AGENCY REPORTS

CALIFORNIA ACADEMY OF SCIENCES

The investigation of food habits and feeding behavior of the northern anchovy in California and Mexican waters initiated on July 1, 1965, has been continued. The number of anchovy stomachs collected to date has been about 1,000, the majority of which were collected and examined by Anatole S. Loukashkin. Of these, between six and seven percent were empty.

Recording of the stomach contents was made by wet volume and the components were then subjected to microscopical analysis. To date some forty kinds of food items have been recorded, and it is anticipated that this number will grow as a greater number of stomachs are analyzed.

It appears that the anchovy feeds on both zoo- and phytoplankton, somewhat in proportion to their availability. In the presence of both types of food the anchovy appears to show a definite preference for zooplankton, especially crustaceans (Copepods, Euphausiids, etc.) over phytoplankton. This modus vivendi has also been displayed by sardines and herring of the Pacific coast as reported by earlier investigators.

So far as the investigation in progress is concerned, the planktonic crustaceans—adults, larvae and eggs—appear to be consumed by preference when available. This conclusion is based on frequency of incidence, and on the wet volume contained in the stomach. The anchovy is either a particulate feeder or a filter feeder, depending on the size of the planktonic organisms available.

The presence of very minute forms of dinoflagellates and silicoflagellates in the anchovy stomachs is apparently to be explained by the ingestion of small copepods which had been feeding on these forms.—*R. C. Miller.*

CALIFORNIA DEPARTMENT OF FISH AND GAME PELAGIC FISH INVESTIGATIONS

The Department's research under the California Cooperative Oceanic Fisheries Investigations is concerned chiefly with studies of the pelagic wet fisheries and with studies of the fishery resources of the California Current System based on echo-sounder surveys. These studies are directed toward assessing the distribution, abundance, and age structure of the northern anchovy, Pacific sardine, jack mackerel, Pacific mackerel and other important fish populations. This information is basic to developing an understanding of fish population dynamics relative to their proper utilization.

The Pelagic Fish Investigations include four research projects; (i) Anchovy, (ii) Sardine-Mackerel, (iii) Sea Survey, and (iv) Sea Survey Data Analysis.

Anchovy

The anchovy tag and recovery study initiated in 1966 has continued with considerable success. Initially the internal, metal tags were recovered on permanent magnets located in the final stages of the reduction process. During the last 6 weeks of the 1965–66 reduction season, mid-March through April, 22,853 anchovies were tagged and 150 recovered. It soon became obvious that tags could not be assigned to the vessel that recovered them, but only to the fleet and consequently to a major fishing area such as Monterey Bay, southern California, or Ensenada. Gross movements, between fishing areas, could be determined but not local movements. Recovery efficiency within and between reduction plants was extremely variable. Project scientists concluded that one of the reasons for poor and varied recovery efficiency was that the abdominal cavity of the anchovy breaks open very easily especially if the fish is small and/or has been dead more than 6-10 hours. This meant that the tags frequently fell out of the fish and never got far enough along in the reduction system to be recovered by the magnets then in use.

During the second period of tagging and recovery, May 1, 1966 to May 1, 1967, project scientists tagged 77,261 anchovies and recovered 323 of the 100,114 tags released since the inception of tagging. We also developed an improved system of magnetic recovery which takes advantage of the size and decomposition rate of the anchovy by pulling the tags out of the anchovies as they are unloaded. This will allow us to assign some of the tags recovered at Terminal Island plants to the vessel that recovered them thus enabling us to determine local movements. A price dispute, in effect since this system was installed (summer, 1967) has curtailed landings at Terminal Island plants and prevented testing the system under production-run conditions.

Assessment of local movements in the Monterey Bay has not been attempted because fishing occurs over a small area. Recovery efficiency at the major plant was increased from 0–10% to 80–100% by installing (summer, 1967) a more efficient magnet.

During the third tag and recovery period, May 1, 1967–January 31, 1968, 124,058 anchovies were tagged and 57 recovered. Total fish tagged and recovered March 14, 1966–January 31, 1968 was 224,172 and 530 respectively.

Since the inception of tagging, considerable has been learned about anchovy movements between major fishing and/or tagging areas. Tag recoveries demonstrate that anchovies moved from Sausalito (San Francisco Bay) to Monterey Bay, Monterey Bay to southern California, southern California to Ensenada, and southern California to Monterey Bay. Movement between southern California offshore areas

and the Los Angeles-Long Beach Harbor was also demonstrated.

Of the 530 tags recovered, 53 demonstrated gross movement: 43 were recovered during the third tag and recovery period, 40 in Monterey Bay. Several had been at liberty over 18 months. The numbers are interesting but should be viewed with caution. Practically no fishing has occurred in southern California during the third tag and recovery period, which accounts for the lack of recoveries in this area. Detailed reports of the tag and recovery study and of the fishery during the first two seasons are nearing completion.

Analysis of fishery and sampling data for the first two seasons of the anchovy reduction fishery (November 1965–April 1966 and October 1966–April 1967) is nearly complete. In southern California the fleet registered gross tonnage increased from 1,406 to 1,950 tons. The gear composition changed from almost 100% lampara when the fishery started to nearly 100% purse seines by the end of the second season. In central California most of the vessels are small lamparas but about 60% of the tonnage is taken by purse seiners.

In southern California the catch per unit effort dropped from 9 tons per hour during 1965–66 season to 7 tons per hour during 1966–67 because the quota in the San Pedro zone was reached before the fish concentrated close to the port of delivery.

Landings in central California increased from 589 tons to 9,275 tons while catch per unit effort increased from 4.5 to 9.2 tons per hour. The fact that the second season's fishery occurred during the fall, the period of best availability, accounts for the increased landings and success.

Preliminary age analysis indicates that fish of age group I dominated the live bait landings followed closely by age group II; together they comprised about 75% of the landings. In the commercial landings, II's dominated (48%) followed by III's (25%) and together accounted for 73% of the landings.

Mackerel-Sardine

Design of a log-interview program to obtain catch and effort data from the San Pedro wet-fish fleet was completed. The program was initiated in May, 1967 and has been successful in monitoring 90 to 95% of all jack mackerel, Pacific mackerel and Pacific bonito landings. Fishing information obtained from successful and unsuccessful trips includes: time, date, and number of sets; area and hours scouted; species and tons per set; airplane assists; and other data incidental to fishing operations.

Sampling of mackerel and sardines continued on a routine basis. A major change was made in the jack mackerel age and length sampling procedure. In May, 1967 we initiated a new age and length sampling plan with probability of selection of a boat for sampling proportional to the weight of its load, and with equal probability for selection of the sample units (fish) from the boat. The new southern California sampling system obtains 50 random samples (determined from a table of random accumulated tons) for every 5,000 tons of fish landed. The samples are by weight (5 pound units) and are obtained as a single unit. In central California sampling differs slightly as the sampling unit has been increased to 15 pounds.

