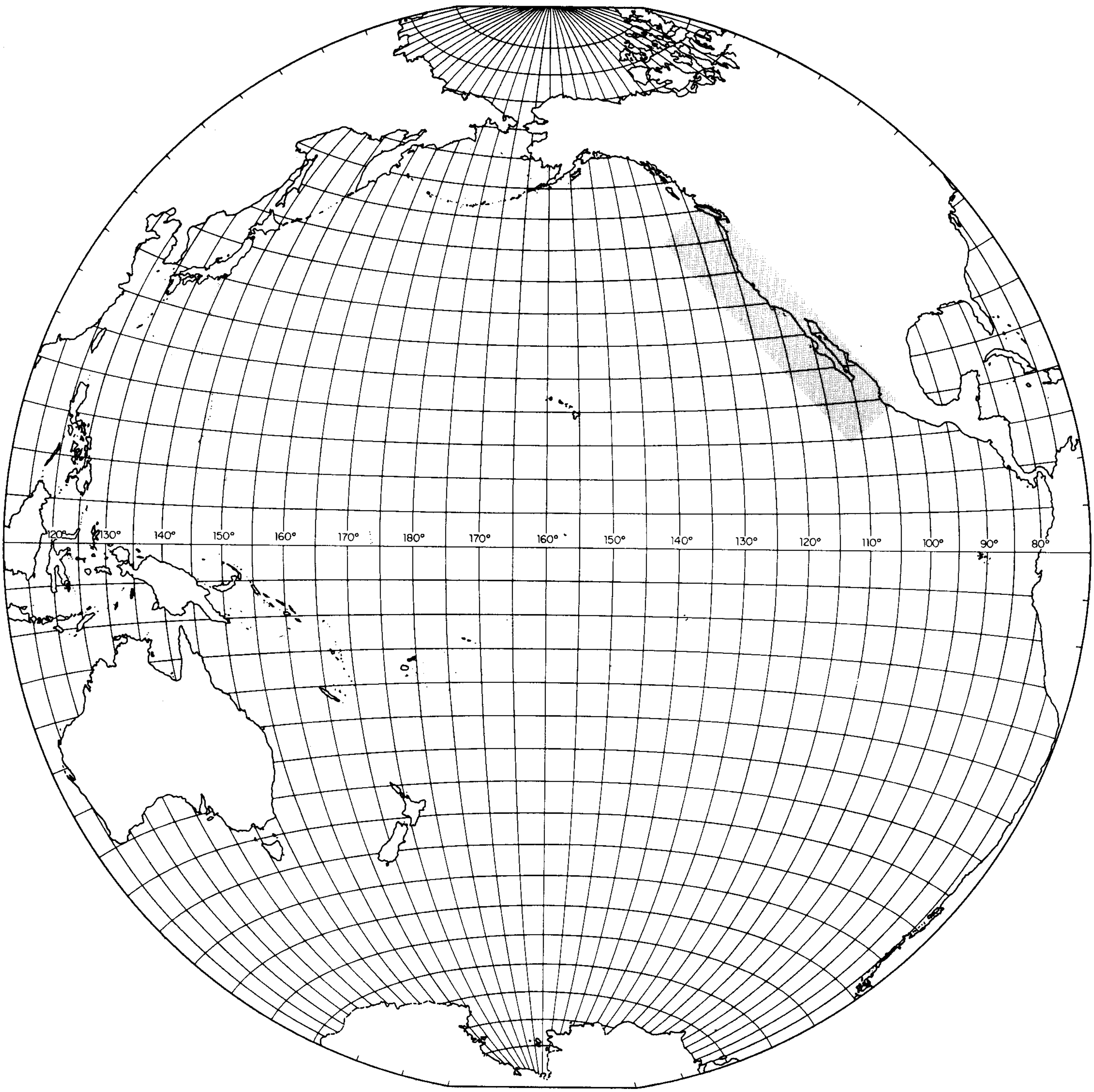
STATE OF CALIFORNIA
MARINE RESEARCH COMMITTEE



CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS

REPORTS

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STATE OF CALIFORNIA
DEPARTMENT OF FISH AND GAME
MARINE RESEARCH COMMITTEE

CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS

Reports

Volume XIII
1 July 1967 to 30 June 1968

Cooperating Agencies:
CALIFORNIA ACADEMY OF SCIENCES
CALIFORNIA DEPARTMENT OF FISH AND GAME
STANFORD UNIVERSITY, HOPKINS MARINE STATION
U. S. FISH AND WILDLIFE SERVICE, BUREAU OF COMMERCIAL FISHERIES
UNIVERSITY OF CALIFORNIA, SCRIPPS INSTITUTION OF OCEANOGRAPHY

1 January 1969

STATE OF CALIFORNIA—RESOURCES AGENCY

RONALD REAGAN, Governor

DEPARTMENT OF FISH AND GAME

MARINE RESEARCH COMMITTEE

1 January 1969

The Honorable Ronald Reagan
Governor of the State of California
Sacramento, California

Dear Governor Reagan:

We have the honor to submit the thirteenth report on the work of the California Cooperative Oceanic Fisheries Investigations.

The report consists of two sections. The first contains a review of the administrative and research activities during the period 1 July 1967 to 30 June 1968, a description of the fisheries, and a list of publications arising from the programs. The second section consists of papers prepared for a symposium, "The living resources of the California Current System, their fluctuating magnitude, distribution and susceptibility to use for the benefit of the State of California," held in December 1967.

Participants in the symposium included key figures from industry, recreational interests and government as well as members of the scientific community. We believe that the symposium served a very useful purpose, reaching its goal of bringing into focus the many factors outside of biology that bear on wise utilization of our living marine resources.

Respectfully submitted,

Charles R Carry

THE MARINE RESEARCH COMMITTEE
Charles R. Carry, *Chairman*

CONTENTS

Page

I. Review of Activities 1 July 1967–30 June 1968
- Report of the CalCOFI Committee 5
- Agency Reports 6
- Review of the Pelagic Wet-Fisheries for the 1967–68 Season 11
- Publications 12

II. Symposium on the living resources of the California Current System; their fluctuating magnitude, distribution, and susceptibility to use for the benefit of the State of California. *J. D. Messersmith*, Editor 17

Keynote: A consideration of the living marine resources off California and the factors affecting their use. *Philip M. Roedel*

Session 1. What are the resources and what is the state of our knowledge? *John L. Baxter,* Convener

- Status of knowledge of the Pacific hake resource. *Dayton L. Alverson* and *Herbert A. Larkins* 24
- The anchovy resources of the California Current Region off California and Baja California. *J. D. Messersmith, John L. Baxter,* and *Philip M. Roedel* 32
- Mesopelagic and bathypelagic fishes in the California Current Region. *Elbert H. Ahlstrom* 39
- The jack mackerel (*Trachurus symmetricus*) resource of the eastern North Pacific. *C. E. Blunt, Jr.* 45
- Bottomfish resources of the California Current System. *H. G. Orcutt* 53
- Pelagic invertebrate resources of the California Current. *Alan R. Longhurst* 60
- History of fish populations inferred from fish scales in anaerobic sediments off California. *Andrew Soutar* and *John D. Isaacs* 63
- Fossil records of certain schooling fishes of the California Current System. *John E. Fitch* 71
- A perspective of a multi-species fishery. *Oscar E. Sette* 81

Session 2. What are the legal, economic, sociological and technological problems impeding their best use? How can these be resolved? *J. D. Isaacs* and *P. M. Roedel,* Conveners

- The State's involvement in maritime and ocean resources development. *Col. T. R. Gillenwaters* 88
- Views concerning use of the living resources of the California Current. *Gerald V. Howard* 91
- Viewpoint of the U.S. Bureau of Sport Fisheries and Wildlife. *G. B. Talbot* 95
- Use of the pelagic living resources: the legislative point of view. *Winfield A. Shoemaker* 97
- The point of view of government: California looks to its ocean resources. *Walter T. Shannon* 99
- The California fish and game code. *E. C. Fullerton* 101
- The point of view of industry: The processor. *Harold F. Cary* 103
- Viewpoint of the industry: fishermen and allied workers. *John J. Royal* 108
- The point of view of industry: Fishing boat owners. *Frank Iacono* 110
- The point of view of recreational interests: The organized sportsmen. *Robert Vile* 111
- The point of view of the partyboat and live bait industries. *R. A. Izor* 113
- The exploitation of the living resources of the California Current: A food technologist's point of view. *Roland Finch* 117
- Development of a fishery resource. *Gordon C. Broadhead* 120
- The legal framework for the development of ocean resources. *Carl Christol* 122
- How can the scientific community best contribute to the resolution of these varied problems? *Alan R. Longhurst* 127

Calif. Mar. Res. Comm., CalCOFI Rept., 13: 5–15, 1969

PART I

REVIEW OF ACTIVITIES

1 July 1967–30 June 1968

REPORT OF THE CALCOFI COMMITTEE

The interval of time covered by this report finds the CalCOFI Program between two salients—the future year of major surveys and studies and the past two years of recapitulation and intense reevaluation of the program objectives and accomplishments.

In their Report XI (1966), the CalCOFI Committee outlined the history, accomplishments, and status of the program. In their Report XII (1967) the Committee reevaluated the status of understanding of the pelagic marine resources of the eastern North Pacific and analyzed the factors that limit their present and future utilization.

From this analysis it is clear that the CalCOFI Program has yielded major accomplishments. The program has slowly stripped away a host of unknowns and uncertainties and has brought into sharp perspective the potentials and probable potentials of a number of species of pelagic marine organisms—an understanding quite sufficient for the initial utilization of a number of the stocks.

Despite these advances of understanding, unequaled elsewhere in the world, no substantial domestic pelagic fisheries have been initiated in the eastern North Pacific (although Soviet fishermen have been active in these waters). As analysis shows, this failure is neither scientific nor is it directly economic, or technological. Rather this inability of California to act reasonably and conservatively on the resources that are rightfully hers, stems from institutional and social factors—a statutory inflexibility and a conservative retention of this inflexibility, under the apprehension that such is the only defense against eventual over-exploitation. There is some substantial past and present basis for this apprehension (e.g., the sardine in the past, and the Pacific mackerel at the present) as has been pointed out in previous reports.

This unfortunate history and condition are recapitulated more directly and bluntly as follows:

As a result of the depletion of sardine stocks a quarter of a century ago, the State of California initiated broad studies of the pelagic ocean environment. These continuing studies have placed her in a position of unprecedented advanced scientific understanding of her potential commercial fisheries. These are great. Two factors now apparently constrain California from profiting from her farseeing investment in understanding: first, a failure to appreciate the hyper-economic benefits from the development of domestic fisheries, and, secondly, a not baseless apprehension that the state government would not be able to restrict a developing fishery to its supportable yield.

Unhappily, the social results of a great investment in advanced research and the efforts of many dedicated scientists over many years have only delineated the stark symptomatic defects of our California institutions and helped accelerate the availability of the resources of the eastern North Pacific to foreign fisheries.

We have said that the CalCOFI Program, in this interval of time, has found itself between two salients. We have described that of the past, the reappraisal of accomplishments, for which the scientists of the program may feel both professional pride and social disappointment.

Despite the practical disappointment described above, we must presume that the causes will be exorcised in a further enlightened future. Thus this year has seen a number of important steps, vital to the scientific program. There have been preparations for monthly sea surveys to take place in 1969, during which the pelagic resources will be subject to the most intense surveys of the entire life of the program. Also there have taken place preparations for and the first steps in launching a broad study of the causes of fluctuations in the conditions of the North Pacific. This involves the cooperation and major sponsorship of the Office of Naval Research and the U.S. Coast Guard. This program will utilize an array of deep-moored instrument stations and will elucidate a vital and fundamental problem—the fluctuations in marine fish stocks. The results of these and other studies will form major portions of subsequent reports. *J. L. Baxter, J. D. Isaacs, A. R. Longhurst, and P. M. Roedel, October 1968.*

AGENCY REPORTS

CALIFORNIA ACADEMY OF SCIENCES

Brief summary on food habits of Northern Anchovy (Engraulis mordax)

Three basic collections of anchovy stomachs were made in Central and Northern Baja California, Southern California, and Central California, and three supplementary small ones were made in Northern Baja California (two) and in Southern California (one). These six collections were made between May, 1965, and February, 1968, totaling 926 stomachs. The collections were chiefly made, and all were examined, by Anatole Loukashkin.

Out of 926 stomachs examined, 86 were empty, in 173 food items were evenly distributed, and in 667 dominance of one type of food over the others was clearly evident.

Stomach contents varied from "very poor" to "full capacity." A majority of stomachs fell into categories "poor" and "very poor."

The best-filled stomachs were found in fishes caught during the day, or in fishes caught at night attracted by an electric light under which they were feeding on plankton swarming within the illuminated zone. Less-filled stomachs and most of the empty ones were found in fishes caught in midwater trawl net hauls during night fishing.

In May and June collections of 1965 (Monterey Bay and Northern Baja California), phytoplankton (diatoms) dominated, up to 34.57 percent and 83.33 percent respectively. In some stomachs diatoms were the only food item found, and quite often 99 percent of the diatoms belonged to a single form (*Chaetoceros*, for instance). In other stomachs, phytoplankton and zooplankton were present in equal volumes. In a greater number of cases, only a few specimens of diatoms were found. Dinoflagellates were found in meager quantities.

From actual observations in the field and in the Steinhart Aquarium, and from the examination of the stomach contents, it is evident that the anchovy is both a filter-feeder and a particulate feeder, depending on the size of the available food organisms. The anchovy is an omnivorous animal feeding on whatever suitable food material is available.—*R. C. Miller*

CALIFORNIA DEPARTMENT OF FISH AND GAME PELAGIC FISH INVESTIGATIONS

The Department's research under CalCOFI 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) Mackerel-Sardine, (iii) Sea Survey, and (iv) Sea Survey Data Analysis.

Anchovy

Routine activities such as fishery sampling and monitoring aimed at determining the age composition of landings, catch-per-unit-effort of the fleet, and areas of fishing were continued. Techniques and sampling procedures have been reported in volumes XI and XII of this report series.

Very few data relative to developing an understanding of the dynamics of the anchovy population were gained during the fiscal year. This can be attributed to the poor fishery, only 852 tons landed in southern California, caused chiefly by the low price of fish meal and oil.

The live-bait project initiated a three-month program of intensive sampling in June 1968. The objective was to obtain background data for the design of a statistically evaluatable live-bait sampling scheme. Preliminary analysis indicate that the past level of sampling must be doubled or tripled to obtain numerical age composition estimates, of the dominant year class, with 90% probability and ± 15% standard error.

During the year ending June 30, 1968, 205,657 anchovies were tagged but only 136 recovered. Total anchovies tagged and recovered since March 14, 1966 were 320,743 and 609 respectively. Tag recoveries were low because of the lack of a fishery in southern California. Recoveries demonstrated nothing new but did corroborate previous findings: That fish from as far away as Sausalito (San Francisco Bay) and San Diego contribute to the Monterey Bay fishery; Monterey fish contribute to the southern California fishery; and southern California fish contribute to the Baja California, Mexico fishery.

Mackerel-Sardine

Two programs, designed to monitor the condition of the fishery, continued through the fiscal year. The first involved estimation of the age compositions of the landings. Due to the sardine moratorium which commenced June 7, 1967, it was difficult to obtain sufficient samples to describe the catch adequately. We intensified work at the markets and sampled all sardine catches that were mixed with mackerel and landed at the canneries.

The new jack mackerel sampling plan installed in May 1967 has worked well and has allowed smoother collection of the necessary data on a sound statistical basis.

Pacific mackerel landings are at an all time low and, as with the sardine, we are forced to sample all landings available. We made a major adjustment in our procedure in that now fewer fish are taken per sample and all are aged and weighed.

The fleet monitoring program continued routinely and seems to be fulfilling its objective of monitoring fishing effort on a sound, systematic basis. Through log-interviews we obtained detailed fishing information on approximately 90% of the southern California vessel landings of mackerel, sardines, and bonito.

Analysis of the backlog of jack mackerel age-length data from 1947–67 continued when time permitted. A paper on the jack mackerel resource was presented to the 1967 CalCOFI conference.

A paper on the current status of the Pacific mackerel fishery and the condition of the resource was presented to the Marine Research Committee. This discussion incorporated some of the preliminary population work by Patrick Tomlinson of the Department's Biostatistical section and highlighted the present depressed state of the resource.

