M. Munasinghe, Property rights in a social and ecological context: Case studies and design applications, p. 47–58. Beijer International Institute of Ecological Economics, Stockholm, Sweden, and The World Bank, Washington, D.C.

Fisheries management, both in theory and in practice, is seeking ways to increase the involvement of the fishing industry and fishing communities in decision making and administration. Some competing models of how to accomplish this greater involvement include cooperative management, comanagement, and rights-based management. The authors propose, however, that it is difficult to establish clear criteria to choose among the competing models to accomplish this greater governance involvement.

Townsend, R. E., and S. G. Pooley. 1995. Distributed governance in the Northwestern Hawaiian Islands lobster fishery. *In* S. Hanna and M. Munasinghe, Property rights in a social and ecological context: Case studies and design applications, p. 33–39. Beijer International Institute of Ecological Economics, Stockholm, Sweden, and The World Bank, Washington, D.C.

Alternative management approaches for the governance of the lobster fishery of the Northwestern Hawaiian Islands are considered. These alternatives are analyzed within the framework of distributed governance: how rights and responsibilities are distributed among the central government, the industry, and local communities.

VenTresca, D. A., R. H. Parrish, J. L. Houk, N. L, Gingras, S. D. Short, and N. L. Crane. 1995. El Niño effects on the somatic and reproductive condition of blue rockfish (*Sebastes mystinus*). CalCOFI Rep. 3:167–174.

Approved by Science and Research Director, SWR

Balazs, G. H., S. G. Pooley, and S. K. Murakawa (eds.). Guidelines for handling marine turtles hooked or entangled in the Hawaii longline fishery: Results of an expert workshop held in Honolulu, Hawaii, March 15–17, 1995. For consideration for publication in NOAA Technical Report Series.

Bigelow, K. A., R. N. Nishimoto, R. M. Laurs, and J. A. Wetherall. Validated age and growth models for North Pacific albacore tuna (*Thunnus alalunga*). For consideration for publication in Marine Biology.

Brownell, R. L., Jr. Hawaiian monk seals: past, present, and future. For consideration for publication in IBI Reports (Japan).

Brownell, R. L., K. Ralls, and W. F. Perrin. Marine mammals biodiversity. For consideration for publication in Oceanus.

Dotson, C. R., and D. A. Griffith. A high-speed midwater rope trawl for collecting coastal pelagic fishes. For consideration for publication in CalCOFI Report.

Herrick, S. F., Jr., K. G. Salvanes, and D. Squires. Environmental regulation and technical efficiency: the case of tuna-dolphin fishing. For consideration for publication in Rand Journal of Economics.

Hobson, E., J. Chess, and D. Howard. Zooplankton consumed by blue rockfish, *Sebastes mystinus*, during brief access to a current on the Sonoma Coast. For consideration for publication in California Fish and Game.

Ohman, M. D., and P. E. Smith. A comparison of zooplankton sampling methods in the CalCOFI time series. For consideration for publication in California Cooperative Fisheries Investigation Reports.

Parker, H. A. Interannual variability of PFEG coastal upwelling indices. For consideration for publication in PACLIM Proceedings 1995.

Parrish, F. A., E. E. DeMartini, and D. M. Ellis. 1995. Effects of physiography and coastal discharge on the longshore distribution of the juvenile snapper (*Pristipomoides filamentosus*) in the Hawaiian Archipelago. For consideration for publication in Marine Ecology Progress Series.

Perrin, W. F. Development and homologies of head stripes in the delphinoid cetaceans. For consideration for publication in Marine Mammal Science.

Polovina, J. J. 1995. Decadal variation in the trans-Pacific migration of northern bluefin tuna (*Thunnus thynnus*) coherent with climate-induced change in prey abundance. For consideration for publication in Fisheries Oceanography.

Prager, M. H., C. P. Goodyear, and G. P. Scott. Application of a surplus-production model to a swordfish-like simulated stock with time-changing gear selectivity. For consideration for publication in Transactions of AFS.

Robertson, K. M., and S. J. Chivers. Prey occurrence in pantropical spotted dolphin, *Stenella attenuata*, from the eastern tropical Pacific. For consideration for publication in Fishery Bulletin, U.S.

Schwing, F. B., and R. Mendelssohn. Increased coastal upwelling in the California Current system. For consideration for publication in Journal of Geophysical Research.

Schwing, F. B., R. Mendelssohn, and R. Parrish. Interdecadal variability in the spatial structure of wind and SST in the California Current system. For consideration for publication in 1995 PACLIM Proceedings.

Schwing, F. B., and R. Mendelssohn. Long-term variability in the seasonality of EBC systems: an example of increased upwelling from the California Current. For consideration for publication in CEOS Volume.

Squires, D., and K. G. Salvanes. Quasi-concavity of fixed factors. For consideration for publication in Quarterly Journal of Economics.

Wade, P. R., R. A. Stehn, and J. F. Cochrane. A Bayesian approach to classification criteria for spectacled eiders. For consideration for publication in Ecological Applications.

Westlake, R. L., W. L. Perryman, and K. A. Ono. Comparison of vertical aerial photographic and ground censuses of stellar sea lions at Año Nuevo Island, July 1990–1993. For consideration for publication in Marine Mammal Science.

Yoklavich, M., V. Loeb, M. Nishimoto, and B. Daly. Nearshore assemblages of larval rockfishes and their physical environment off central California during an extended El Niño event, 1991–93. For consideration for publication in Fishery Bulletin, U.S.

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