Analysis of the backlog of jack mackerel data continued. All otoliths collected between the 1947–48 and 1965–66 seasons have been processed. Final analysis and preparation of manuscripts describing these data are in progress.

Analysis of the Pacific mackerel age composition data was completed for the 1964–65, 1965–66, and 1966–67 seasons and a paper presenting these data neared completion.

Sea Surveys

During the year, 7 fish surveys and one experimental cruise were conducted aboard the R/V ALASKA which logged 148 operational days at sea. A long delay in the research vessel's annual overhaul resulted in cancellation of 2 other scheduled surveys.

Anchovy. This species has been found in every area surveyed in highly varying densities. Most fish were found within 20 miles of shore but at times considerable quantities were present 50 to 80 miles offshore. They are generally found in coastal waters of moderate to high turbidities. Thus far none have been detected in the very clear deep waters of oceanic character. Southern California appears to be by far the area of greatest population density with Baja California ranking second. Central California waters contained light, scattered distributions with concentrations in a few localized areas. Although no cruises were made this year in northern California, past surveys using different methods indicate low anchovy abundance in the area.

A diurnal schooling behavior, occurring in all seasons and areas, was discovered. During the day anchovies are densely schooled well below the surface. At the approach of darkness they rise to the surface and disperse into the uppermost portion of the scattering layer where they feed on organisms constituting this layer. The most common food item in stomachs of night-caught fish was euphausiids. At the approach of dawn, the fish aggregate again into schools and submerge. This behavioral pattern, which is extremely common, is unfavorable for effective harvest with purse seines. The daytime schools were usually too deep and the night schools dispersed. Occasionally in localized areas, schools remain intact during the night and rise close to the surface where they are visible as large bioluminescent spots. It is this behavior that is necessary for efficient harvest by existing purse seining methods. As yet no seasonal or spatial occurrence of this behavior has been established.

In the more southern areas surveyed a preference for cool water by anchovies was observed. During the warm months fish were usually found at deeper levels or concentrated in areas of the coolest temperatures. Off Baja California anchovies were found at the deeper levels or concentrated in areas of upwelling.

Fish off southern California moved to the northern parts of that region during late summer and fall.

Central California surveys are difficult to conduct due to bad weather conditions throughout much of the year and lack of anchorages over long stretches of the coast. This region was surveyed in July and November of 1966 and March and June of 1967. The March survey was very superficial due to poor weather conditions.

It appears that this region is populated by a portion of the older and larger fish from southern California. The fish in this area may be a marginal extension of the main population located in southern California and consist chiefly of migrants. Tagging studies have established that migration between the 2 regions occurs. There is also some evidence of extensive migration from southern California into the southernmost portion of central California in summer and early fall. Surveys next fiscal year will check this possibility.

Surveys thus far have found anchovies distributed in low densities and in discontinuous patches within 20 miles of the coast. Densities of schools per square mile ranged from 12 to 16 during fall and early summer surveys. The fall survey found a more widespread distribution than that of summer. Local concentrations were found in Monterey Bay, off Pfeiffer Point and in a larger area from San Simeon to Point Arguello. Very large schools exceeding 50 tons were found close to shore in the first 2 areas.

The fish were almost exclusively large adults. Length frequency data from this region contained the largest size groups found anywhere. The highest proportion of older age groups was also found. Only in the extreme southern part of this region were younger and smaller fish present.

Southern California surveys were made in October of 1966, April of 1967, and June of 1967. Extreme variations in school numbers were experienced between all cruises. School densitites per square mile averaged 14.0 in October, 45.4 in April and 132.9 in June. Similar variation has been experienced in previous years.

This region had by far the highest anchovy school abundance. No other region has yet equalled the number of schools detected or observed. During the spring months hundreds of thousands of small surface schools are distributed over extensive areas from shore to 85 miles seaward. Echo sounding has given evidence of school densities of up to 1,200 schools per square mile in localized areas. An estimated 1,895,000 schools were present during the June 1967 survey. A somewhat similar survey in April of 1965 produced an estimate of over 2,000,000 schools. Although no accurate measure of school size has been developed, these schools are obviously small, probably averaging less than 2 tons as judged by experienced biologists on the cruises.

Schools observed or detected during the spring surveys are comprised of adult fish in or near spawning condition. Samples, taken by trawl, have consisted of fish that were spawning at time of capture. It appears that the anchovy population concentrates in this region during spring to spawn. Very low densities or a complete absence of fish were found in areas adjacent to southern California at this time.

During the fall survey only about 10 percent of the number of schools present in spring were detected or observed. Schools were found much closer to shore and were of larger size. A shift towards the northern extremity of the region and deeper schooling were also evident. The location of the larger numbers of fish present in spring remains unknown. There is some evidence that they migrate into the southern extremity of central California.

The northern portion of Baja California is usually surveyed at the same time as southern California. To date very low densities have been detected with some local abundances in Todos Santos and Soledad Bays.

Baja California was surveyed in September 1966. Anchovies were found over much of the region except in southern Sebastian Vizcaino Bay where sardines prevailed. Anchovy schools were generally quite small with most estimated at less than 5 tons. An average of 22.7 schools per square mile was estimated by echo sounding. San Roque Bay and San Carlos anchorages produced the highest school counts and midwater-trawl catches. Concentrations suitable for commercial harvest were found at these locations. The principal areas of abundance are from Cape Colnett to Point Canoas and from Cedros Island to Point Abreojos. Both areas are characterized by upwelling and accompanying low surface temperatures.

Anchovies taken by midwater trawl were conspicuously smaller than those taken in regions to the north. Adult fish were much smaller for their age and maximum sizes were far smaller than fish taken off California. It has been hypothesized that Baja California anchovies comprise a separate stock such as has been established for sardines.

Other Species. This group consists chiefly of lanternfishes, deep sea smelts, and juvenile jack mackerel. They are generally not detected by the echo sounder because they do not school compactly. Small catches of 1–50 fish are frequently taken by midwater trawl. The first 2 groups are found in low densities over vast areas. The total amount present is probably quite large but due to lack of concentrations they are not suitable for present methods of harvest.

Lanternfishes are the most common group. They are regularly taken in midwater trawls over bottom depths exceeding 200 fathoms and occur in 40 to 50 percent of all trawl tows. Catches usually consist of 1–20 fish and rarely exceed 200. A large number of species have been taken but 10–12 different species per tow comprise a large percentage of the total. Lanternfishes are distributed over all regions with the highest densities in central California.

Deepsea smelts are usually taken in catches mixed with lanternfishes but in far less quantity. Most catches consist of 1–3 specimens. Spring surveys in southern California produced some unusually large catches of smooth tongues (*Bathylagus stilbius*).