Reports on the age composition of the landings were completed for the 1965–1966 sardine season and the 1964–65 through 1966–67 seasons for Pacific mackerel.

Sea Survey

During the past year 10 sea survey cruises averaging 20 days each were conducted in the California Current System. Nine were routine and one was experimental.

Northern California was surveyed once in the summer of 1967, and central and southern California three times each by cruises during fall, winter and spring. An additional experimental cruise to test trawl gear and a new sonar was made in southern California. Baja California, Mexico was surveyed during late fall and early spring.

After two years of work, all regions have been surveyed during every season except summer. The principal pelagic species, as determined by echo sounding and midwater trawling, are in order of abundance: northern anchovies (*Engraulis mordax*), lanternfishes (family Myctophidae) and deep sea smelts (family Bathylagidae), juvenile rockfishes (*Sebastodes* spp.), Pacific hake (*Merluccius productus*), jack mackerel, (*Trachurus symmetricus*), and Pacific sardine (*Sardinops caeruleus*). Pacific herring (*Clupea pallasi*) and whitebait smelt (*Allosmerus elongatus*) were locally abundant at times in northern and central California. Anchovies completely dominated as the most abundant species in terms of biomass. The bathypelagic lanternfishes and deep sea smelts very likely constitute a fairly large biomass but their dispersed schooling habits would make it difficult to utilize them directly. Rockfishes, although not a true pelagic species, constitute a large resource. The remaining species occurred in relatively minor amounts due either to ineffectiveness of the surveys or actual low species density.

A new fish finding sonar was installed aboard the R/V ALASKA during the last week of June, 1968. Preliminary trials indicate this equipment will be of great value, both as a survey tool and as an aid in fishing operations. Thus far it has been very effective in locating and tracking anchovy schools and may be of potential value in determining school sizes.

This instrument can also be used as an echo sounder. Comparisons made with our regular echo sounder indicate the sonar has much better fish detecting sensitivity. This capability should enhance the detection of scattered fishes such as lanternfish and hake.

A net reel for improving midwater trawl operations was delivered in late June and was later installed aboard the ALASKA.

A new method of coding permits direct coded data entry during collection at sea. This method eliminates tedious shoreside work and reduces chances for error. All 1968 data have been collected in this manner.

Sea Survey Data Analysis

During the 1967–68 fiscal year several computer programs were written and utilized to extract data from past Sea Survey cruises.

The sardine length-age composition computer program was completed and data obtained on Sea Surveys for twelve years (1950 through 1961) were analyzed. After examination of the data it does not appear that the dynamite and blanket net surveys gave us any quantitative measure of the Pacific sardine populations, or any new insight into their biology. However, general trends of abundance by year and by area were apparent.

The sardine length-age program was modified to compile similar data on the northern anchovy. At best the data were spotty and inconsistent. Modifications of anchovy sampling techniques under the new midwater trawl surveys are expected to give us new insight as to migration patterns and population parameters of this species.

The transfer of over 50,000 cards to tape was completed. Sea Survey data from 1950 to 1966 is now on tape and in usable form. The cost and time involved in making these tapes made it of vital importance to have duplicates in case of loss or damage. Therefore, duplicate tapes were copied using a Univac 1107 tape "soft ware" program.

Besides the obvious assets of tapes over cards as a storage facility, tapes will allow us to analyze many years of data concurrently instead of one year at a time which the card system necessitated. Conversely, easy cruise by cruise analysis and even the ability to pick out any particular cruise is made available to us by an end-of-file routine. This routine requires a minimum of computer programming instructions.

With the completion of the card-to-tape program work was resumed on the computer program which will relate Sea Survey catches of economically important fish and invertebrates to environmental conditions.—*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 off central California. Under the program, the marine station monitors the marine environment and phytoplankton of Monterey Bay, and is starting a study of the food chain of the anchovy and its relation to the biological oceanography of Monterey Bay.

Approximately weekly cruises to six stations on Monterey Bay are made. At every station cruise data consist of: concentrations of dissolved oxygen, phosphate, silicate, nitrite and nitrate at 0 and 10 meters; plankton wet volumes collected in a $\frac{1}{4}$ meter net towed vertically 15 meters; depth of thermocline as recorded on a bathythermographic slide; secchi disk extinction depth; and general comments on the weather, condition of the sea, marine mammals and oceanic birds.

At stations 2, 4, and 6 salinities and reversing thermometer temperatures are recorded for 0, 10, 15, 20, 30, and 50 meters. At the shallow water stations, 1 and 5, these same parameters are measured at 0, 10, 15, 20, and 30 meters and 0, 10, and 15 meters respectively. At station 3, over the submarine canyon, salinities, reversing thermometer temperatures, and concentrations of dissolved oxygen, phosphate, silicate, nitrite and nitrate are recorded for the depths 0, 10, 15, 20, 30, 50, 100, 200, 300, 400, and 500 meters.

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.—*M. Gilmartin.*

SCRIPPS INSTITUTION OF OCEANOGRAPHY MARINE LIFE RESEARCH PROGRAM

The Marine Life Research Program is the administrative unit of the Scripps Institution of Oceanography which carries out the portion of the California Cooperative Fisheries Investigations that has been assigned to the University of California. The program is broadly involved in investigations of the ecology of the California Current System—with its currents, temperatures, chemistry, climate, and populations of organisms, and with the fluctuations of these parameters.

As was pointed out in the preceding CalCOFI Report (Vol. XII), the scope of the Marine Life Research Program has, over the years, become considerably augmented and expanded by research grants from a number of agencies. This has allowed us to extend the program's inquiries both in depth and width into the conditions and processes of the North Pacific. This has been possible because of the fundamental and perception broadness with which the cooperative investigations were imbued by its prescient originators, two decades ago.

The basic report of the Marine Life Research Program is contained in the publications of its investigators. This resume briefly points out some of the present conditions of the eastern North Pacific and some of the scientific developments.

Recent Oceanographic Conditions in the Pacific

The northeast Pacific Ocean was generally warmer than normal by 2° F from July, 1967 to June, 1968. A colder than normal area in the Gulf of Alaska from September, 1967 through February, 1968 became approximately normal from March through June, 1968. A cold area off the west coasts of the United States and northern Baja California developed in April, 1968 but it had become much smaller by July, 1968.

North Pacific Study

A program to study the large-scale oceanographic and meteorological conditions in the North Pacific, reported in Volume XII, is progressing smoothly.

An array of unmanned instrument platforms is being prepared to collect data from the central North Pacific. Data is now being collected off Monterey by such stations. Extensive records from two moored stations in the tropical eastern North Pacific are being analyzed. Such information in conjunction with an extensive historical study in progress should provide a greater understanding of the ocean conditions and weather of the California coast.

Zooplankton

This extremely important component of the living populations of the sea continues to be studied intensively. Plankton collections at sea have always been a major part of the CalCOFI Surveys. There is now in the archives at Scripps the greatest and most complete plankton collection of any area in the world. Only a miniscule fraction of the value of such a collection can be realized unless careful scholarly analysis is continuously conducted. Analysis of this collection and publication of results has thus always been a major portion of the Marine Life Research Program. All of the major groups of zooplankton are under continuous study.

Results of these studies have shed more and more light on the processes in the California Current. For example, a study of the community structure and distribution of zooplankton sampled during a spring cruise that covered a large part of the California Current has shown: (1) very little pattern of community distribution, (2) no relationship to physical stability. This lends support to an earlier conclusion based on purely biogeographic data, namely that the primary factor influencing the numerical species relationships in most of the California Current is advection, not trophic relationships. That is, the principal factor that determines the composition of the important zooplankton populations in the California Current is the current system rather than the level of phytoplankton, the chemistry or other conditions. This is a most important confirmation of earlier indications.

The discoveries of the scientists working with the zooplankton urge that the coming surveys in 1969 include a considerable number of stratified net tows.

For example, some of the important species of zooplankton seemingly disappear from the California Current in certain regions. Actually these species descend in those regions out of the range of the conventional plankton nets. This and other sorts of changes in vertical distribution require the vertically stratified sampling that is to be an important part of the 1969 cruises.

Considerable advances have been made in artificially rearing some of the larvae of the planktonic organisms. This, of course, finally allows these larval organisms to be identified positively. This and other research throws important light on the rate of growth and reproduction of the zooplankton. The growth rates of plankton appear to be much more rapid than they were previously thought to be. That unexpectedly rapid growth may be the rule rather than the exception is also indicated by studies of the rate of production of the sediments, which is discussed later.

Biomass Analysis

Although the exact species identification of the creatures in the plankton is essential for a complete understanding of the planktonic populations, such identification of all species in all samples is an extremely lengthy task. Insofar as concerns the plankton as food for higher organisms, such as fish, the exact *species* spectrum of plankton present is undoubtedly not as important as are the abundances of important *types* of plankton. For example, the proportion of crustacea, worms, jellies, etc. in the plankton is more important to a fish such as the sardine or anchovy than is the exact species composition.

Thus, several years ago, techniques for biomass analysis were developed in the Marine Life Research Program. This work of the Biomass Analysis Laboratory has developed very satisfactorily. The plankton are separated into about twenty "functional" groups and their total biomass is measured.

The first major results of this work are now in advanced stages of publication. They show that profound changes in the functional groups of zooplankton have occurred in critical years.

Varved Sediments

The analysis of the varved (layered) sediments from the Santa Barbara Basin and elsewhere (previously reported) continues, and continues to show increasing details of the history of oceanic conditions and of fish populations along the eastern North Pacific. About eight periods of abundance of sardine scales have now been identified during the last two thousand years. These periods on the average occurred about every two hundred and fifty years and their average duration was of the order of seventy to one hundred and twenty years. The populations of hake and anchovies apparently remained relatively large throughout the entire period, although also fluctuating.

Attempts to separate and study the relative populations of Pacific and jack mackerel were unsuccessful, because of the rarity of Pacific mackerel scales.

The indicated *minimum* total populations of anchovies and hake are close to but somewhat below the present estimates from larval and other data.

Sedimentation

This new entree into the productivity of the California Current involves the collection of the debris from the surface waters that is falling to the bottom. Development of an autonomous collector to carry out this difficult task has been successful. The results indicate that the maximum generation time of the planktonic organisms studied was much briefer than supposed. This supports the findings reported above from studies of the zooplankton populations.

Deep Currents

Autonomous current recorders, developed by the Marine Life Research Program, now permit the long term measurement of the bottom water flow over large areas. Since the major part of the productivity of the North Pacific is the ultimate result of this deep flow, the measurement of the total flow into the North Pacific is of substantial importance. Exploratory attempts at measuring the flow have been encouraging and a major effort is now being undertaken.

Deep Creatures

The photographs of large populations of fish and crabs have been published previously. Analysis of the large number of photographs now available indicate that the populations are much larger than previously thought and that they must, in a large part, be dependent upon windfalls of large particles of food, such as the carcasses of whales, large sharks, or large fish, and possibly upon quantities of smaller fish debris resulting from predator attacks on large near-surface schools of prey.

General

In consonance with the CalCOFI Program, in general, the Marine Life Research Program is continuing its task of fundamental elucidation of the potential of the eastern North Pacific for man's use.

Although the major constraints to this use by the State of California appear now to be institutional rather than strictly scientific, technical, or economic, the continued expansion of knowledge of these important resources cannot fail to be of ultimate benefit in a future enlightened period.—*John D. Isaacs.*

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

This fiscal year is the first in which the Fishery-Oceanography Center has been operated as a unit, following the amalgamation of the former Tuna Resources and California Current Resources Laboratories. Research at the Center, which is the Federal laboratory responsible for fishery research in the BCF's Pacific Southwest region, is intended to supplement that of the State agencies, with which it collaborates, mainly within the framework of the California Cooperative Oceanic Fisheries Investigations.

In addition to conducting research on problems which are relevant to specific fisheries and designed to improve their status, the Center is also charged with advancing basic fisheries science. The work of the Center is carried out under four research programs, each of which confines its activities to a single discipline of fisheries science.

One of the main accomplishments of the past year in the *Fishery-Oceanography* Program has been completion of the field surveys for EASTROPAC, a multiagency, international series of expeditions designed to investigate seasonal changes over a large part of the eastern tropical Pacific. Under Bureau leadership, EASTROPAC was a major oceanographic effort, comparable with the largest oceanographic expeditions in numbers of stations and observations. With the completion of work at sea, the EASTROPAC staff has turned to the task of processing a vast amount of data. To expedite the job, computer programs were written for data processing and for the generation of vertical sections and horizontal plots of physical, chemical, and biological properties to be presented in a comprehensive published atlas.

Aided by an increased use of automatic data processing and communication techniques, the environmental monitoring and fishery forecasting project continued its services to fishermen through publication of fishing information, weather summaries, and radio broadcasts. Towards the end of the year, the project staff prepared for an albacore oceanography cruise designed to measure the distribution and availability of albacore in offshore waters.

In the *Behavior-Physiology* Program, a long-term study of the energy budget of the Pacific sardine has been completed. Measurements have shown that growth accounts for about a fifth of the assimilated energy of the average sardine during its first year of life, declining in succeeding years to as little as 1 percent. Respiration is the dominant energy-consuming process throughout the sardine's life. With the historical decline of the sardine biomass, a major part of the calories formerly needed for its respiration became available to other predators, e.g., the anchovy; the amount of energy made available to anchovies by the demise of sardines is about 30×10^{12} kilocalories per year in the California Current.

This program has also completed its studies on the mechanism of feeding in the northern anchovy, on the development of automatic data processing techniques for the quantitative analysis of fish schools from photographs and on the perfection of an effective, if empirical, rearing technique for pelagic fish larvae in the experimental aquarium at the Center.

Among the accomplishments of the *Population Dynamics* Program this year has been the demonstration that there are at least two genetically distinct subpopulations of the northern anchovy off the coast of California and Baja California. Samples from these two areas differ significantly in the frequency of three genes which control six recognizable transferrin types. The location of the division between the two subpopulations has not been established and the existence of a third, far northern stock, postulated by earlier investigators, has not yet been confirmed.

During the past year all of the biological and many of the physical data, including those taken on monthly CalCOFI cruises from 1951-60, have been coded for automatic data processing. This work furnishes an excellent data base for analyses of spawning seasons for each species, and of yearly anomalies from the long-term average and will be used in the design of the extensive CalCOFI cruises planned for calendar year 1969.

Because Mexico and the United States have a common fishery for sardines, anchovies, jack mackerel and Pacific mackerel from the California Current, arrangements were made this year to bring the Mexican Federal Laboratory into the fish sampling and ageing program carried out cooperatively by BCF and the State for more than 25 years.

Designed and built by scientists in the *Operations Research* Program this spring, the hybrid tuna purse seine combines the fast-sinking qualities of the North Atlantic purse-seine with the strength, deep fishing, and ease of handling of the American tuna seine. Data from field trials indicate that the new net sinks approximately 70% deeper and at a faster rate than conventional 7-strip tuna seines while maintaining its initial diameter well into pursing. If the net performs as well as expected under actual fishing conditions, American tuna fishermen could save more than $1 million annually in operating costs.

Other work in this program has been concerned with reactivating a basking shark fishery for extraction of squalene from liver oil, evaluation of the Continuous-Transmission-Frequency-Modulated sonar as a tactical fishing tool, and the beginning of a study to investigate the economic base of the California industrial fishery, presently in a depressed state.—*A. R. Longhurst.*

REVIEW OF THE PELAGIC WET-FISHERIES FOR THE 1967–68 SEASON

The 1967–68 season produced one of the smallest wet-fish catches on record. A moratorium on the taking of sardines forced the already low sardine landings even lower. The anchovy fishery, expected to take up the slack in landings as it has in the past two seasons, failed to develop in southern California, and landings in central California remained below the previous year. Pacific mackerel landings were the lowest since Department of Fish and Game records began in 1925. Jack mackerel landings were the lowest in ten years.

Landings for the calendar year, 1967, reveal a slight increase over the previous two years, but the anchovy catch for reduction, made late in the 1966–67 season, accounts for the increase. If the present rate of landing continues, 1968 will be a record low year for wet-fish landings (Table 1).

Vessels continued to leave the wet-fish fleet, and by June of 1968 it consisted of 21 large purse seiners (60 ft. and over), 12 small purse seiners, and 20 lampara boats, a loss of 4 large and 1 small purse seiners since the 1966–67 season. One large and two small purse-seiners fished in central California, and 15 lampara boats fished Monterey Bay. The remainder of the fleet fished southern California waters.