Catches of 10,000–12,000 individuals per tow were made, indicating seasonal schooling.

Juvenile jack mackerel have been taken in all regions during late summer and fall. Catches usually consist of less than 10 fish per tow ranging from 30–120 mm SL. Most are young hatched the previous spring. In southern California and upper Baja California small schools of up to 500 fish have been regularly observed under patches of floating kelp.

Larger jack mackerel are occasionally detected on the offshore banks of southern California and infrequent catches are made in the midwater trawl. Making abundance estimates is hazardous due to their ability to avoid the trawl and the uncertainty of identifying the schools at depths where they occur.

Sardines have been detected and sampled only in Baja California. The population center and area of greatest density is located in the southern half of Sebastian Vizcaino Bay. Sardine schools were found in fewer numbers and in more scattered locations from Point Eugenia to Point Abreojos. The midwater trawl has been very successful in determining the presence or absence of this species.

Other species occurring infrequently include Pacific hake, juvenile rockfishes, and whitebait smelt. Rockfishes are occasionally found over shallow banks off southern and central California. Hake and whitebait smelt are most often taken in central California waters.

Pacific sauries have been visually observed, but none have ever been taken by trawl or identified from echograms. The present survey apparently is ineffective for this species.

Invertebrate species consisted chiefly of jellyfishes, salps, and pelagic red crabs. These organisms frequently hinder trawl operations by clogging the meshes and often damaging the net. Jellyfishes, which abound in central California waters, have prevented trawl operations in areas near San Francisco and Monterey. Salps are dominant in southern California and pelagic red crabs in Baja California. The midwater trawl is highly effective for capturing red crabs. Catches of up to several tons have been made in tows of 20 minutes duration.

Data Reports: A computer program has been written to produce reports directly from computer output through a lithographic process. All data will be entered on punch cards for utilization by the program and for future analytical studies. Progress on this aspect has been minimal due to serious personnel shortages and delays in obtaining age data of completed surveys.

Data reports for surveys from 1950 to 1965 have been published through 1962.

Future Plans: A sonar will replace the echo sounder for anchovy surveys. This will greatly increase the search area which in turn will give more accurate estimates of school numbers.

A major effort will be made to determine school sizes from echograms. If a successful method can be developed, reliable estimates of absolute population sizes can be made.

Sea Survey Data Analysis

This project was established in June 1966. Most of the year was spent learning computer programming techniques, evaluating the many approaches to summarizing the large amount of data obtained during the past 15 years of Sea Survey and devising suitable computer programs for extracting pertinent information from this backlog.

About mid-year it was decided, that for the present, we would concentrate our effort on summarizing the age and size composition of the Pacific sardines taken in samples collected during past Sea Surveys off California and Baja California. The computer program can be adapted to other species such as anchovies, Pacific mackerel and jack mackerel with minor changes.

By years end, the final program was de-bugged and operational, and we are now in position to summarize Pacific sardine age-size composition in each of six geographical areas covering 1,000 miles of coast line.

Our plans for the future are to, as soon as possible, process all years for which we have data on edited, punched cards (1950 through 1960). This will give us 11 consecutive years of sardine data broken down into two time periods (January–June, July–December) per year and six geographical areas. The geographical areas correspond by design quite closely to those used by the U.S. Bureau of Commercial Fisheries to summarize the results of their egg and larva surveys.

Within the above time periods and areas, sardine data will be summarized in a manner which will give us a relative measure of year class composition and abundance as well as a monthly summary of surface temperature conditions.

It must be kept in mind that this first program has many of our subjective concepts incorporated into it and is by no means final. We do, however, feel that it gives us a summary that can be used to formulate further concepts and hypotheses.—*J. L. Baxter*

HOPKINS MARINE STATION

The Hopkins Marine Station of Stanford University at Pacific Grove, California, conducts studies on the environment and organisms of the coastal waters of central California. Under the CalCOFI program, the marine station monitors the marine environment and phytoplankton of Monterey Bay.

Approximately weekly cruises to six stations on Monterey Bay are made. Cruise data consist of: temperatures at 0 and 15 meters as recorded on reversing thermometers, salinities at 0 and 15 meters determined by titration, temperatures at 0, 10, 20, 30, 40, and 50 meters as recorded on a bathythermographic slide, and plankton wet volumes collected in a ¼ meter net towed vertically 15 meters. Also general comments on the weather, condition of the sea, marine mammals and oceanic birds are made.

In addition, daily shore temperatures are recorded at Pacific Grove and Santa Cruz.

Both shore and cruise data are compiled and distributed to interested agencies and individuals in the

form of quarterly and annual reports.—*D. B. Seielstad*

SAN DIEGO STATE COLLEGE

Studies on the Sablefish and the Pacific Hake

The food relationships of the Sablefish (*Anoplopoma fimbria*) and the Pacific hake (*Merluccius productus*) were studied under contracts M-4 and M-8 between the California Marine Research Committee and the San Diego State College Foundation. Samples, taken weekly, from Newport Beach setline dory fishery yielded 1071 sablefish stomachs and 23 hake stomachs. Hake were not taken in great abundance because of low consumer demand. Analyses were made of the stomach contents, identified to the lowest possible taxonomic category, on the basis of weight and number of food items. Additional data were obtained on horizontal and vertical position of capture, condition of the gonads, the length and weight of the fish, and sex.

As soon as possible after the fish were displayed for sale the stomachs were taken and preserved in buffered formalin. In the laboratory, the stomachs were opened and their contents sorted to the lowest possible taxonomic category. The blotted wet weight of each component was measured. These data were grouped by monthly intervals. The stomach contents composition was also partitioned by the age of the fish. Ages were determined by length frequency analysis as well as scale ring counts. Ripening ovaries were also taken and the frequency of ripe ovaries in the catch was computed for each month.

Some inherent problems with data collected by the methods used in this study are: 1) the sample is restricted to those fish large enough to be taken by a specific hook size (5/0 and 4/0), 2) the varying periods of time between catching and processing the fish on the beach allow continued digestion of food organisms to take place so that the stomach contents are more difficult to identify, and 3) completely random sampling of the fishery is difficult because the dories are positioned in such a way that it is impossible to sample from more than one boat at a time. Weekly sampling resulted in field and laboratory examination of 1071 *A. fimbria* and 23 *M. productus*. An additional 113 juvenile *A. fimbria*, collected by miniature purse seine off the coasts of California and Baja California, were examined in order to study the smaller size groups that could not be obtained from the Newport Beach fishery.

A. fimbria, the Sablefish, is a species of minor commercial importance that in the later juvenile and adult stages is very abundant on and above a clay or firm mud bottom at depths of 400 to 1200 meters off the Pacific coast of North America. The geographic range of *A. fimbria* extends from Cape Colnett, in northern Baja California, to Cape Spencer, Alaska. Individuals attain a maximum size of 914 mm in fork length. Approximately 50% of the females are mature at a total length of 610 mm and an age of five years. The eggs are of the free-floating, pelagic type, and fertilization is external.

M. productus, the Pacific hake, is also a dominant benthic or near benthic species of very limited commercial importance that occurs off the coast of California at depths of 55 to 366 meters. Available information indicates that it is abundant throughout its geographic range, which extends from the Gulf of Alaska to the Gulf of California. Males and females attain maximum sizes of 660 mm and 760 mm in total length, respectively. Individuals over 400 mm in total length are sexually mature. The eggs are pelagic, round, and just over 1 mm in diameter when spawned. Fertilization is external.

The bathymetric distribution of *A. fimbria* appears to be strongly correlated with fish size, with the largest individuals in general occurring at the greatest depths. There is fairly conclusive evidence that this species occurs in deeper water in southern California than in the northern part of its range and that the bathymetric ranges of particular size groups in the population may be modified accordingly. The population of *A. fimbria* sampled off Newport Beach exhibits a typical age structure, in which the younger age groups (II and III) predominate. This population exhibited no apparent changes in its age structure distribution throughout the year sampling period, suggesting that the population is quite stable and that there were no major seasonal migrations of particular size groups.

Separate length-weight relationships were determined for adult *A. fimbria* sampled at Newport Beach and for age 0 fish sampled near the surface off southern California.

A. fimbria were grouped into size categories approximating age groups to study the influence of size on the diet of the fish. Juvenile fish (age group 0), which occur near the surface, feed primarily on small pelagic organisms, including copepods, amphipods, euphausiids, and the urochordate, *Oikopleura* sp. The urochordates constituted 53% of the diet by weight, while the crustaceans 23%. Generally a single type of food organism constituted the major portion of the stomach contents at a given locality.

The diet of age group 2 fish includes squid, salps, pyrosomes, and polychaetes, all larger prey species than found in a juvenile diet. Small zooplankton makes up a very small portion of the diet. Age 2 individuals thus appear to be undergoing a transition in food habits in that both benthic and pelagic food organisms are utilized. *A. fimbria* of age group 3 and older are primarily piscivorous (72% by weight) and at least in the area sampled, show a definite preference for one species of benthic fish, *Sebastolobus alascanus*. *A. fimbria* thus exhibits a shift in its food habits and position in the food chain from a primary and secondary carnivore as a juvenile fish to a higher order carnivore as an adult fish.

Considering all *A. fimbria* examined in this study, fishes Urochordata, Cephalopoda, and Crustacea were the major contributors to the total biomass of the diet, comprising 92% of the total wet weight of food material in all stomachs. Fish alone contributed 93% of the total stomach content biomass of the *A. fimbria* taken on the benthic setlines off Newport Beach. *A.*

fimbria of all ages appear to be highly opportunistic in their feeding habits, ingesting whatever suitable prey species are most abundant or available in their immediate surroundings. However, adults appear to be more selective in their choice of prey than the young.

Seasonal changes in the occurrence of fish in the diet of adult *A. fimbria* appear to be a real phenomenon. The main prey species, *S. alascanus,* was most abundant, in terms of stomach content biomass, during the period from September to February and was low in abundance during the remaining spring and summer period. The occurrence in stomachs of other fish species and squid also followed this general seasonal trend. Salps and pyrosomes remained a constant diet item, in terms of stomach content biomass, throughout the year. A larger variety of food items were found in the stomach contents during the spring and summer months (Echinodermata, Decapoda, and Cumacea), suggesting that *A. fimbria* may supplement its diet with less desirable prey when preferred prey species are not available.

Females grow at a faster rate and attain a greater maximum length and weight than males and thus predominate in the larger sizes. Individuals age 6 or younger comprise the largest part of this population (97.6%) and the majority (53%) of the fish sampled were in age group 2. Thus, in common with other fish species, the *A. fimbria* population consists primarily of young fish still undergoing rapid growth.

Female *A. fimbria* are reported to reach reproductive maturity at five years of age (larger than 470 mm). This was confirmed by the fact that all gravid female *A. fimbria* observed at Newport Beach were over 500 mm in fork length. The spawning season of *A. fimbria* is thought to be from December through April in northern California, with peak spawning activity in January and February. Mature eggs were found in *A. fimbria* sampled at Newport Beach during the period October through December, indicating that there may be a different or more extensive spawning period in southern California. As a result of this long spawning period, recruitment of young occurs over an extended period of time, resulting in a wide range of lengths for each corresponding age group and considerable size overlap between age groups.

Digestive tract parasites of *A. fimbria* were examined. These included *Anisakis* sp., a nematode parasitic on the stomach lining, a trematode of the family Hemiuridae, and an isopod, *Livoneca* sp., normally found in the gill region.

Most of the *M. productus* sampled at Newport Beach were mature individuals. They ranged from age group 3 to 13, with the majority in age group 6 or older. The length-weight relationship for *M. productus* sampled at Newport Beach compares favorably with that determined by Best (1963).

No definite conclusions can be drawn about the food habits of *M. productus* based on the small sample examined in this study. Three species of fish, *Anchoa compressa, A. fimbria* and *M. productus* and a single squid occurred in the stomach contents examined. Based on these results and information reported in the literature, *M. productus* appears to be primarily piscivorous, and thus can be classified as a higher order carnivore.

Because of their high population densities, size, and food habits, both *A. fimbria* and *M. productus* are undoubtedly important members of bottom communities in which they occur and both represent important latent food resources.—*J. B. Conway, D. A. Farris and R. F. Ford.*

SCRIPPS INSTITUTION OF OCEANOGRAPHY MARINE LIFE RESEARCH PROGRAM

The Marine Life Research Program carries out the portion of the California Cooperative Oceanic Fisheries Investigations that is the responsibility of the University of California. The program is principally concerned with the ecology of the California Current system—that is, with its currents, temperatures, populations of organisms, chemistry, climate, etc. and with the fluctuations in all of these.

In the period of existence the Marine Life Research Program has considerably extended its scope, principally through research grants and contracts from Federal Agencies such as the Office of Naval Research, the Atomic Energy Commission, the National Science Foundation, and by informal cooperation with the Environmental Scientific Services Administration (including the Weather Bureau, and the Geodetic Survey), with Naval Activities such as the Fleet Numerical Weather Facility, and with other research programs of the University. All of these expanded activities of the Marine Life Research Program have stemmed from the broadness of the basic concept of the California Cooperative Oceanic Fisheries Investigations as conceived and initiated by its genitors.

In addition to the broadened program, the central responsibility of the University to monitor the California Current and its fisheries remains highly viable.

The entire Marine Life Research Program was discussed in some detail and depth in the CalCOFI Reports Volume XI, issued in January, 1967. The present statement will thus serve mainly to point out some of the most recent developments and to enter in some depth into a discussion of developments in the important problem of plankton sampling.