Sardine

A moratorium on the take of sardines in California, effective June 7, 1967, limited the catch to mixed loads with no more than 15% sardines. A total of 41 tons were sold to the fresh-fish markets and brought up to $500 per ton primarily for use as dead bait. Canners processed 30 tons.

In Baja California the sardine catch was up from last season, at 27,657 tons with most of the catch made in southern Baja California waters (Table 2).

Anchovy

The California Fish and Game Commission again authorized a 75,000 ton fishery for reduction beginning September 15, 1967, and ending May 15, 1968. The fishery failed to develop in southern California, with only 852 tons landed in the southern area (south of Pt. Conception). Low world prices for fish meal and oil and the resulting low prices paid to fishermen for their catch ($14–15 per ton), plus a lack of large fish schools close to port combined to inhibit the fishery.

Fishermen in the northern area (north of Pt. Conception) fared much better, delivering 5,651 tons to reduction plants on Monterey Bay, mostly in October, November, and December. This total, however, failed to equal the 8,021 ton catch of the previous season (Table 3).

Reported live-bait catches were below previous 2–3 years (Table 4). The lack of reports from two large operators, who reported in past years, make this total minimal compared to past reports.[1] As in the past, Los Angeles-Long Beach Harbor accounted for about 80% of the take.

Mackerel

Jack and Pacific mackerel catches continued to decline. Pacific mackerel landings of 691 tons were the lowest in the recorded history of the fishery. Jack mackerel landings, although higher than ten years ago, were the lowest since that time. Most of the 18,712 tons taken were caught at Tanner and Cortes Banks, as were some of the Pacific mackerel (Table 5.)—*Robson A. Collins, California Department of Fish and Game.*

[1] Live-bait catch records are derived from voluntary reports made to the Department of Fish and Game by each fisherman. Not all fishermen report, so these figures should be regarded as minimal.

TABLE 1

LANDINGS OF PELAGIC WET-FISHES IN CALIFORNIA IN TONS, 1967–1968

Year	Sardines	Anchovies	Pacific Mackerel	Jack Mackerel	Herring	Squid	Total
1963	3,566	2,285	20,121	47,721	315	5,780	79,788
1964	6,569	2,488	13,414	44,846	175	8,217	75,709
1965	969	2,866	3,525	33,333	258	9,310	50,288
1966	443	31,140	2,314	20,431	121	9,512	63,961
1967	74	34,805	583	19,090	136	9,801	64,489

TABLE 2

SARDINE CATCH IN TONS, 1963–64 THROUGH 1967–68

(Period June Through The Following May)

Season	California	Baja California	Total
1963-64	2,942	18,384	21,362
1964-65	6,103	27,120	33,223
1965-66	962	22,247	23,109
1966-67	344	19,529	19,873
1967-68*	71	27,036	28,007

* Preliminary.

TABLE 3

ANCHOVY LANDINGS FOR REDUCTION IN THE SOUTHERN AND NORTHERN PERMIT AREAS 1965–66 Through 1967–68

Season	Southern Permit Area	Northern Permit Area	Total
1965-66*	16,468	375	16,843
1966-67†	29,589	8,021	37,610
1967-68‡	852	5,651	6,503
Total	46,909	14,047	60,956

Seasons:
* October 15, 1965 through April 30, 1966.
† October 1, 1966 through April 30, 1967.
‡ September 15, 1967 through May 15, 1968.

TABLE 4

COMMERCIAL LANDINGS AND LIVE BAIT CATCH OF ANCHOVIES IN TONS 1963 THROUGH 1967

Year	Reduction	Other Commercial	Live Bait	Total
1963	0	2,285	4,442	6,727
1964	0	2,488	5,191	7,679
1965	170	2,866	6,148	9,184
1966	27,335	3,705	6,691	37,731
1967	32,349	2,455	5,387	40,191

TABLE 5

JACK AND PACIFIC MACKEREL CATCH IN TONS, 1963–64 THROUGH 1965–66 (Period May Through April)

Season	Jack Mackerel	Pacific Mackerel
1963–64	42,038	17,105
1964–65	39,557	12,437
1965–66	33,831	3,794
1966–67	22,889	2,037
1967–68	18,712	691

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PART II

SYMPOSIUM ON THE LIVING RESOURCES OF THE CALIFORNIA CURRENT SYSTEM: THEIR FLUCTUATING MAGNITUDE, DISTRIBUTION, AND SUSCEPTIBILITY TO USE FOR THE BENEFIT OF THE STATE OF CALIFORNIA

J. D. MESSERSMITH
Editor

Lake Arrowhead, California
11–12 December 1967

INTRODUCTION

The 1967 CalCOFI Conference was a radical, but temporary, departure from traditional meetings which have dealt with biological and oceanographic subjects of interest primarily to CalCOFI scientists. The heart of this conference was a symposium entitled "The living resources of the California Current System; their fluctuating magnitude, distribution and susceptibility to use for the benefit of the State of California." This symposium was conceived in an attempt to cope with today's economic and political "climate" which is having such an impact on our thinking in California. We felt that it was appropriate to consider some of these problems, both for the benefit of the scientific community, which is directly involved, and for others who have a stake in the matter. The conference was organized by the California Department of Fish and Game.

I thank all who participated at the conference and submitted papers for publication. I am especially thankful for the candid points of view of those who are not members of CalCOFI agencies. Regrettably one paper, The Saury as a Latent Resource of the California Current System, was not received in time to meet publishing deadlines.

Philip M. Roedel and John L. Baxter, California Department of Fish and Game, were especially helpful and encouraging from the time the symposium was conceived until the last paper was submitted for publication.

Gertrude M. Cutler served as Conference hostess, assisted in proofreading, and distribution of preprints, and in many other ways made my task much easier.

Patricia Powell, Supervisor of the Marine Technical Information Center, California Department of Fish and Game, performed the difficult task of checking and standardizing references with her usual competence.

I am particularly grateful to Kathleen O'Rear and Micaela Wolfe for the many hours they spent mimeographing preprints for early distribution, and typing and proofreading manuscripts.

JAMES D. MESSERSMITH, Editor

Calif. Mar. Res. Comm., CalCOFI Rept. 13:19–23, 1969

A CONSIDERATION OF THE LIVING MARINE RESOURCES OFF CALIFORNIA AND THE FACTORS AFFECTING THEIR USE

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INTRODUCTION

> "The living resources of the California Current System; their fluctuating magnitude, distribution, and susceptibility to use for the benefit of the State of California.
> "What are the resources and what is the state of our knowledge?
> "What are the legal, economic, sociological and technological problems impeding their best use? How can these be resolved?"

Such is the scope of the symposium to which we will address ourselves during the next day and a half. It is an ambitious undertaking, and I am neither so sanguine nor naive as to expect either an in-depth examination of the subject or final resolution of any major problems. If awareness and empathy result, the symposium will have served its purpose.

My role is to help set the stage. In doing so, I expect to look a bit at history, review today's problems, pose (but not answer) questions, suggest possible courses of action, editorialize and philosophize when it suits my fancy, and, in what I hope will be a subtle fashion, propound my point of view.

To start, let us look backward. It seems a fruitful way to begin, for an appreciation of the past can help us understand some of the attitudes of today.

THE PHILOSOPHY OF PLENTY

A philosophy of plenty so far as natural resources are concerned prevailed for generations in this country. It is quite understandable, for it was a philosophy borne out in truth for a very long time. A man named Richard Harlan stated it most succinctly:

> "The manor of living nature is so ample, that all may be allowed to sport on it freely; the most jealous proprietor cannot entertain any apprehension that the game will be exhausted, or even perceptibly thinned."

This appears on the title page of his book "Fauna Americana", published in Philadelphia in 1825. This was both a long time ago and yet only yesterday. It was a long time ago, we like to think, in terms of our knowledge and understanding today, but it expresses a basic belief of Americans that is hard dying, particularly when we change the frame of reference from the land to the sea. It is only in the very near past that we, as a society, have come to realize that the activities of man can indeed overpower, "the manor of living nature."

My grandfather lived in San Mateo on the San Francisco peninsula at the turn of the century. He was an avid duck hunter, and lived only a short buggy ride from Coyote Point, an isolated spot on the bay where waterfowl abounded. He would have been astounded to know that a few decades later I found slim pickings in the sloughs and on the bay near there, and had reasonably good hunting only at the isolated south end of the bay near Milpitas. He would be even more astounded to see suburban Coyote Point today, lying under the approach to San Francisco International Airport, and the industrial and residential complex impinging on the Milpitas marshes. I am sure my grandfather and his friends never conceived of a day when ducks might be in short supply, for they lived in a local extension of Richard Harlan's time. Things were different when I came along.

It was as a duck hunter and student of what was —though I didn't know it then—marsh ecology that I learned in my early teens that resources were not inexhaustible, that man could and did control the environment, and that wildlife existed only on his sufferance.

This was of course nothing new. Such prominent men as Theodore Roosevelt and John Muir had long preached the doctrine, and it was a well-established principle ashore before I reached my unschooled conclusion. There is, however, nothing like experience to drive a point home, and it sometimes takes little short of economic or biological disaster to convince the man who does not want to believe.

Yet when one looks to the ocean and considers its vast extent and seemingly endless resources, it is not difficult to understand why the lessons learned on land seemed of little consequence. The passenger pigeon, the buffalo, yes, man could annihilate these terrestrial creatures, but the ocean must be a bottomless cornucopia. Thus man fished without restraint, and, with few exceptions, did so with little or no fear of a decline in stocks until the last few decades.

It was so in California, when the sardine fishery reached its zenith in the thirties and early forties. The conviction of processors and fishermen alike, that the supply was endless, was so strong and so powerful that early warnings by scientists that a danger point had been reached were unheeded, ignored, or, if necessary, refuted by political force or by public scorn. This conviction was widespread and honest, and those few who had their secret reservations generally sublimated them to the hope that at very least the evil day lay far ahead.

It is said by some today that the scientists of the 1930's and 1940's were right but for the wrong reasons; that the industry recognized the basic scientific fault and thus was justified in its stand. I would say the scientists were right for the right reasons in the frame of reference of their time, and that the more powerful analytical tools of today only emphasize how right they were.

Be that as it may. In our society of the 1960's there is general acceptance (grudging though it may be in some circles) that there is a bottom to the cornucopia, that the resources of the sea are not boundless, that man must exercise some restraints upon himself if he is to reap maximum benefit from what there is.

CALIFORNIA OPINION: TEMPERS AND TEMPERAMENTS

People are slow to forget, and it is small wonder that many of us today look back on the fate of the sardine fishery and say: "That must not happen again to any other of our marine resources, even if, to insure against it, we must curtail fishing effort to a level far below that which the scientists say is there for the taking." The findings of the scientists, the desires of the commercial fishing industry, the fears of the sportsmen have all combined to bring about today's muddled situation. It is a situation in which biology, sociology, economics, politics and law have met head on, a situation which has brought about a stalemate, vituperation of good men by good men, a choosing of sides, an outward unwillingness to compromise, a resultant vacuum in fisheries utilization which will none-the-less be filled ultimately by someone more anxious than we to make full use of what the ocean has to offer.

We hope that reason will prevail, that it will be Californians who reap the harvest of the adjacent sea, reap it with the blessings of all Californians in such a fashion as to fulfill the needs and protect the legitimate requirements of all segments of our society.

Today we in California are directly up against a major confrontation between two user groups, a confrontation which has so far precluded development of a latent resource which scientists feel is there for the taking. The resource, obviously, is the anchovy, the user-groups the sportsmen and the commercial fishing industry. Industry says, "Look—the scientists demonstrate a big population capable of withstanding a large fishery within the framework of maximum sustainable yield. Allow us to harvest it." The sportsman replies, "Even if we assume the scientists are right (and they just could be wrong), who is to assure us that once the camel's nose is under the edge of the tent he will be satisfied, and not through sheer force take over full occupancy. We need anchovies for game fish forage and for bait; let us take no chances that the history of the sardine will be repeated."

There is nothing new about sports-commercial conflicts. To help set today's conflict in perspective, I quote from two books published nearly two decades ago. J. Charles Davis 2nd in his "California Salt Water Fishing" published in 1949 had this to say,

> "It is an axiom that the fish and game of America belong to the people, and it is too bad to have to report that the people have sadly neglected their property. They have allowed ruthless commercialism to step in and almost exterminate the food and game fish of the ocean.
>
> "Conservation is a fine, high-sounding word but so long as it remains just a word and not a fact it might just as well be left buried in the dictionary.
>
> "Many of us have been preaching conservation for years; urging the enactment of legislation to curb the wanton destruction of the fish of the ocean. Our efforts, I am sorry to say, have borne little fruit. Always we were met with the specious statement that 'the ocean can never be depleted.' We were told that the ocean was vast and teeming with fish. They could never be exhausted.
>
> "The signs were there, plain for anyone to read. But men failed to heed them."

Not every sportsman was that pessimistic, for the chronicler of "History of the Tuna Club (Avalon)" said in 1948,

> "To define 'conservation' succinctly is to say that commercial fishing and angling for sport should be carried out in such a manner that salt-water game fish will, at the very least, be preserved for all future fishermen. We say, 'at the very least;' the preferable goal, of course, would be that the supply of game-fish should actually be increased.
>
> "So far as the California Fish and Game Commission and ocean sport-fishing are concerned, it is an important fact, always present in the minds of the Commissioners, that the interests of commercial fishermen and anglers overlap. . . .
>
> "For some fifteen years there has been much bitterness between the two groups. In 1946, it was possible by means of meetings between the conflicting parties, to compose many of the difficulties hitherto existing.
>
> "In its latest report, the Bureau of Marine Fisheries states: 'under the guidance of their present capable leaders, the organized sportsmen and the commercial fishing industry should enjoy more harmonious relations, to the benefit of the entire fishery.' "

What happened at those meetings in 1946 obviously was of little lasting value, and Mr. Davis apparently discounted it completely.

The important thing is that the effort was made and for a brief moment it seemed that rational agreement might prevail. Instead the situation has deteriorated, and Mr. Davis' remarks seem quite mild when compared to some of the public statements made by proponents of both camps during the past few years.

If the sociological problem with reference to anchovies were the only one facing us, life would be relatively simple. But there are other resources which can be tapped, and there are other problems which we must solve. It behooves us to attack them rather than each other, for sooner or later, others will harvest that which could be ours if we, as Californians, persist in fighting among ourselves. We cannot afford the luxury of this conflict.

A LOOK AT THE WORLD TODAY

Before we can evaluate realistically the internal problems which beset us, we must first place the problems of California (which are not unique) in perspective, and look at them as part of a much larger framework, that of the real world of today.

A number of people [1] have estimated the food potential of the sea. These authors arrive at divergent answers from different assumptions but all show the existing world harvest to be far below potential production. It is evident that (i) there are far more fish (or their equal in protein) in the sea than man is harvesting, and that an unharvested surplus each year is dying and adding to the accumulated nutrient reserve of the ocean; (ii) a large proportion of the world's people are undernourished and animal protein deficiency is in no small measure responsible for mankind's woes; (iii) the population of the world is increasing at a rate which will see a doubling of the globe's population during the lifetimes of the younger of us; (iv) the need for food will be intensified with population growth, and the need for recreation will become even more important than it is today to the well-being of man on a crowded planet,[2] and (v) an obvious partial solution to the food problem is the efficient harvest of living marine resources.

Powerful forces throughout the world are moving toward the sea today. These forces are stirring in our country, other nations are already actively harvesting the global resources; still others wish their share. Witness the aggressive program of the USSR which finds it fishing today throughout the world ocean, including many banks off the California coast. Witness the proposals before the United Nations, which if implemented would place the resources of the sea bed under the control of that body with the products and profits of their extraction internationalized and the primary benefits falling to the emerging nations, the ones in which burgeoning population and protein deficiency are paramount facts of life.

We in the United States have an obvious responsibility in world affairs to bear a major portion of the load in resolving these matters. We have as well a responsibility to ourselves to insure that what resources we have are husbanded.

[1] For example, see Bogorov, 1965; Chapman, n.d.; Schaefer, 1965; Schmitt, 1965.

[2] This begs the question of how long the affluent society of the U.S. can afford the luxury of recreational fishing if it comes to a case of food or recreation. For the moment we are lucky.

If we do not choose to harvest what is available to us, we cannot quarrel with those who wish to fish off our shores. But at the same time we can choose to utilize to the fullest that which is available to us, utilize it for purposes of food for ourselves and for others, and to provide as well the recreational outlet so vital to society in our country today.