Recent Oceanographic Conditions in the Pacific

The northeast Pacific Ocean was generally warmer than normal by 2° F from July, 1966 to June, 1967. A colder than normal area in the Gulf of Alaska in August, September, and October, 1966 became approximately normal the remainder of 1966 and the first half of 1967; by mid-1967 it had warmed to 2° to 4° F above normal. A cold area off the west coast of the United States and Baja California developed in April, 1967 but it had become much smaller by July, 1967.

North Pacific Study

Preparations for a rather large program to study conditions in the North Pacific were reported in Volume XI. This study is progressing well.

A newly-designed stable mooring has been designed and will soon be installed in the Western Pacific in deep water to appraise its ability to survive typhoon conditions. The experience of the four moorings already placed some hundreds of miles offshore of California has shown the survivability of such instruments and the value of their data. By the fall of 1968 we plan to have a number of such stations in the North Pacific where the ocean conditions and weather of the California coast receive some of their most important inputs.

Deep Benthic Conditions

Deep fish populations have been under investigation and were reported upon in CalCOFI Reports Volume XI. This research has continued and is yielding interesting and important findings. These can be summarized as follows:

1. Very large predators (sharks) are common in the deep water between 600 m and 2000 m. At 5 stations out of 8 sharks estimated to be longer than 6 m were photographed.
2. All stations showed abundant deep fish. Surprisingly very deep stations, 3400 m and 6000 m, photographed many fish—at the latter station and in a single photographic frame, there were more than 50 fish, mostly between 0.5 and 1.0 m long.
3. All but one station (10 total) photographed fish within the first 30 minutes after the camera had reached the sea floor and five stations photographed fish within 5 or 15 minutes after the camera reached the bottom.
4. The tanner crab and the sablefish are important underdeveloped resources of the California and Mexico coasts and are present in great abundance at depths of 600 to 2000 meters.

Deep currents have now been measured in many places and are found to be both simpler and somewhat stronger than expected. The fluctuating component of these deep currents mainly results from the semidiurnal surface tides.

Zooplankton

During the last few years, the ecology of the California Current and adjacent regions, both in the near-surface waters and the deeper waters, has become much better known through the research of the zooplanktologists in the Marine Life Research Program at Scripps Institution of Oceanography.

Some of this research has been to evaluate various plankton nets with species diversity, and avoidance of zooplankton. Other research that is being carried out now is an attempt to determine patchiness of zooplankton. These studies are of primary importance to the evaluation of the past zooplankton collections and will help determine what is necessary to improve our methods of sampling in order that more accurate estimates of populations can be made. This work is highly relevant to the population estimates of pelagic fish using fish larvae, since the larvae react much the same as zooplankton to various nets.

The findings of Dr. Fleminger, Dr. Clutter (Bureau of Commercial Fisheries) and Dr. McGowan are the following:

1. The smaller the net, the smaller the number of species caught, even though the volume of water filtered is held constant for each net.
2. The smaller the net, the smaller the species abundance in the collections.
3. The degree of avoidance varies among species.
4. All nets used had bridles, tow lines, cable clamps, and cables preceding them; this hardware may have been an important cue to various zooplankton to facilitate their escape.

This research brought about the development of the Brown-McGowan Opening and Closing Paired Zooplankton Net (BMOC) and the opening and closing mid-water trawl. These nets have been designed to minimize the problems encountered by many others. They are helping to solve the problems of zooplankton patchiness and avoidance. Also they filter large volumes of water in a reasonably short time and can be opened and closed at known depths so that zooplankton diversity at various depths plus vertical migration of zooplankton can be studied more meaningfully.

The BMOC net has two nets with a combined mouth area that is almost exactly the same as the one-meter net used for the last 17 years on the CalCOFI patterned cruises. No bridle, tow line, or cable precedes the mouth openings. The nets can be opened and closed at any desired depth. In tests between the one-meter net and the BMOC net, it was shown that a single BMOC tow caught as many species as a cumulative species list based on five one-meter net tows. In a comparison between a BMOC tow and tow using a net with a mouth diameter of 1.4 m, the latter caught 23 percent less species than the BMOC net. The BMOC net has since been used for zooplankton studies to study the important problem of the vertical distribution of zooplankton.

Dr. Angeles Alvariño has recently published on the vertical distribution of Chaetognatha, Siphonophorae, Medusae, and Ctenophorae between the surface and 3000 meters from data obtained using this equipment.

An important study to understanding replenishment of various zooplankton that live primarily in the California Current has been carried out by Dr. Abraham Fleminger. There are certain California Current copepods that are most abundant at or above the thermocline. Where these copepods encounter the mixing of central water with California Current water, these zooplankton are found in greatest abundance between 250 and 350 meters below the surface, the locations of the northerly flowing current underlying the California Current. By this mechanism, these animals are able to maintain their population despite the net southward transport of the upper layers of the California Current.

The determination of the zooplankton biomass of selected cruises is continuing and the first Biomass Atlas is being prepared.

Historical Study

During the period, Dr. Alvariño of Scripps visited Spain to examine some of the early documents of Spanish exploration of the California coast. It was expected that such documents clearly would contain valuable clues of the past, and hence, to the anticipated climatological and oceanographic conditions in the California Current, but the extent of the documentation found far exceeded any expectations. For example, the Malaspina Expedition visited this coast in 1784 to 1790, and described the conditions, fishes, invertebrates, harbors and peoples. Over 50 extremely fine unpublished color plates record details and identifiable marine organisms. Clearly a wealth of data rests in the archives of Spain and Portugal, all awaiting attention to extend our knowledge of the conditions and fauna of the California Current system back almost two centuries, and hence vastly to extend our knowledge of the range of events to be expected in the future.—*J. D. Isaacs*

U.S. BUREAU OF COMMERCIAL FISHERIES FISHERY-OCEANOGRAPHY CENTER

At the end of the period under review a major reorganization of Bureau of Commercial Fisheries activities at La Jolla occurred with the merger of the California Current Resources Laboratory and the Tuna Resources Laboratory into a single laboratory, subsequently to be known as the Fishery-Oceanography Center. Within the new unit all research programs of the earlier laboratories were organized into four unified programs: *Fishery-Oceanography; Behavior and Physiology; Population Dynamics;* and *Operations Research.*

Since the new research programs are essentially based on disciplines rather than species groups or geographical regions as were the previous laboratories, CalCOFI-coordinated research may be performed in several administrative units within the new laboratory. In fact, most has been placed in Dr. Smith's Population Dynamics Program, with some elements in Dr. Lasker's Behavior and Physiology Program. Dr. Flittner's program, though not formally associated with the work of the CalCOFI Committee is very germane to fisheries research in general in the California Current.