California thus occupies a unique position as of this moment. It can prosecute sea fisheries for its benefit and for the benefit of others if it wishes. The option, however, will not last forever.

A CLOSER LOOK AT CALIFORNIA'S PROBLEMS

What must we as Californians do, what problems must we resolve, if we are to do that which we can? Where do California's fisheries stand in the real world of today?

We have only to look at the catch figures to see that our commercial fisheries have been on a downward slide for years. We are lucky recreationally for the stocks of fishes which are the concern of sportsmen still provide good fishing for them. Fish do not abound as in the good old days, but things never seem as good as they once were. And true, the pot is being divided many more ways, so the apparent yield in terms of you and me is less.

Yet the scientific findings point toward the existence of stocks which could support commercial fisheries greater than we have ever known in this state. There is no reason to believe that their harvest would impinge on the legitimate requirements of sportsfishermen, given only realistic controls by reasonable men.

We need to inquire deeply into the factors impeding fishery development in California, which leads one back to a consideration of the matters alluded to earlier. The inhibitions facing us result from the interaction of many disciplines, and seem to stem from lack of knowledge, lack of trust, simple greed, and fear. Simultaneously, the solution lies in the framework of these same interactions.

Science

The scientific problems are fundamental. Without their resolution there is little hope for solution of the broader aspects. Just what are the resources, what is their magnitude, their availability, their susceptibility to capture, their sustainable yield? We know a great deal—what happened to the sardine, the general magnitude of the anchovy population, estimates of the size of some others—but there is much more to be learned. Further, and what is more important, the scientist has so far failed to interpret to the concerned public that which he does know. Until the interpreter acts, the results of the finest scientific analysis remain unused in the broad sense; the worthy publications may bring fame to the authors among their peers but they fail so far as society is concerned to fill the need.

Scientific inquiry continues, the bank of scientific knowledge grows, the problems of interpretation can be solved. Then what?

Given at least first order estimates of population magnitude, what factors still impede resource development? And what do we mean by development? Maximum sustainable biological yield, the usual measuring stick; maximum sustainable economic yield, a lower value in terms of tonnage; maximum sociological yield—that which would provide optimal recreational value and yield a tonnage smaller yet; or still something else?

Economics and Technology

Economic and technological problems from the standpoint of commercial exploitation are no small matter. Can we, with our standard of living and our wage scales, compete in the world market with our products; can we even market them profitably in our own country? The market exists and is increasing but it is being filled by an ever-growing level of imports concurrent with a decrease in domestic production. The California tuna fishery is strong, but that is our only bright light. But surely if the tuna industry can compete successfully on the world market, so can our local seiners and trawlers, given some ingredient which may be no more than a realistic hope for the future which will revivify the spirit of our fishermen and restore the confidence of those in a position to venture capital in fisheries development.

Sociology

The sociological problems exemplified by the conflict between recreational and commercial fishermen have been defined, and these are most serious. There are as well conflicts within the sport and commercial communities, and conflicts between either or both of them and other extractive users of the ocean plus conflicts with non-extractive users.

There are many examples. For instance there was for years a law prohibiting the possession of a drag net within three miles of the southern California coast. This was not, according to people with long memories, a restriction imposed by sportsmen's request, but rather one stemming from the fear of commercial set line fishermen that the efficient trawl would put them out of business. Development of offshore oil islands near Santa Barbara has brought cries of dismay from non-extractive users of the ocean who feel this is not an area to be commercialized, and from worried commercial fishermen who see potential diminution of their fishing grounds. The interaction of sea otters on abalones in the last year or so has put sportsmen, commercial men and nature lovers at loggerheads.

Law

Given solutions to the scientific, the sociological and the economic problems, there remain those of law. The several states have the responsibility and the authority to regulate the take of living resources save where the federal government has preempted this authority through international agreement. California can regulate the anchovy fishery which is not under international control, but it cannot regulate the take of yellowfin tuna which is the subject of an international treaty to which the U.S. is a partner.

It is incumbent upon the states to pass wise regulations permitting the allowable take with a minimum of restrictions if commercial fisheries are to reach their full potential. Unfortunately, the pattern of the past in this country has been to impose severe restrictions as to seasons, gear and areas which too often have acted to preserve the inefficient operator and to prevent or inhibit the investment of capital in modernization of plants, boats and gear, and in the development of more efficient fishing techniques.

Beyond state and federal law there lies international law. Much of California's fishing effort takes place more than 12 miles from shore. State waters extend to 3 miles, the contiguous fishery zone to 12; beyond that are the high seas where anyone may fish subject only to international law and to terms of such bilateral and multilateral treaties as the flag of the individual fishing vessel may be party.

The Geneva Convention of 1958 on Fishing and Conservation of the Living Resources of the High Seas provides for international cooperation to insure conservation of the living marine resources, requires that conservation measures be based on scientific findings, and says, in effect, that a coastal nation has no claim on living resources of the adjacent high seas unless they are subject to scientific management. Any nation can fish off another; it can be constrained only if the scientific data show the fishery to be exploited beyond its maximum sustainable yield and then only through procedures set forth in the Convention. The coastal nation has no day in court unless its fishery management program is based on scientific findings and only a leg up on other nations if it is practicing scientific management.

Obviously, legal matters at the state, federal or international level can make or break any given fishery in California or elsewhere.

ROLES, RESPONSIBILITIES AND GOALS

The interaction of these various disciplines—biology, sociology, economics, and law—can be disastrous or it can be fruitful. The interaction is severe in California today, and whether the long-term results will be fruitful or disastrous remains to be seen. The fishery scientist has been rather aloof if not innocent of this interplay and the impact it has on the application of the results of his research.

The role of the scientist in a broadly-based research program such as CalCOFI is a matter of argument. While the scientist tends to believe his work is done when the results are published, many people believe he should consider socio-economic and political factors in making his recommendations. The present CalCOFI Committee takes the stand that

> "The CalCOFI Committee adheres to the principle that the individual scientist's work is finished with publication but that the committee itself has an obligation to recognize and so far as its capabilities permit aid in placing these

findings in perspective within the social, economic, and political milieu." [3]

Because of the critical state of affairs in California, and because it seemed wise both to inform the individual scientist of the facts of bio-political life, and to provide a scientific forum before which the protagonists of various interests could express their points of view, the CalCOFI Committee has made a deliberate departure from past patterns in organizing this symposium. Earlier conferences were designed specifically to provide an interchange of ideas on scientific research in progress, and we anticipate that future ones will revert to the original format. But this year seemed the time for deviation; the scientists are wondering if their efforts are appreciated, whether the work is worth doing in view of the seeming failure by both the public and private sectors to act on the scientific findings. Their questions deserve answer. Further, bringing proponents of widely divergent interests together will, we hope, be a first step toward mutual understanding in the area of sport-commercial relationships.

California has too much at stake to let its fishery resources go by the boards, be they sport or commercial. It behooves those responsible for administration of the fisheries, those interested in harvesting them for whatever purpose, and for the public at large which wishes as viable a state economy as possible, to see that differences are resolved and that a management plan for living marine resource utilization is evolved and implemented on a sound scientific basis. Failure to do so can only result in loss of many of these resources to some nation other than the U.S. With the growing demand for animal protein food in the world, the latent resources will not long go unfished, and the underfished resources will be exploited to the extent that is feasible.

We hope to see this fishery development undertaken by Californians for the sake of the recreation that can be provided for our citizens, the economic contribution that can accrue to the state, and the contribution we can make toward a solution of world problems through the export of food, of technology and of scientific knowledge.

To these ends this symposium is dedicated.

[3] From text of approved final draft, November 1967, of CalCOFI Committee report "Partial review and proposed program for research toward utilization of the California Current fishery resources," later published in Calif. Mar. Res. Com., CalCOFI Rept., 12:5–9, 1968.

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STATUS OF KNOWLEDGE OF THE PACIFIC HAKE RESOURCE

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INTRODUCTION

The Pacific hake (*Merluccius productus*) has been known to be relatively abundant in the northeastern Pacific Ocean since the early part of this century. It had long been considered a "trash" fish by U.S. and Canadian trawl fishermen, who commonly attempted to avoid catching it during their exploitation of more desirable species.

Except for studies in California on its eggs and larvae and on its life history, little scientific effort was expended on the Pacific hake before 1960. Especially lacking was information concerning total abundance, seasonal and depth distribution, and population dynamics. Interest in a commercial hake fishery was stimulated in the early 1960's by: (1) the development of an efficient pelagic trawling system, (2) an expanded world market for fish meal, and (3) approval of the highly publicized fish protein concentrate (FPC). At that time, the Bureau of Commercial Fisheries expanded its exploratory fishing and technological and biological research on this species. The U.S. coastal hake fishery began in 1966 but was hampered by decreasing prices for fish meal and the appearance off Washington and Oregon of a large Soviet hake fishing fleet.

GENERAL BIOLOGY

Pacific hake is often classified as a demersal species, but its distribution and behavior suggest a largely pelagic existence, although it is often found near the seabed over the continental shelf. It feeds almost exclusively on a variety of pelagic fishes and animal plankton; inhabits oceanic and neretic areas; grows relatively fast, especially during its first 4 years (Figure 1); and matures at the age of 3 or 4 years. Few individuals older than 9 years have been observed from unexploited stocks, and the maximum age is about 16 years. Mature hake on the average weigh about 2.68 pounds (1 kg) and are 20.5 inches (52 cm) long; maximum observed length has been about 33.5 inches (85 cm). The sharply descending right portion of age-frequency curves suggests rather high natural mortality, and comparisons of age composition of the catch in different years suggest variable year-class strength (Figure 2). The species is pelagic-spawning; fecundity ranges from about 80,000 to 500,000 eggs per female, depending on body size (MacGregor, 1966).

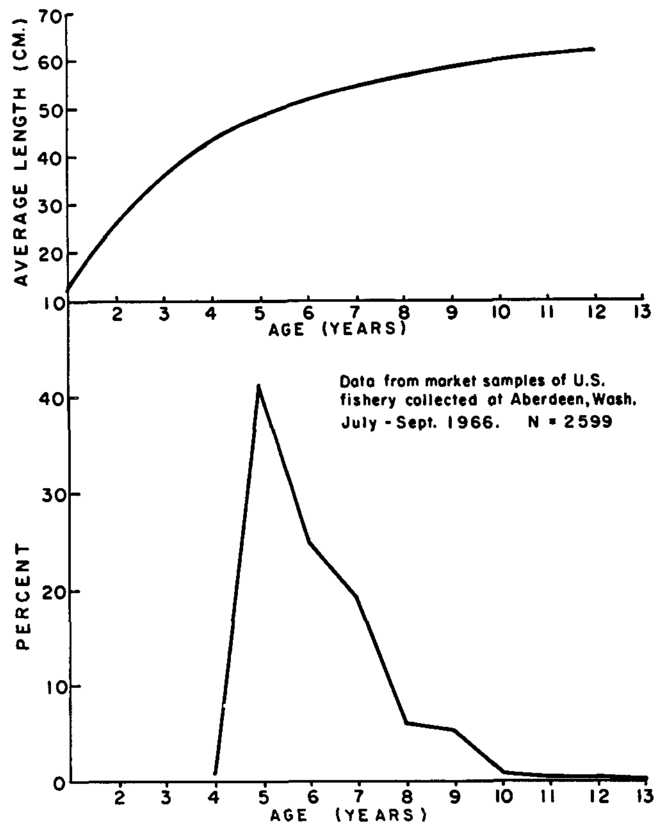

FIGURE 1. Relation between age and length (upper panel) and age composition (lower panel) of Pacific hake in 1966 commercial landings.

DISTRIBUTION

The Pacific hake has been reported from the Gulf of Alaska (Alverson, Pruter, and Ronholt, 1964) to the Gulf of California (Starks and Morris, 1907). Although this range represents the extreme zoogeographic distribution, large accumulations of this species appear to be limited to the coastal areas between Baja California, Mexico, and central Vancouver Island, British Columbia (Figure 3). Pacific hake have

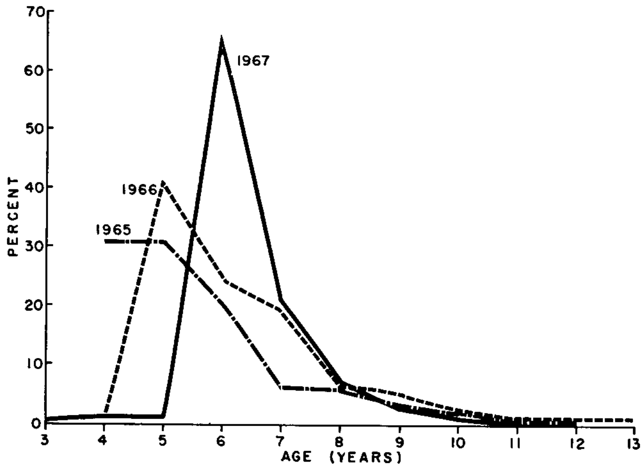

FIGURE 2. Comparison of age composition of Pacific hake in 1965–67 commercial landings showing annual progression of the dominant 1961 year-class.

been taken in bottom or mid-water trawls in waters from near the surface to at least 435 fathoms (800 m) deep (Clemens and Wilby, 1961), but are only occasionally taken at depths exceeding 328 fathoms (600 m). Commercial concentrations of Pacific hake have been found at depths between 27 and 273 fathoms (50 and 500 m). The mature or adult population is normally confined to waters overlying the continental slope and shelf except during the spawning season when hake may be found several hundred km seaward in the southern part of the range.

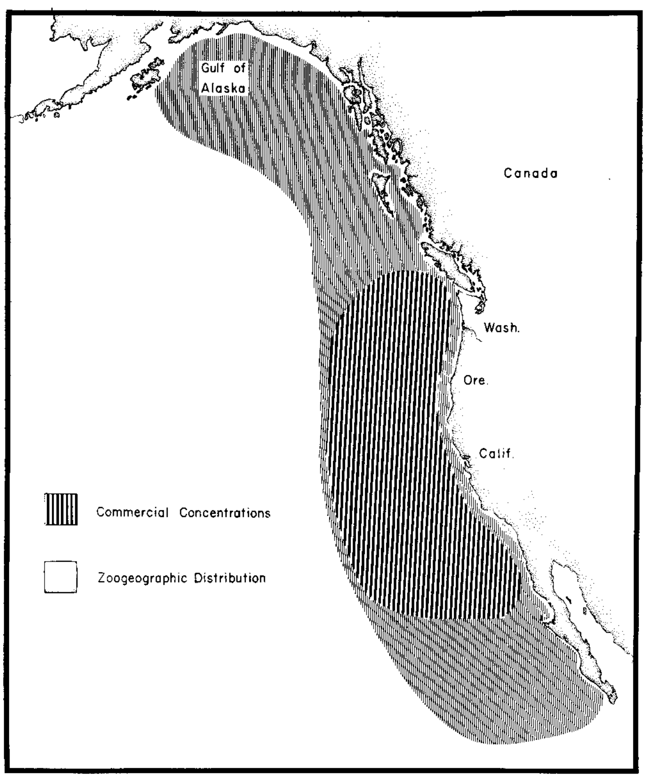

FIGURE 3. Zoogeographic distribution of Pacific hake showing area of commercial concentrations.

Investigations by the U.S. Bureau of Commercial Fisheries and Soviet scientists indicate that the adult portion of the coastal stock occupies the northern portion of the range (northern California, Oregon, Washington, and British Columbia) during the spring, summer, and fall and the southern portion (southern California and Baja California) during the winter. The availability of Pacific hake to bottom and mid-water trawls off Oregon, Washington, and Vancouver Island drops sharply in November and is practically nil in the winter. During late April and May, hake again become available in the northern part of the range, and abundance increases sharply during the early spring. The adult stock remains in the northern areas until late fall.

In the waters adjacent to southern California and Baja California, large quantities of spawning hake have been taken offshore during the winter by the research vessel *John N. Cobb*. The mature stock is concentrated during spawning in the deeper portion of its bathymetric range (100 to 275 fathoms, 200 to 500 m); for the remainder of the year (May through November), it is concentrated in waters overlying the continental shelf at depths less than 109 fathoms (200 m).