In order to avoid future confusion, the present organization of the Fishery-Oceanography Center will be used in this report, though in fact during most of the period under consideration the older laboratory arrangement was still used at La Jolla. This report is concerned only with research activities directly related to the interests of the CalCOFI Committee and coordinated by it; other research, even if performed in the region of the California Current, is not described here and interested persons are referred to the general report of the Fishery-Oceanography Center for information. Much of what follows is extracted from the report for the fiscal year 1966–67.

Vessel operations

During calendar year 1966 monthly coverage was resumed over part or all of the CalCOFI pattern between lines 60-140, using the new research vessel *David Starr Jordan* and cooperating vessels from the SIO and the CF&G.

The *David Starr Jordan* returned from CalCOFI cruise 6606 on July 1. On July 7, the *Jordan* teamed with the Scripps research vessel *Alexander Agassiz,* departed on CalCOFI cruse 6607. The *Jordan* covered lines 60-97 (San Francisco, California to Descanso Point, Baja California) taking 81 hydrographic stations with net tows and 26 stations with net tows only. The *Agassiz* covered lines 100–137 (Todos Santos Bay to Point San Juanico, Baja California) taking 81 hydrographic stations with net tows and 52 stations with net tows only. The vessel completed the cruise and returned to port on July 28.

On August 4 the *Jordan* departed San Diego on CalCOFI cruise 6608. Despite returning to port briefly for repairs, the *Jordan* completed its assigned pattern station, lines 80-137 from off Point Conception, California to off Santo Domingo, Baja California, making 134 double net tow stations. The *Jordan* returned to San Diego on August 27.

The *Jordan* left San Diego on September 6 to begin CalCOFI cruise 6609. Taking up the first station on line 80, off Point Conception, the ship worked south until September 12 when it returned to San Diego to land a crew member who was ill.

Leaving again on September 14, the *Jordan* continued south to the Sebastian Viscaino Bay area where failure of the rudder bearing made it necessary for the ship to return to San Diego for emergency repairs.

The *Jordan* worked in cooperation with the Scripps research vessel, *Alexander Agassiz,* in conducting CalCOFI cruise 6610. From October 7–24 the *Jordan* occupied 98 stations in that portion of the pattern from just north of San Francisco to San Diego. The *Agassiz* began work on October 13 from south of San Diego and worked to lower central Baja California, occupying a total of 126 oceanographic-biological stations; the *Agassiz* returned to port on October 29.

On October 28, for the first time, the *Jordan* was used to operate trawling gear during a 1-day trip off San Diego when a pelagic trawl belonging to the CF&G was rigged and operated successfully on a number of tows.

The *Jordan* was chartered in November by the Scripps Tuna Oceanography Research program (STOR) for a survey off southern Baja California. In addition to the STOR survey, 22 net-tow stations were occupied between San Diego and Punta Eugenia, Baja California for the CCRL. The STOR survey was conducted between Punta Eugenia and Cape San Lucas.

On December 1, *Jordan* teamed with the Scripps research vessel, *Alexander Agassiz,* departed on CalCOFI cruise 6612, *Jordan* covered lines 60-93 just north of San Diego, taking 20 net-tow stations and 72 hydrographic stations with net tows. *Agassiz* cov-

ered line 97, off Ensenada, to line 137, occupying 52 net-tow stations and 72 hydrographic stations with net tows. The *Jordan* returned to home port on December 19.

In January, 1967, the *Jordan* was turned over to Eastropac for outfitting for Eastropac cruises.

Stock assessment

This program has as its objective an understanding of the population dynamics of fishes found in the California Current system, that is, to determine at various levels of fishing intensity the quantity and quality (sizes of fish) in the average annual catch. For many years, the principal research effort was centered on the Pacific sardine. Since 1952, however, age determinations have been made of the anchovy catch as well. With the start of a modest 75,000 ton reduction fishery on the anchovy, authorized by the California Fish and Game Commission in November, 1965, attention has been focused on this species.

Information for this program is derived, in part, from age and growth studies carried out cooperatively by scientists of the CF&G and the BCF. Through a contract with the California Academy of Sciences, the Bureau samples landings of anchovies as well as sardines in Baja California and gathers statistics on landings of sardines, anchovies, Pacific mackerel, jack mackerel, and thread herring.

A paper on anchovy fecundity and its application to estimation of anchovy biomass in conjunction with egg census data is in the final stages of revision. Examination of anchovy catch data shows that female anchovies are somewhat more numerous than males in the commercial catch. Females are also somewhat larger and heavier than males. Females made up 57 percent by weight of the catch and males 43 percent, or the biomass of males was only 75 percent of the biomass of females. This would reduce total anchovy biomass estimates by 12½ percent from those based on the assumption that the biomass of the two sexes is equal.

The California sardine fishery produced less than 300 tons in the 1966–67 season, the lowest catch on record. The catch, mainly from schools of mixed species, consisted entirely of northern subpopulation fish as it has for the past several seasons. As in other years of low catch, the fish were older, larger and fatter than in years of very high catch. Analysis of sardine scales during the 1965–66 season indicate that 98 percent of the fish samples were 4-ring and older. During periods of high catch, the dominant ages are 2 and 3. Average length of the fish samples was 231 mm and the average condition factor 141, both much higher than in years of high catch. Although the scale reading of California sardines is incomplete for the 1966–67 season, preliminary results show that the few fish taken were as large and old as in the past few seasons of low catch.

It was planned to have monthly survey cruises during calendar 1966. Due to a breakdown in the *David Starr Jordan* during the initial January cruise, this vessel was not available again until May. As a consequence, the February cruise, made by the *Alexander Agassiz,* was an abbreviated one and there was only one full coverage of the CalCOFI area during the March-April period (mostly made in April). During the remainder of the year two-vessel coverage was obtained during the months of July, October and December, single vessel coverage on the remaining months. The November cruise, cooperative with the STOR group, occupied only two inner stations on each line between 97–120, but full coverage was obtained on lines 123–153. Despite the abbreviated coverage on some cruises, 1,990 plankton hauls were obtained during the year.

PLANKTON HAULS OBTAINED ON CALCOFI DURING 1966

Cruise	Station Lines	Jordan	Agassiz	Alaska	Total
6601	60-137	86	134		220
6602	80-120	--	140		140
6603–4	60-137	--	136	101	237
6605	80-137	195	--		195
6606	60-103	134	--		134
6607	60-137	104	133		237
6608	80-137	177	--		177
6609	80-120	130	--		130
6610	60-137	98	126		224
6611	97-153	80	--		80
6612	60-137	92	124		216
		1,096	793	101	1,990

The reintroduction of the monthly survey in the CalCOFI survey program during calendar 1966 permitted precise information to be obtained about the distribution and abundance of the larvae of a number of species of present or potential commercial importance, including the northern anchovy, Pacific sardine, Pacific hake, and jack mackerel. During the preceding 5 years, surveys had been limited to four cruises per year, spaced at 3-month intervals.