The work of Ahlstrom and Counts (1955) provides the best usable data on the general bathymetric distribution of hake eggs and larvae, and hence the distribution of spawning adult stocks. Eggs and larvae

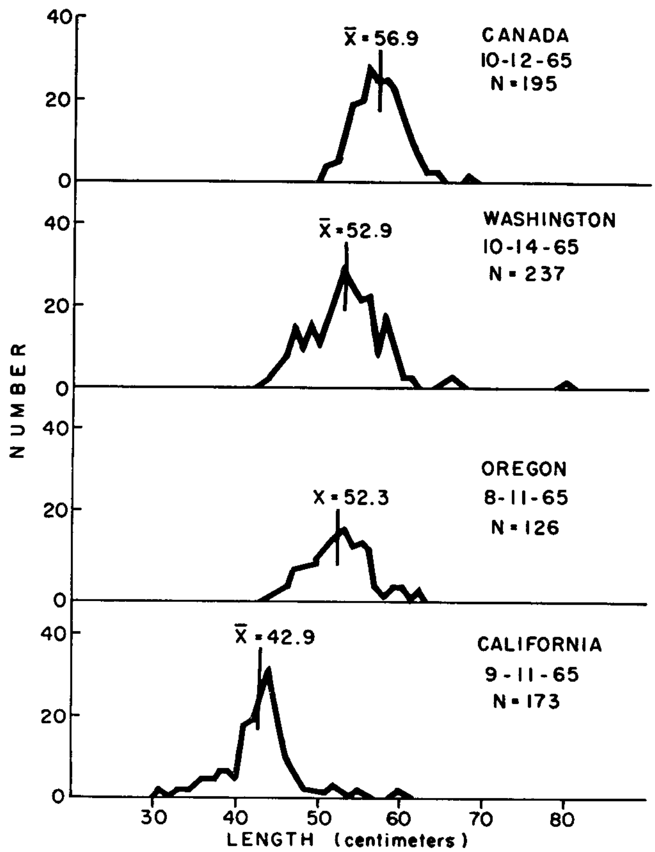

FIGURE 4. Length composition of Pacific hake in 1965 research vessel catches by coastal area showing north-south size cline.

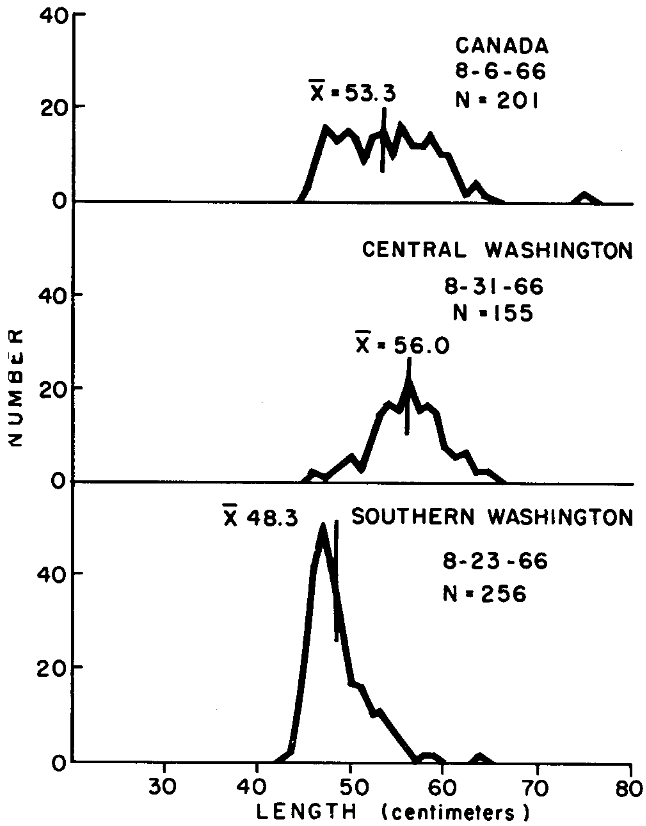

FIGURE 5. Length composition of Pacific hake in 1966 commercial landings from northern area showing irregularity in north-south size cline.

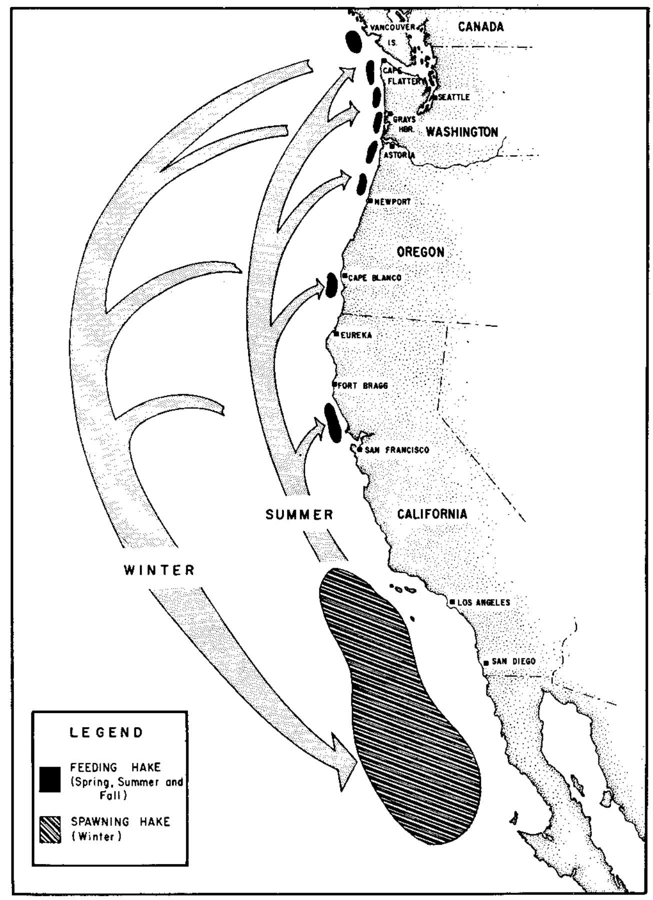

FIGURE 6. Seasonal migrations and distribution of Pacific hake.

of the Pacific hake are abundant off the coast of southern California and Baja California during the late winter and spring (February through April). Concentrations are greatest between Santa Barbara, California and central Baja California, but annual variations in distribution are substantial. Eggs and larvae have been encountered in relatively large numbers several hundred km seaward, but concentrations are generally highest within 199 miles (320 km) of the coast. Large-scale sampling of plankton by the Bureau of Commercial Fisheries in April 1967 revealed no hake eggs or larvae between northern Vancouver Island and the California-Oregon border, offshore to 298 miles (480 km). Except for local, resident stocks in Puget Sound and perhaps other inshore areas, the entire coastal hake population apparently spawns off southern California and Baja California.

Catches of Pacific hake during exploratory fishing surveys between Vancouver Island, British Columbia, and Baja California have suggested that during the summer the average length (and presumably age) of hake decreases from north to south (Figure 4). This size gradient, however, is often non-existent or even reversed within smaller areas (Figure 5). This difference in average length appears to be associated with increased availability of juveniles in the southern portion of the range and an almost complete absence of juveniles off Washington and British Columbia.

Investigations of the seasonal and annual distribution and abundance of Pacific hake allow us to propose the following hypotheses concerning hake migrations:

1) Within the geographic range occupied by Pacific hake, the adult segment of the population exhibits a large-scale north-south movement.
2) The movement is to the north during the spring and summer and to the south during the late fall and winter (Figure 6).
3) The northward migration of adults is accompanied by movement towards shore and into shallower water (Figure 7).
4) The southward migration is accompanied by movement into deeper water and seaward.
5) Spawning occurs during the winter when the species occupies the southern portion of its geographic range.
6) The young live in the waters over the continental shelf but apparently do not make the large-scale migrations demonstrated for the adult portion of the stock, although 1- and 2-year-olds have been collected as far north as central Oregon.

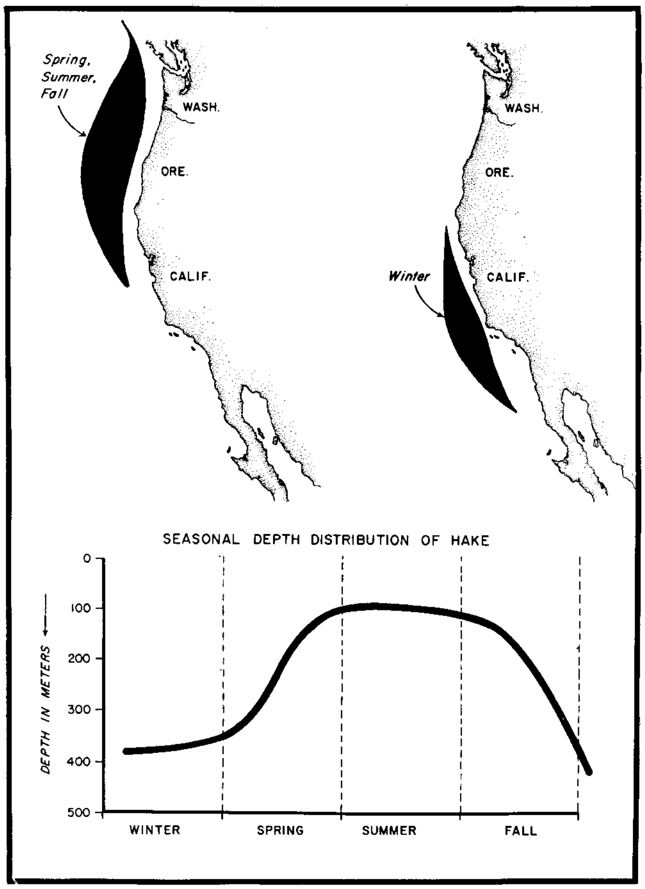

FIGURE 7. Seasonal depth distribution of Pacific hake related to geographic area.

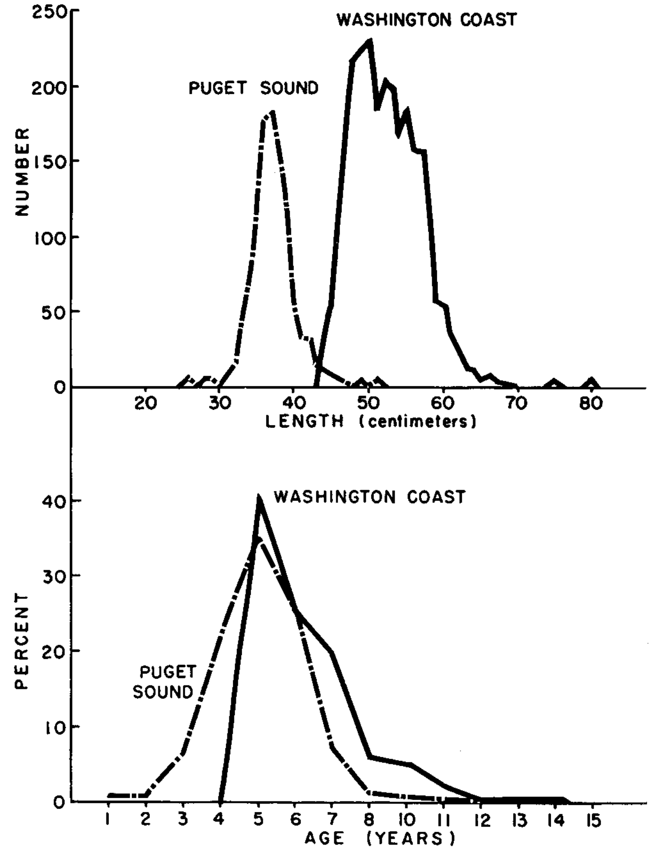

FIGURE 8. Length-frequency distributions (upper panel) and percentage frequency distributions of ages (lower panel) in 1966 commercial landings of Pacific hake from coastal Washington and Puget Sound.

SIZE OF MATURE STOCK

The size of the standing stock of Pacific hake that inhabits the waters off Oregon and Washington during summer (based on sonic surveys and test fishing) has been estimated at 609.5 thousand short tons (455 million kg) by U.S. biologists and near 1,206 thousand short tons (900 million kg) by Soviet fishery scientists. The estimated sustainable yield at these population levels ranges from about 174 thousand to 349 thousand short tons (130 million to 260 million kg) annually. The Pacific hake resource off California, estimated to be in the order of 3.6 million tons (2.7 billion kg), is reported to be second in size only to the northern anchovy (*Engraulis mordax*) in the California current system.

STOCK COMPONENTS

Available data are insufficient to indicate whether or not segments of the coastal Pacific hake population are isolated genetically. The apparent migration pattern and the distribution of eggs and larvae suggest one large homogeneous offshore population. This indication, however, does not preclude the possibility that after spawning, segments of the adult stock colonize specific regions of the continental shelf. Evidence is good that Pacific hake from the inside waters of Puget Sound, and perhaps the Strait of Georgia, are a separate stock or population from those in coastal waters (Figure 8). Not only are the spawning grounds widely separated, but the growth rate of the Puget Sound stock is substantially lower than that of the offshore population. Enough Pacific hake are present in Puget Sound during the winter to support a yield of 6 thousand tons (4.5 million kg) per year.

GENERAL BEHAVIOR

During the period that the mature stock inhabits the water overlying the continental shelf and slope, Pacific hake form schools which may be characterized as long, narrow bands (Nelson, 1967). The axes of these schools are usually oriented parallel to the isobath with the exception of the schools near the continental break (about 98 fathoms, 180 m, depth). At times these schools lie normal to the depth contours and extend in an offshore direction. In such instances the inner portion of the school is closer to the seabed than the outer portion. That is, the school maintains approximately the same depth in the water column regardless of the depth of the water.

The length of the schools may vary from several hundred yards (meters) to 11.8 miles (19 km). Usually the schools range from 0.16 to 1.99 miles ($\frac{1}{4}$ to 3.2 km) wide, but a width as great as 7.96 miles (12.8

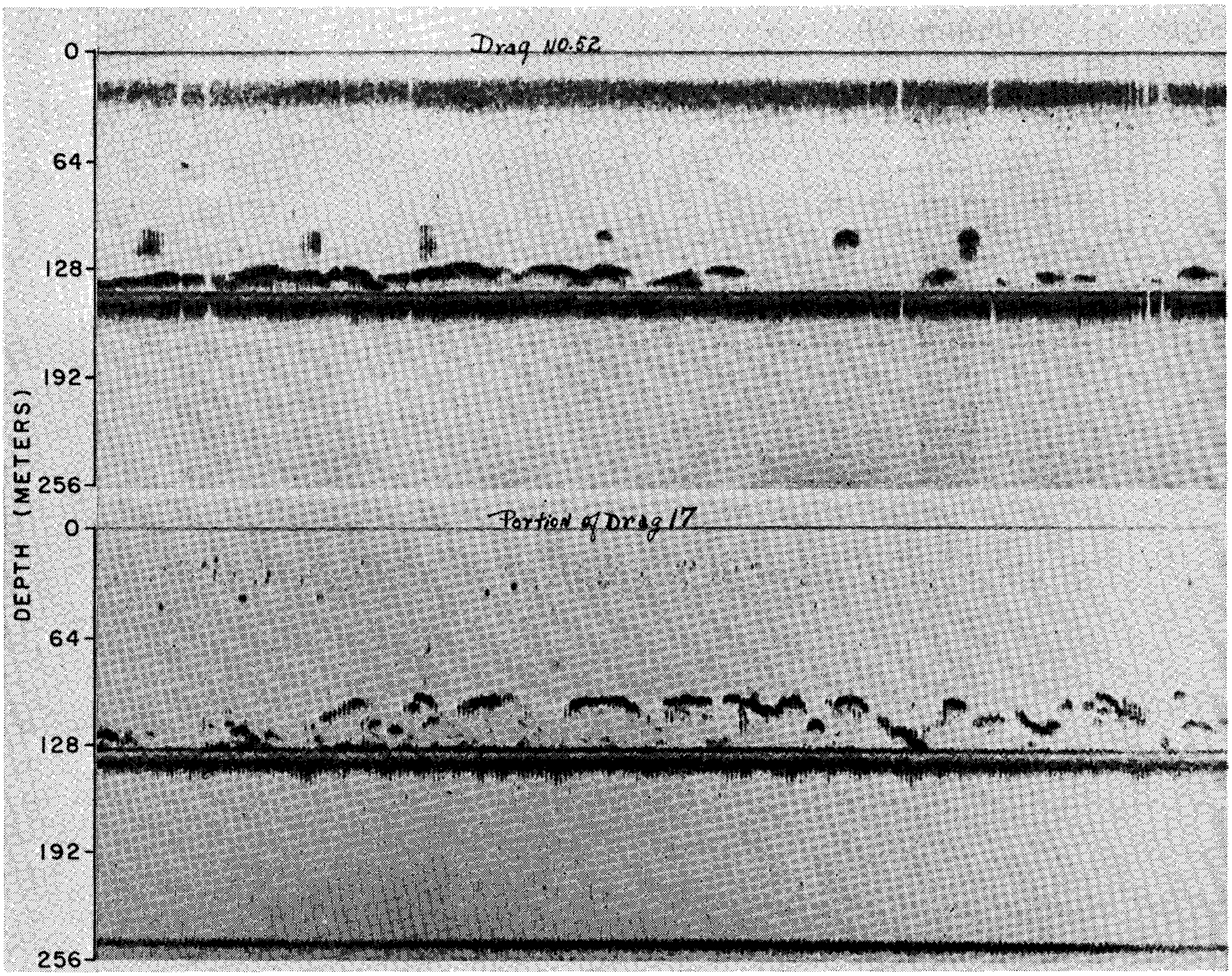

FIGURE 9. Echogram showing Pacific hake at various depths off the bottom.

km) has been recorded. In a vertical plane most of the schools are from 3.28 to 10.9 fathoms (6 to 20 m) thick. During daylight the schools lie just off the seabed; at times the bottom of the school is in contact with the seabed. When the schools lie off the bottom, the lower portion of the school can range from 1.1 to 10.9 fathoms (2 to 20 m) above the ocean floor. The distance above the seabed varies during each day and within the season. Most of these schools form on the continental shelf at depths between 19 and 109 fathoms (35 and 200 m); the greatest number of schools or concentrations encountered during exploratory cruises were at depths between 27.3 and 82 fathoms (50 and 150 m). The schools may persist for several days or disperse within several hours after they have been detected only to regroup several hours later.

In the vertical plane during daylight, the schools seem to be confined to a relatively narrow bathymetric zone, all within the same general depth strata. Density of the schools ranges from nearly constant to highly variable—or schools may be composed of a series of clusters or patches throughout (Figure 9). We have no evidence, however, that the hake form vertical feather-like schools such as those observed for herring-like fishes.

During the summer when the adult population is distributed over the continental shelf, the schools characteristically rise and disperse in the water column during the evening—a tendency that has been confirmed by acoustical studies and experimental fishing. Echo-sounding studies suggest that movement begins between 1800 and 2100 hours, and that by 2300 the schools have lost their integrity. Data from experimental fishing imply a general scattering of the fish throughout the water column during darkness. By dawn the fish descend and begin to regroup in schools near the seabed, in the same general region where they were detected the previous day but not necessarily in the exact area.

Observations of hake spawning in Port Susan, Puget Sound, suggest the presence of one large contin-

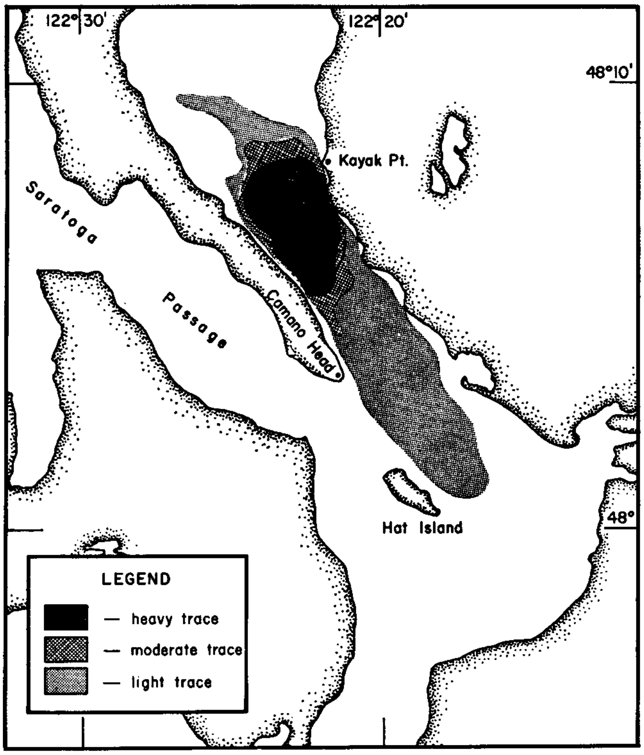

FIGURE 10. Distribution of Pacific hake in Port Susan, Puget Sound, during the spawning season.

uous body of ripening or spawning fish that increases in density toward the center of the spawning area (Figure 10). These schools may be as thick as 40 m in the vertical plane. The population of adult hake off California in winter appears to congregate in several schools of uniform density, but density did not appear to be as high as in Puget Sound.

Although spawning schools of Pacific hake in Puget Sound tend to become more scattered as darkness approaches, pronounced vertical dispersal has not been observed. Similarly, surveys off southern California indicate that spawning hake do not engage in the kind of vertical movement observed on the continental shelf. Although there is apparently some movement of nearly ripe fish, most of this diel migration occurs at depths of 98.4 to 218.6 fathoms (180 to 400 m) over bottom depths of, at times, greater than 1,092.9 fathoms (2,000 m); no fish appear to migrate above the thermocline.

The diel movement of Pacific hake, the depths at which schools are found off the bottom, and the relative compactness and size of schools are complex, interrelated phenomena that significantly affect the conduct and success of fishing. Knowing the reasons for these behavior patterns is perhaps not as important to fishing success as knowing where and when they occur; in a predictive sense, however, knowing *why* they occur should be of value in planning fishing operations. Alton and Nelson (in press) stated the de-

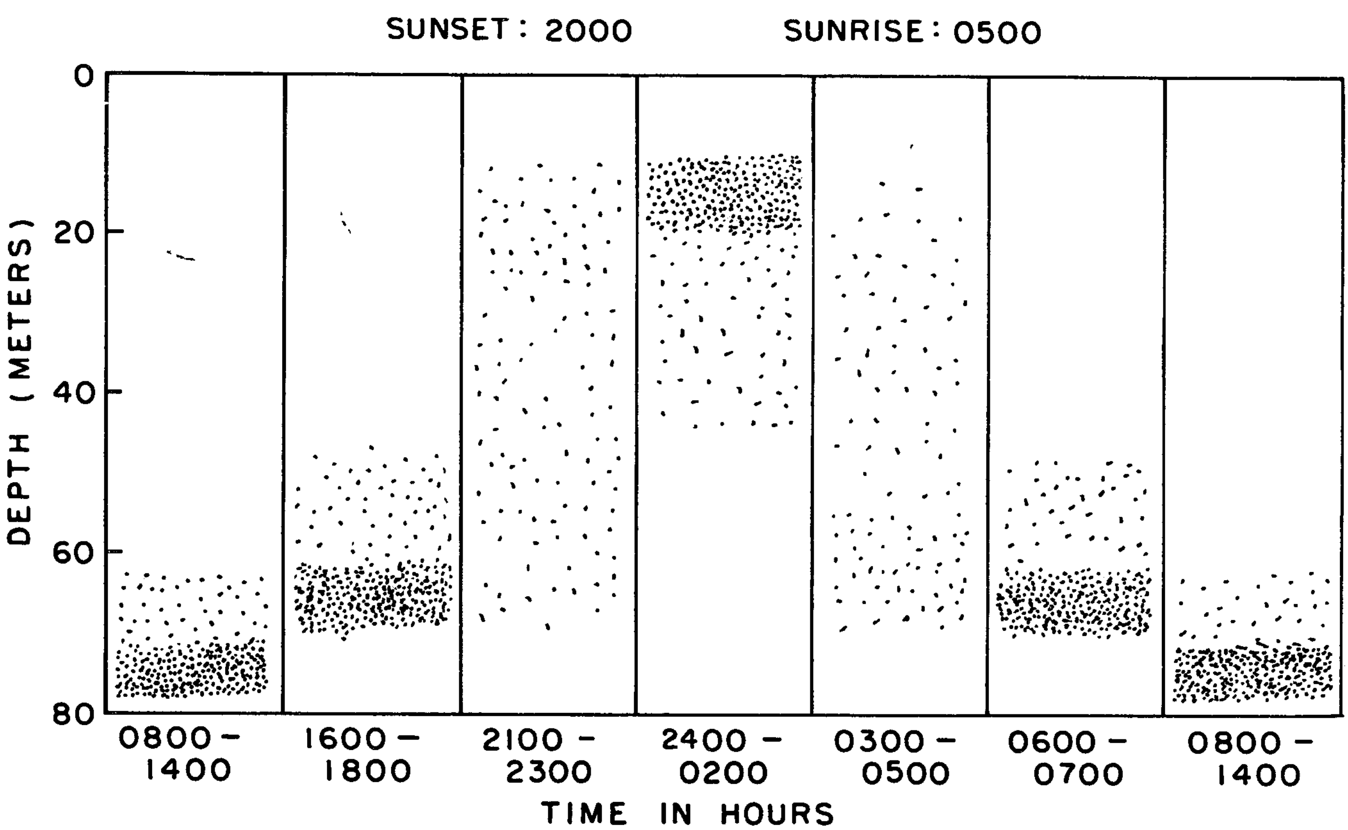

FIGURE 11. Diagram showing diel movement of the euphasiid *(Thysanoessa spinifera)* off the Washington coast.

gree to which hake are congregated or in schools during the day, and indicated that their dispersal at night relates to the feeding habits of the species. In the northern portion of their geographic range, adult hake appear to feed extensively on two species of euphausiids, *Thysanoessa spinifera* and *Euphausia pacifica*. High catch rates by commercial vessels appear to be supported largely by hake that feed almost exclusively on euphausiids; catch rates are lower when the diet of the hake is varied (Alton and Nelson, in press).

On the continental shelf *Thysanoessa spinifera* has been the dominant euphausiid in stomach samples of Pacific hake taken off the Oregon-Washington coast. The diel vertical distribution and migration of this species have demonstrated that hake are near the seabed during daylight, migrate toward the surface during the early part of the night, concentrate near the surface between 2400 and 0200 hours, and migrate toward the bottom at dawn (Figure 11). The timing of the diel migration of the euphausiid is similar to that of Pacific hake (Figure 12) and suggests that the daily migration and schooling of hake may be largely influenced by the distribution and abundance of its food.

DESIGN OF FISHING RATIONALE

Analysis of biological samples collected off Oregon, Washington, and British Columbia from 1964 through 1967 indicates that growth is rapid in juveniles but approaches an asymptote within 1 or 2 years after maturity; natural mortality of the adults appears to be at least 40% annually and perhaps is much higher. Only mature fish are available in the summer range from northern Oregon to British Columbia. If these preliminary findings are substantiated, it would seem that high yields could be sustained by applying a rather high rate of exploitation on the standing stocks off the Pacific Northwest during summer. This rationale provides almost complete protection for the fast growing juvenile segment of the population that also represents a substantial spawning potential for the near future.

This same argument might also be used to justify a commercial fishery on the spawning stocks off California during winter, but two serious reservations are involved. First, although many millions of fish would be in the general spawning area, the location and size of individual schools have been highly variable and not conducive to high harvest efficiency. Second is

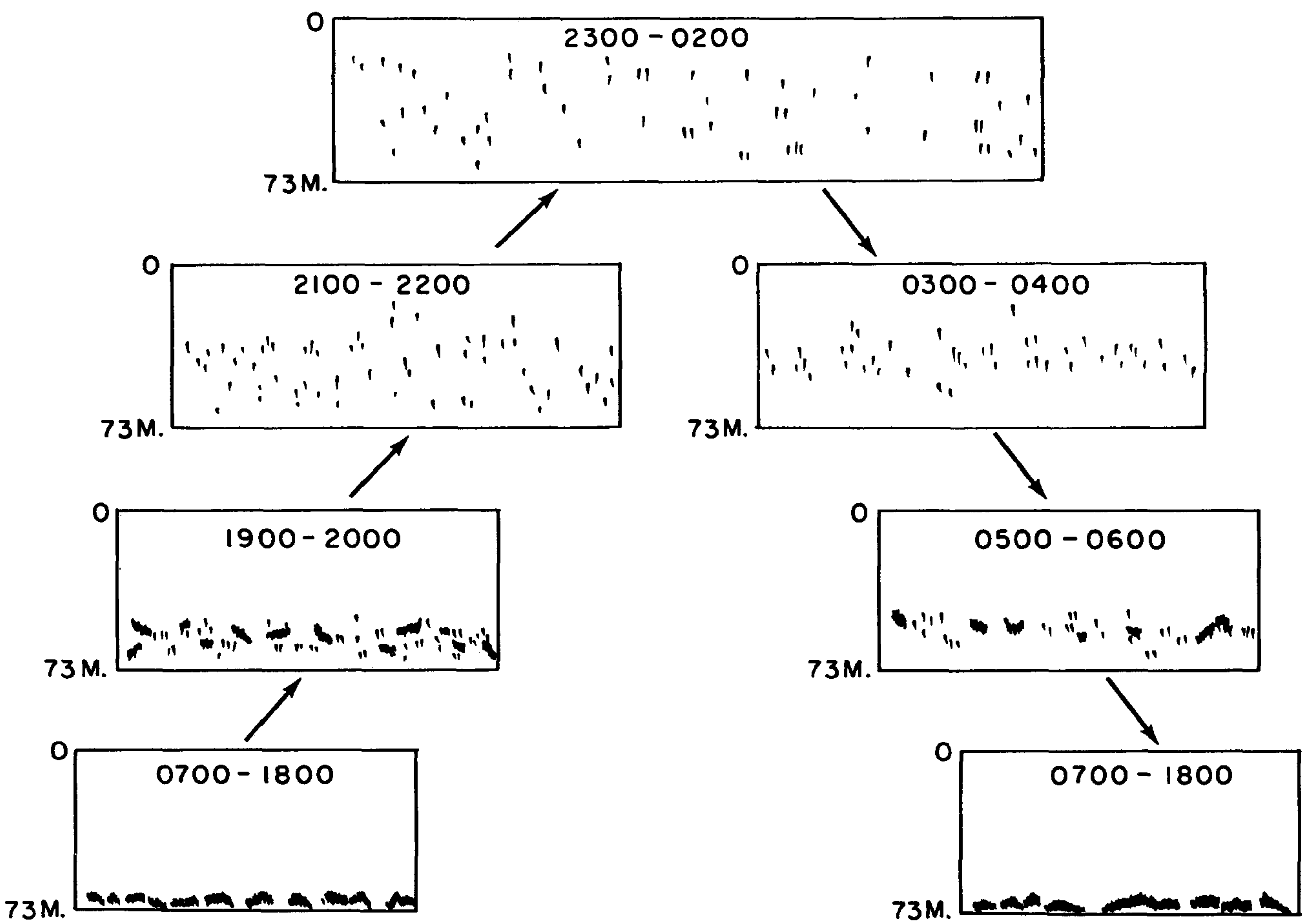

FIGURE 12. Diagram showing diel movement of Pacific hake off the Washington coast.

the possible effect of an intense fishery on the spawning behavior of hake. During the heavy concentration of Soviet fishing off Washington in 1966, it became difficult to detect schools of hake with acoustic gear; some fish were being caught by the Soviet vessels, but the normal concentrations had apparently been dispersed. Should this happen to the spawning schools there could be a resultant decrease in spawning success through a reduction in the density of eggs and sperm.

If extreme variations in year-class strength do occur they will affect the management and efficient harvest of the hake resource because the bulk of available fish are typically in only one or two age groups. When a weak year class reaches the age that would normally dominate the total catch, the catch per unit of effort might be seriously reduced. On the other hand when an unusually strong year class is recruited, high natural mortality would prevent it from supporting the fishery at a high level for more than 1 or 2 years. Therefore, a system of indexing the relative abundance of juvenile hake 1 or 2 years before their recruitment to the fishery should be beneficial to the managers for setting quotas, to the industry for allocating their fishing and processing efforts among the other fisheries, and to the resource itself by preventing over-fishing when the population is weak.

Although the concerted research on the Pacific hake in the past few years has provided the information required by industry to establish a fishery, a considerable amount of knowledge must still be gained before a coast-wide, international management scheme can be developed.

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THE ANCHOVY RESOURCES OF THE CALIFORNIA CURRENT REGION OFF CALIFORNIA AND BAJA CALIFORNIA

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INTRODUCTION

The northern anchovy (*Engraulis mordax*) is probably the most abundant species in the California Current System and has exhibited a dramatic increase during the past 15 years. Because of its great abundance and the small amount harvested it is a relatively unexploited resource.

Our purpose is to review the data relating to anchovy biology and to the growth in magnitude of the population during recent years.