As expected, anchovy larvae dominated the collections. The population size based on abundance of larvae is comparable to that found during the preceding 4 years, 1962–65. There has been a northward shift in the abundance of larvae. In the 1966 collections, sorted to date, over 50 percent of the anchovy larvae have been obtained off California.

There is a great deal of interest in determining the present abundance of hake in CalCOFI cruises, because it can be used for producing Marine Protein Concentrate and because the Russians are developing a fishery on this species. Hake has a spawning season restricted to 4 months, January–April. The peak of spawning usually occurs in February or March, months not adequately covered by the quarterly survey cruises of the preceding 5 years. Hake larvae have been abundant in CalCOFI collections during the January–April period. Spawning in 1966 appeared to be earlier than usual, and a higher portion was obtained off central California.

The numbers of hake larvae taken on the first four cruises of the year were as follows:

Hake larvae	Station lines	Number of occurrences	Standard haul totals
January cruise	60-137	87	28,820
February cruise	80-120	102	29,600
March–April cruise	60-137	122	13,460
May cruise	80-137	40	350
			72,230

The 1966 estimate of hake larvae was one of the larger on record, despite the fact that only one cruise was made during the 2-month period, March–April. The indicated high abundance estimate is gratifying inasmuch as the 1959 and 1960 estimate, the last ones available, were considerably below average.

The scant year for the jack mackerel fishery in California during 1966 has stimulated interest in determining whether this was due to poor availability, poor success of year classes or to an actual decrease in the size of the spawning population. Only the younger ages are taken by the fishery.

Jack mackerel larvae mostly are obtained during the months of April through July. The number of larvae obtained during this period was as follows:

Cruise	Area covered	Occurrences	Number of larvae standard haul totals
March–April	60-137	68	2,390
May	80-137	82	3,660
June	60-137	71	2,950
July	60-137	109	6,185
		330	15,185

Yearly estimates of jack mackerel larvae of CalCOFI cruises usually range between 8,000–20,000 larvae. The 1966 estimate is somewhat above average. Hence, both the wide distribution of jack mackerel larvae in 1966 and their abundance in the CalCOFI area indicate that the spawning population of jack mackerel is still large and of comparable size to that measured during the 1950's.

A distributional atlas of the anchovy-larvae is being prepared for all cruises of the CalCOFI from 1951–1965. The data will be presented on two charts for each cruise; one will be for the size group, 6.26–12.25 mm, the one most adequately sampled, and the other will be for total numbers collected.

Data processing

In an effort to make the egg and larval data collected on the CalCOFI oceanographic-biological surveys more readily accessible, a program was initiated for recording the data for automatic data processing. The decision was made to record not only current and future data in this manner, but also to transfer historical data of important species for automatic data processing.

The historical data for the 2 years 1958 and 1959 were selected for a pilot study of sardine and anchovy larvae data and this was completed first. Subsequently, transferral of data of these two species for the years 1951–57 and 1960–64 was undertaken. Supplementary haul data and information on other species are also being incorporated as follows:

Identification	Haul data	Larvae data
1. Cruise 2. Station 3. Date 4. Position coordinates 5. Type and number of tows	1. Starting time 2. Stopping time 3. Depth 4. Volume strained 5. Plankton volumes 6. Standardizing haul factor 7. Area factor 8. Local sunrise 9. Local sunset	1. Sized anchovy larvae 2. Sized sardine larvae 3. Total jack mackerel larvae 4. Total Pacific mackerel larvae 5. Total hake larvae 6. Total rockfish larvae
Physical data	**Egg data**	
1. 10 meter temperature 2. 10 meter salinity 3. 10 meter O_2	1. Total sardine eggs 2. Total anchovy eggs 3. Total saury eggs	

The recording and standardization of current data has become simplified. Information from the original data sheets and the meter calibrations is reproduced directly onto punched cards. Tables of standardized eggs and larvae and standardized plankton volumes, together with the calibration and regression plot are thus obtained without further hand manipulation.

Sampling techniques

Previous studies have established the importance of sampler performance and plankton avoidance in quantitative sampling. A study has been made of mesh selectivity and the size distribution of zooplankton in the California Current. One phase is concerned with 2,000 plankton samples taken over the entire California Current area in 1965 and 1966 using paired nets of different mesh size and the other involves a comparison of four different mesh sizes used in a series of samples taken at an inshore and offshore station.

The CalCOFI survey has included a fine mesh net dubbed the "anchovy egg net" which is towed simultaneously with the standard CalCOFI net in a rectangular-shaped frame. Displacement volumes of the 0.55 mm mesh width CalCOFI net averages 60 percent of the volumes taken by the 0.333 mm mesh anchovy egg net. The differences in plankton volume change with region, being greater onshore than offshore. The differences are greater in the northern section of the California Current than in the southern section while the fine mesh volumes exceed the regular mesh volumes to a greater degree in winter and

spring than they do in the summer and fall. Although both nets indicate the same areas to be productive, the catch of the fine net includes much of the food of filter-feeding fishes missed by the regular net.

The geological technique of successively graded sieves has been applied to the preliminary sorting of plankton samples. The eight grades of mesh sizes were used ranging from 0.15–2.20 mm. The technique appears most useful for organisms of simple form, such as fish eggs, although it can be used for removing salps, ctenophores and filamentous algae from the samples.

Extreme variability in replicate and paired plankton tows have emphasized the importance of small-scale patterns in the microdistribution (the study of vertical, etc.) of zooplankton organisms. One implication of this finding is that such organisms as pelagic fish larvae having limited mobility and large food requirements may depend on coincidence to locate dense concentrations of food organisms. This is shown by Dr. Schumann's experiments in fish rearing where he has observed that a sardine larva, at the onset of feeding, is capable of searching approximately one cubic centimeter of water in one hour. Since it is known that copepods, for example, tend to aggregate in the sea, larvae in a barren area would incur an energy deficit and die.

Sonar studies

The sonar cruises of May, June, August and October, 1966, on the Bureau research vessel, *David Starr Jordan*, have produced a record of abundant targets likely to be schools of fish and have demonstrated that these are frequently massed in large groups extending over tens of miles. The largest group was encountered in May and extended over a distance of 30 miles with a peak registration of 190 schools in 10 miles. Two other groups of half this magnitude were also encountered in May. In June five large groups were recorded, with a peak abundance of between 100 schools and 170 schools per ten miles. These extended over distances of 20 to 80 miles. In August, on the other hand, there were only two groups of any size, one with a peak of 100 schools, the other with a peak of 40 schools per ten miles. Again in October only two groups were recorded. The largest, extending over a distance of fifty miles from Point Fermin south to Del Mar, had a peak of 70 schools per ten miles, and the other, off Santa Monica Bay, had a peak of only 30 schools per ten miles.