The basic evidence demonstrating the tremendous population increase is derived largely from egg and larva survey data obtained by the U.S. Bureau of Commercial Fisheries from 1951 through 1966 (Ahlstrom, 1966a, and pers. commun.). These data show that the spawning population grew rapidly from 1951 through 1954, remained relatively stable through 1957, increased gradually through 1961 and then exploded to its present high plateau (4–5 million short tons) in 1962. Based on relative numbers of larvae, the spawning population is now about 21 times as large as it was in 1951 and about 2½ times as large as it was in 1958.

BIOLOGY

General

Anchovies are pelagic schooling fishes generally found in coastal waters with surface temperatures between 14.5° and 20.0° C (58.1° and 68.0°F). They are short-lived, rarely exceeding 4 years of age and 7 inches (17.78 cm) in length, although individuals 7 years old and 9 inches (22.86 cm) long have been recorded. Anchovies are apparently indiscriminate filter feeders, accepting zooplankton or phytoplankton. They also have been observed preying on small fish. The species of fish, birds and mammals which prey upon anchovies probably include most of the predatory species in our waters (Baxter, 1967).

Distribution

Anchovies occur from the Queen Charlotte Islands, British Columbia to Cape San Lucas, Baja California. California Cooperative Oceanic Fisheries Investigations (CalCOFI) surveys show they are most abundant from San Francisco to Magdalena Bay. North of San Francisco, occasional surveys by the Department of Fish and Game have not found anchovies in abundance. Pruter (1966) reported that anchovies occur in dense schools along the Oregon and Washington coasts. Eggs and larvae have been found from Cape Mendocino, California to Cap San Lucas and as far as 300 miles offshore; however, most occur within 100 miles of shore. Egg and larva surveys have not been conducted with any regularity north of San Francisco and the distribution off Oregon and Washington is not known.

Movements

During March 1966, the Department began a tag and recapture study on the anchovy to determine migratory habits, mortality rates, and population estimates. The study has progressed only far enough to comment on large-scale movements.

Anchovies are tagged with a type 430 stainless steel alloy internal tag (Vrooman et al., 1966; Wood and Collins, ms). The tags are recovered by permanet magnets placed in the final stages of the reduction process. This method of recovery precludes assigning tags to individual vessels and specific recapture localities. Consequently recoveries can be assigned only to major fishing areas such as Monterey Bay, southern California, and northern Baja California. This method is excellent for determining movements between major fishing areas, but is of little value for determining local movements. An additional system of magnets, which should allow study of local movements off southern California, has been installed but as yet has not been tested under production conditions.

During the period March 14, 1966–January 31, 1968, 224,168 anchovies were tagged and 531 recovered. Recoveries demonstrate that anchovies move from San Francisco Bay (Sausalito) to Monterey Bay, from Monterey Bay to southern California (south of Pt. Conception), from southern California to northern Baja California (Ensenada), and from southern California to Monterey Bay (Figure 1). Fish also moved between southern California offshore areas and Los Angeles Harbor.

Fishing effort and consequently tag recoveries have been sporadic and therefore conclusions concerning migratory patterns are preliminary at best. It is obvious that fish from as far away as San Diego and San Francisco contribute to the Monterey Bay fishery and that fish from Monterey Bay reach southern California. Some exchange of anchovies between major fishing areas occurs; however, the extent of the exchange cannot be determined as yet. There has not been enough tagging in Monterey Bay where fishing has been most consistent, or sustained fishing

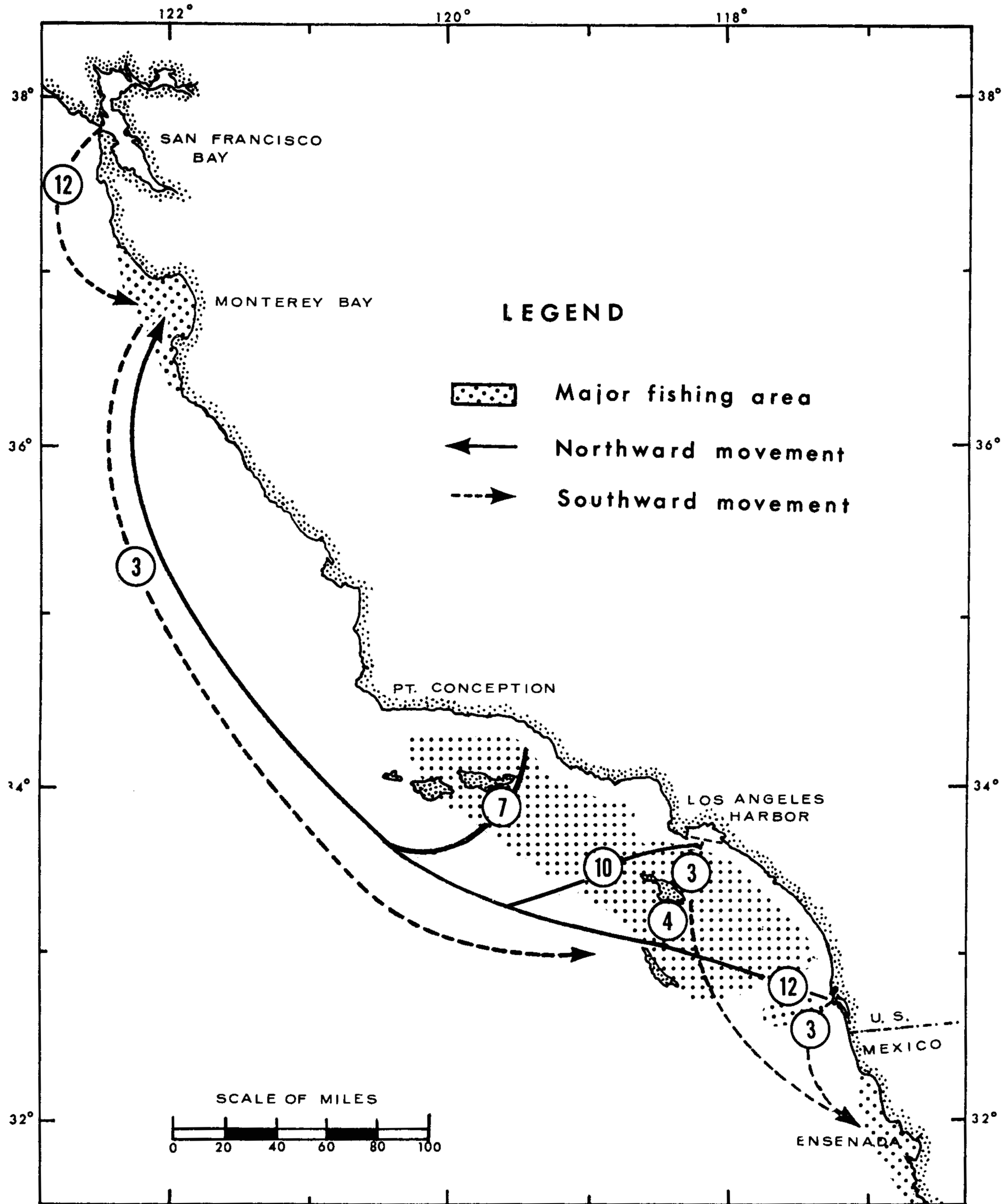

FIGURE 1. Gross movements of anchovies tagged and recaptured March 14, 1966–January 31, 1968. Tags are recovered from magnets in reduction plants and therefore can only be assigned to major fishing areas.

in southern California where most of the tagging has occurred.

Subpopulations

McHugh (1951) concluded that the anchovy population is divided into three subpopulations which do not intermingle completely: (i) British Columbia to northern California (Monterey Bay), (ii) off southern California and northern Baja California, and (iii) off central and southern Baja California. His conclusions were based on an analysis of meristic data (dorsal, anal, and pectoral fin rays, vertebrae and gill rakers).

Miller (1956), working with age and size compositions of commercial and live-bait catches from central and southern California, aerial surveys, and sea surveys, suggested the possible exitence of "local" stocks and the complete separation of central and southern California populations.

The tagging studies have shown considerable movement between southern and central California as well as some movement from southern California to northern Baja California. However, returns to date are too fragmentary either to refute or substantiate the findings of McHugh. To obtain sufficient tag returns to do so will require a sustained fishery and one much larger than now exists.

Reproduction

Some anchovies reach sexual maturity at the end of their first year of life when 3.5 to 3.9 inches (90 to 100 mm) SL; about 50 percent are mature at 5.1 inches (130 mm) SL when between 2 and 3 years old; all are mature when 5.9 inches (150 mm) SL or 4 years old (Clark and Phillips, 1952). MacGregor (1968) reports that female anchovies, 3.8 to 5.4 inches (97-138 mm) SL, contained 4,025 to 21,297 eggs in an advanced stage of development. This equals 574 per gram of fish or 520 million eggs per short ton of female biomass. He was unable to determine the number of times a female spawns in a season.

Although spawning has been noted in every month of the year it usually peaks during late winter and spring. The eggs are pelagic, typically ovoid, clear and translucent and require 2 to 4 days to hatch depending on the temperature of the water (Bolin, 1936).

Ahlstrom (1959) reports that approximately 95 percent of the larvae are taken in water between 14.0° and 17.4° C (57.2° and 67.3° F) while most eggs are taken between 13.0° and 17.5° C (55.4° and 63.5° F). Fish-of-the-year apparently tolerate somewhat higher water temperatures than do adults.

MAGNITUDE OF THE RESOURCE

Because of the lack of fishery data, population estimates are based on egg and larva surveys conducted by the U.S. Bureau of Commercial Fisheries with some independent confirmation by the California Department of Fish and Game which is conducting echo-sounder surveys of adult populations.

Egg and Larva Survey

The egg and larva survey consists of sampling a systematic pattern of stations designed initially to cover the entire spawning range of the Pacific sardine (*Sardinops caeruleus*). The pattern extends from the Oregon-California border to Cape San Lucas, Baja California, but coverage has been most intensive between San Francisco and Magdalena Bay. The stations run from about 2 miles (3.2 km) to as much as 300 miles (482.7 km) offshore. These surveys were conducted at monthly intervals from 1951 to 1960 and at quarterly intervals from 1961 through 1965. Monthly surveys were resumed for calendar 1966.

Estimates of the size of the anchovy spawning population are based on these egg and larva surveys following the method developed by Ahlstrom (1966b). He tied the measure of anchovy abundance to that of sardine for which good estimates of population size were available. Ahlstrom used 1958 as a reference year because that was the last year of a substantial enough sardine fishery to provide a good population estimate. Sardines were highly available that year and the California-Baja California catch reached 126,000 short tons. This represented a fishing mortality of about 50 percent so the adult sardine population would have been on the order of 250,000 tons. These estimates agree well with those of Murph (1966). To be ultra-conservative, Ahlstrom placed the figure at 200 to 250,000 tons. During 1958 the ratio of sardine to anchovy larvae in the egg and larva surveys was 1 to 18 (11,000 vs. 206,000 larvae).

Ahlstrom equates one sardine larva to two anchovy larvae, on the basis of studies by John S. MacGregor that showed that adult anchovies spawn two times as many eggs per unit of weight as sardines. He assumed that the mortality rates of the two species between their egg and larval stages were the same, therefore the adult anchovy population was 9 times, not 18 times, as large as the sardine population. On this basis the estimated weight of the 1958 anchovy population off California and Baja California was 1.8 to 2.25 million tons.

Based on published data through 1964 and unpublished data for 1965 and 1966 (Ahlstrom, 1966a and pers. commun.), the anchovy population continued to increase in abundance and in 1962 reached a plateau roughly $2\frac{1}{2}$ to 4 times greater than it was in 1958 where it remains (Figure 2). Ahlstom's (1966b) estimate of the present population size, 4.5 to 5.625 million tons for California and Baja California, was based on the minimal observed increase of $2\frac{1}{2}$X. Although the portion of the anchovy population occurring off California during spawning is somewhat variable from year to year, it exceeded 50 percent in 1964, was close to 50 percent in 1965, and was again over 50 percent during 1966. Therefore, based on a 50-50 split the adult population now available off California is 2.25 to 2.81 million tons. During the period 1951–59 about one-third of the larvae were taken in the California area.

Radovich (1965) postulated that Ahlstrom's estimates should be reduced somewhat to take into ac-

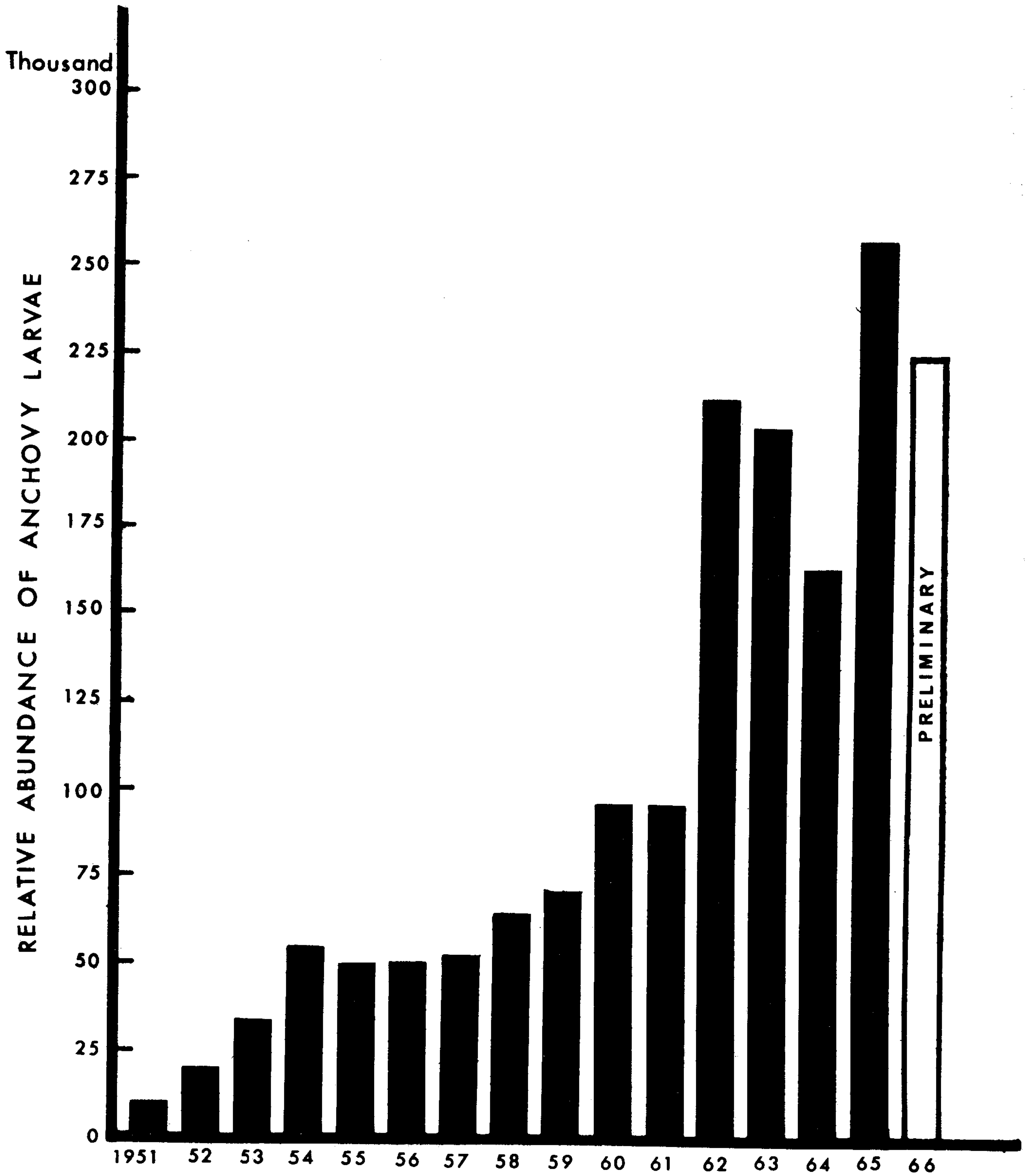

FIGURE 2. Relative abundance of anchovy larvae in the CalCOFI survey area during 1951–1966 (Data from Ahlstrom 1966a).

count different mortality rates for sardines and anchovies. He calculated that the annual survival rate for anchovies from 1951 through 1959 was 1.4 times that of sardines and divided Ahlstrom's population estimates by that factor. He deliberately attributed the entire differential to deaths between the egg stage and the larva stage to obtain the most conservative position possible. This gives a total population estimate of 3.2 to 4.0 million tons. However, since fishing pressure was heavier on sardines than anchovies during the 1950's, the entire difference cannot be attributed to differential mortality between egg and larva. Therefore Baxter (1966), Roedel (1967), and Ahlstrom et al. (1967) placed the total population size between the two estimates, or 4 to 5 million tons. This means there were between 2 and 2½ million tons of anchovies off California during the period 1962–1966.