Most, but not all of these aggregations were close to the coast or off islands. The two largest in May were centered about 40 miles off the coast between Point Fermin and San Diego and did not extend any closer than 30 miles to the coast. These were identified visually as anchovies. Two of the five groups encountered in June were over 100 miles southwest of Ensenada Bay. No offshore aggregations of comparable magnitude were recorded in August or October.

Since the distribution of many fishes is known to be associated with temperature, the sonar data from these cruises were examined in respect to surface temperature distribution. Only one dynamic event indicative of association was found. The two major concentrations of May were approximately centered on the 16° C isotherm, which was about 50 miles offshore from San Diego. In June the isotherm had moved offshore and northward and no concentrations existed in these locations where the water was about 5° warmer, but a large concentration occurred along the seaward side of the Channel Islands, and another along the coast from Point Conception north, again in association with 16° isotherm. Other large groups in June were far to the south in warmer water, and no large groups were associated with this isotherm in August or October. These data are too scant to warrant generalizations about associations between school groups and temperature, especially since most of the groups were unidentified, but they do indicate that any such associations can be delineated as survey information accumulates.

Temperature is important in another sense in regard to acoustic survey work. The directional dispersion of sonar sound emission is strongly influenced by the vertical temperature profile. Sound transmission patterns generated by the U.S. Navy Fleet Numerical Weather Facility in Monterey for temperature profiles taken on other cruises in the region vary from situations where the center four degrees of the emission cone propagates horizontally close to the surface to situations where the entire cone is refracted sharply downward. Such differences would alter the volume of water searched by the sonar at different depth strata, an important consideration if estimates of school abundance are to be attempted from acoustic records. As a first approach to examining the relation between temperature structure and sonar records those BT's taken closest to the large concentrations recorded during the above cruises have been selected for processing by the U.S. Navy Fleet Numerical Weather Facility.

The records of these large concentrations do vary considerably in character, possibly in relation to temperature structure, but probably also in relation to the nature of the targets themselves and to their depth in the water. Some register only close to the vessel, others at only a considerable distance. Some show echoes that are stronger and larger than others for equivalent distances from the vessel, and some show two groups of echoes at different distances. The importance of school depth in interpreting such variation is illustrated clearly by matched depth sounder and (horizontal) sonar records of the one notable concentration registered on the October cruise. During the afternoon the schools of this group were at a depth of 250 meters, as shown by the depth recorder, and were registering at distances of 800 to 1,500 meters from the vessel horizontally, as shown by the sonar recorder. These schools started to rise in late afternoon and by 1800 hours had disappeared from the depth sounder record. As this occurred the distance at which schools registered on the sonar record shortened so that by 1800 hours echoes were all within 500 meters of the vessel. The distance of registration continued to shorten and by 1900 only

occasional schools appeared on the sonar record at distances no greater than 100 meters from the vessel. It is obvious that as schools become shallower they intercepted the conical beam of the horizontal sonar transducer sooner, and hence closer to the vessel. It is also obvious from this sequence of events that special care must be taken to avoid bias in estimates of school abundance. In estimating this group, for example, the nighttime record should probably be discounted on the assumption that many schools close to the surface do not show on the sonar record; or on the assumption that the schools tend to break up when they reach the surface. In a more general sense, however, the changes seen on the sonar record as schools ascend, suggests that the water volume attributable to any recorded group for the purpose of estimating abundance over a broad area will be a function of its vertical distribution as well as of the temperature profile of the water. Obviously many more combined sounder-sonar records should be obtained for study to establish the effect of target depth on the nature of the sonar record.

In addition to the problems of understanding the variable character of sonar records in relation to refraction of sonar sound emission and depth of schools, there are the problems of counting criteria and identification of targets. When schools are close to the vessel they produce strong but small echoes which are not always distinguishable from random background noise. As distance from the vessel increases echoes become larger and eventually weaker, so that at the outer margin of any registered group there are some considerable number of faint traces that merge into the background. To deal with the near-vessel problem when the sonar transducer is fixed at right angles to the course of the vessel we have arbitrarily adopted the criterion that only traces composed of at least three successive echoes are valid targets. No criteria have yet been established for dealing with uncertainties at the outer margins of recorded groups. Overcoming these and other counting difficulties is of little consequence where the objective is only to delineate general distribution, but would be quite important, where the numbers counted are to be the basis for abundance estimates.

Identification of targets will be necessary, of course, whether the purpose is to define distribution or to estimate abundance. Prospects of achieving identification from sonar or sounder traces themselves where the schooling species most commonly encountered are of similar size are not promising, and we have concluded that sampling by midwater trawl will be the most reliable if not the simplest procedure. For this purpose we have assembled and tested a small midwater trawl. Though not yet used on a survey cruise, the device tows satisfactorily and is easily set and retrieved.

Genetic studies

The subpopulations project is investigating the population structure of the northern anchovy off California and Baja California, Mexico, through genetic studies and tagging. In the genetic studies we are looking into blood-typing and electrophoresis of various tissue proteins; the tagging work is reported on in the following section.

In order to blood-type anchovies it is necessary to develop the specific typing reagents. Experiments have been conducted with several species of fish as sources of these reagents by immunizing them with a series of injections of washed anchovy red blood cells. Four or five species proved to be adequate producers of immune sera but the best was the ocean whitefish, *Caulolatilus princeps*, because it was quite readily available, easy to keep in captivity, withstood frequent anesthetization and handling, produced a relatively large volume of blood per unit of body weight, and most important—produced quite high titer immune sera. There was however some variability between individuals; for instance, the average titer from the weakest individual was 1/512 and the strongest was 1/32,768. A paper is being prepared on the results of these experiments.

Electrophoretic analysis of the proteins from various anchovy tissues is also being tried as a means of determining the genetic make-up of our anchovy population. The patterns produced in polyacrylamide gel from the soluble proteins of the eye lenses showed no differences in anchovies sampled from southern Baja California to San Francisco.

The lactate dehydrogenase isoenzymes were investigated by electrophoretic separation of starch gel but no polymorphism was found among local individual anchovies in the LDH of the three tissues looked at. Anchovy serum contains a single isoenzyme band, muscle has two bands, and eye lens homogenate has three. Additional studies will be made of LDH of other tissues of local anchovies as well as anchovies from other areas.

The proteins which show the greatest promise now for genetic analysis of the anchovy population structure are the transferrins. Transferrins are a specific group of iron-carrying proteins found in blood serum. Genetically controlled polymorphic types of transferrins have been found in fish, reptiles, mammals, and birds. Anchovy transferrins labeled with radioactive iron and electrophoresed on starch gel show six phenotypes which appear to be controlled by a three allele genetic system. The frequency of occurrence of these genes in the anchovies from various areas is being investigated.—*A. R. Longhurst*