Sea Survey

With funds obtained through the Federal Aid for Commercial Fisheries Research and Development Act, the Department has greatly expanded its oceanic surveys of adult and juvenile fishery resources. The scope of the cruises was changed in June, 1966 from a survey of the inshore area during the fall months to a year-around survey of all pelagic and bathypelagic fishery resources. The survey covers the area from Oregon to Magdalena Bay, Baja California.

An echo sounder is operated continuously during the day over predetermined transect lines that extend perpendicularly from shore for at least 35 miles (56.3 km) or until the 1,000-fathom (1.829 m) depth contour is reached. These lines are spaced 15 to 30 miles (24.1 to 48.3 km) apart and average about 50 miles (80.5 km) in length. Hourly fixes are obtained and the number of schools appearing on the echo sounder are recorded for each hour of running time. Identification of species is accomplished visually, by echo trace characteristics and by midwater trawl. The trawl is also fished at regular 10-mile (16.1 km) intervals during the night as the vessel returns inshore over the outbound transect lines. A record is kept of all surface school sightings and other indications of fish during both day and night.

These surveys indicate that, in general, the fish spread over a large area in spring to spawn and concentrate in coastal areas during summer and fall. The most opportune time to estimate population size appears to be spring. With the large number of schools and extensive distribution, echo-sounder surveys are much more effective. School size and species identification are also more easily determined. Fall and summer distributions, with fewer and large schools, decrease the probability of detection by echo sounder and make species identification and school size determination more difficult.

A rough estimate of the schools present in southern California in June 1967 was based on a survey of this area. A school density factor per square mile searched (164.77) was applied to the total area (11,500 square miles) encompassed by the survey, producing an estimate of 1,895,000 schools. Although we do not have accurate means of determining school size, scientists and experienced fishermen on the survey judged that the schools were approximately one ton each (Kenneth F. Mais, pers. commun.). This preliminary study thus bears out the estimates based on egg and larva surveys.

AVAILABILITY

Anchovies have been the dominant species in all areas covered by echo-sounder cruises. These surveys have revealed important aspects of seasonal distribution and behavior. During spring the anchovy population was composed of thousands of very small schools distributed over large areas extending at least 50 to 80 miles offshore. These schools were located near the surface in clear, deep water and normally contained less than 2 tons of fish. All were adults in advanced spawning stages. Large compact schools, suitable for purse-seine fishing, were scarce and found only in a few localized areas. Juvenile fish were generally found close to shore in water shallower than 50 fathoms (91.5 m). During summer and fall all sizes of anchovies were found much closer to shore, at greater depths, and in larger but fewer schools. Decreases in school numbers from spring to fall in the southern California area exceeded 800 percent.

The sea surveys have also revealed school types and behavior patterns. During the day small numbers of horizontal-layer school types, 80 to 100 fathoms (146 to 183 m) below the surface, and more numerous "plumes", located 20 to 50 fathoms (36.6 to 91.5 m) deep, were the predominant schools in northern Baja California and central California (Figure 3). Plumes at shallower depths as well as the other types were observed off southern California. At nightfall all types came to the surface where almost all dispersed into surface scatter or loose detached school segments. Only a very few remained compact enough to be visible as a bioluminescent spot or register as an echo trace. As dawn approaches the fish aggregate into schools and go down.

The night behavior of anchovies appears closely associated with the upper extremity of the scattering layer that approaches the surface after dark. The after-dark rise and surface disperal suggests a feeding behavior as evidenced by the large numbers of recently ingested food organisms observed in stomachs of night-caught fish. A very high percentage of these food organisms were euphausiids, an important constituent of the upper scattering layer.

PROPOSAL FOR STOCK UTILIZATION

The role of the CalCOFI Committee has, since its organization in 1957, been one of acting as a scientific coordinating body, overseeing the cooperative research programs under the aegis of the Marine Research Committee, and reporting on its findings of interest.

It was in the latter context that CalCOFI, on 6 March 1964, submitted a paper entitled "Requirements for Understanding the Impact of a New Fish-

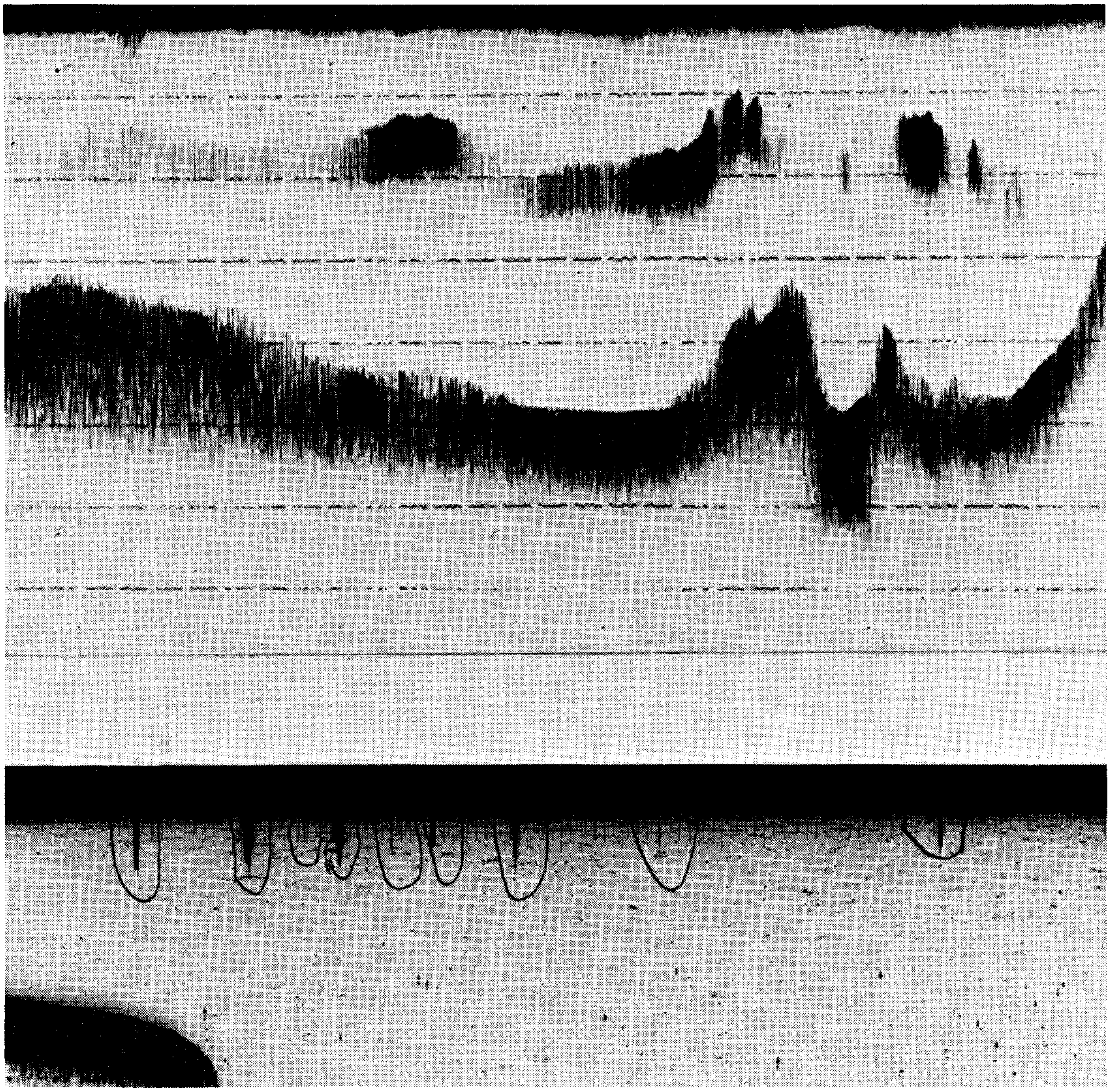

FIGURE 3. Echograms showing horizontal layer (upper photo) and plume type (lower photo) anchovy schools. The dark margin at the top of each echogram represents the surface. The circular marks around each plume in the lower photo are pencil marks made by cruise biologists when enumerating anchovy schools. The horizontal layer is located 20–40 fathoms (36.6–73.2m) below the surface. Plume type schools represent about 98% of the schools recorded and on this echogram are about 10 fathoms (18.3m) below the surface. *Photographs by Jack W. Schott.*

ery in the California Current System'' (Murphy et al., 1964). In this paper, based on 1951–1959 data, the authors called attention to the rise of the anchovy population which closely followed the fall of the sardine. They suggested that ''there is a real chance that simultaneously reducing the pressure on sardines and imposing pressure on anchovies will reverse the present equilibrium and assist in bringing back the more valuable sardine. This constitutes an exciting opportunity for marine science to assist society in meeting its complex needs'' and proposed establishing a new fishery on the sardine-anchovy system devised as a careful scientific experiment.

This long-range CalCOFI proposal consisted of three phases, each lasting a minimum of 3 years. Phase 1 called for a harvest of 200,000 short tons of anchovies and 10,000 tons of sardines, 35 percent of both of these limits to be taken north of lat. 31° N. This line, near Cape Colnett, Baja California, was chosen because it is a natural oceanographic and faunal boundary. The 200,000 ton limit represented 10 percent of the minimum estimate of the total anchovy population. This is a conservative value as harvest rates of $\frac{1}{4}$ to $\frac{1}{3}$ are thought quite reasonable for fish of this sort. The annual harvest rate of the Peruvian anchovy (*E. ringens*) is about 43 percent (derived from data in Schaefer, 1967). However, CalCOFI felt that a 10 percent harvest would be sufficient to produce a measurable perturbation in the anchovy-sardine system. The amounts of anchovies and sardines to be taken during Phase 2 were to be based on the results of studies of the fishery and fish populations conducted during Phase 1. Phase 3 had the ultimate objective of restoring the pre-decline balance between sardines and anchovies and maximizing the harvests consistent with all uses, i.e., food, recreation, etc.

This proposal was updated in February 1967 on the basis of additional data for eggs and larvae and called for raising the anchovy quota to 400,000 tons, 200,000 tons to be taken north of lat. 31° N., or 10 percent of the minimum standing crop during 1962–1966 (Ahlstrom et al. 1967). It also called for a moratorium on the sardine fishery. A law placing a moratorium on the take of sardines for 2 years became effective June 7, 1967.

The anchovy fishery remains very small for a variety of reasons, including those of a political, economic and sociological nature. Until these are resolved to the extent that a substantial fishery can exist, the CalCOFI proposal remains only that while its hypothesis gathers dust, untested.

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MESOPELAGIC AND BATHYPELAGIC FISHES IN THE CALIFORNIA CURRENT REGION

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The title of my talk "Mesopelagic and Bathypelagic Fishes" was assigned by the convenors of this symposium. I prefer to call the fishes that I will talk about "deep-sea pelagic fishes"; most are mesopelagic, some are bathypelagic, and a few are epipelagic. The word "deep" of deep-sea refers more particularly to the depth of the bottom, rather than the depth at which the fishes are distributed. Stated realistically, I am talking about all the small pelagic fishes not covered by the other speakers.

Most of my information is derived from CalCOFI surveys carried out over an 18-year period. As you know, fish eggs and larvae are sampled by quantitative plankton hauls. Standard CalCOFI plankton hauls sample a relatively shallow depth zone—from the surface to about 76.5 fathoms (140 meters) on the average. Recently, the depth of the hauls was increased to about 114.8 fathoms (210 meters)—the depth also sampled on EASTROPAC cruises, currently underway.

If I were dealing with adults exclusively, the depths sampled would be much too shallow to obtain meaningful information on mesopelagic and bathypelagic fishes. It is fortunate, consequently, that most of these fishes spawn either in the upper mixed layer or in the layer immediately below the thermocline, where the larvae become available to the CalCOFI sampling gear.

In a previous CalCOFI Symposium, I discussed the "Kinds and Abundance of Fishes in the California Current Region Based on Egg and Larval Surveys" (Ahlstrom 1965). In that presentation, I listed the 25 most abundant kinds of larvae obtained in each of 4 years, 1955–58. In those years larvae of deep-sea pelagic fishes made up 14 or 15 of the 25 most abundant kinds. A similar relation held in the 2 succeeding years: 17 kinds of deep-sea pelagic fishes were among the top 25 in 1959 and 15 kinds in 1960.

I will use data from these 6 years in my discussion of deep-sea pelagic fishes because they were collected during cruises spaced at approximately monthly intervals, and constitute our best series of data on the relative abundance of fish larvae. From 1961 through 1965, CalCOFI cruises were made at 3-month intervals; data on fish larvae from these cruises are similar to those derived from the earlier years but are less reliable because of the smaller number of surveys per year. In addition, the earlier series of years (1955–60) is particularly interesting because it included periods of contrasting oceanographic conditions; water temperatures over much of the CalCOFI area in 1956 were the lowest encountered during CalCOFI surveys, whereas they were markedly higher than average during 1958 and 1959.

Based on abundance of larvae, deep-sea pelagic fishes are predominantly of three kinds—myctophid lanternfishes, gonostomatid lightfishes, and deep-sea smelts of the family Bathylagidae. Larvae of these three families usually make up over 90% of the larvae of deep-sea pelagic fishes taken on CalCOFI surveys. The other 10%, however, constitute a very interesting and diverse group of fishes, including such bizarre kinds as hatchetfish, viperfish, and anglerfishes.

I have prepared a series of tables that will permit us to fit the "deep-sea pelagic fishes" into the total fish picture as determined from surveys of larvae; to look at the contributions, by family, of all the deep-sea pelagic fishes that occurred with any frequency in our larval collections; and then to look more closely at the kinds of larvae we take of myctophid lanternfishes, gonostomatid lightfishes, and deep-sea smelts of the families Bathylagidae and Argentinidae.

The values given in the tables, unless otherwise noted, are standard haul summations. The larvae taken in each collection are standarized to the number of larvae under 10 square meters of sea surface. The two essential pieces of information needed in deriving a standardization factor for the oblique planton hauls are (1) an estimate of the amount of water strained during a haul (based on revolutions registered by a current meter fastened in the mouth of the net), and (2) information on the depth stratum sampled (determined from length of towing cable payed out and the cosine of the angle of stray of the towing cable from the vertical). A standard haul total for a cruise is simply the summation of the standardized values for all stations occupied; the yearly total for a species is a summation of monthly cruise totals.

Larvae of deep-sea pelagic fishes made up about 20% to over 40% of the larvae obtained on CalCOFI survey cruises during 1955–60 (Tables 1 and 2). They represented a number of faunal groups: some are subarctic-temperate water forms, some are tropical-subtropical forms, and some are oceanic forms. The contribution of subarctic-temperate species tends to be largest during colder-than-average years, whereas tropical-subtropical and oceanic species occur in largest numbers during warmer-than-average years. The tenfold change in relative abundance of gonostomatid larvae—from 2.6% of the total larvae in 1956 to 26.0% in 1959—largely reflects changes in abundance related to water temperature. The bathylagid smelts exhibit a threefold range in relative abundance, whereas the contribution of myctophid larvae is less variable from year to year (9.1% to 14.3% of the total). The larvae of all other deep-sea pelagic fishes constitute 1.0% to 1.85% of the larvae taken on CalCOFI surveys.

It should be noted that the CalCOFI collections are not typical of oceanic waters generally. They are dominated by the larvae of two species—northern anchovy, *Engraulis mordax,* and Pacific hake, *Merluccius productus*, which usually make up 45% to 60% the larvae—whereas deep-sea fishes are the dominant forms over vast expanses of the world's oceans.

TABLE 1

RELATIVE ABUNDANCE OF LARVAE OF THE MAJOR FAMILIES OF FISHES IN THE CALIFORNIA CURRENT REGION OFF CALIFORNIA AND BAJA CALIFORNIA DURING 1955–60

(Standard haul summations)

Family	Year					
	1955	1956	1957	1958	1959	1960
Epipelagic and bottom fishes						
Engraulidae	151,192	134,926	146,628	205,871	206,876	292,401
Clupeidae	14,181	15,934	10,384	12,228	5,983	9,081
Carangidae	13,282	8,330	20,402	6,547	4,558	5,584
Scombridae	1,956	1,784	2,280	1,455	970	1,464
Gadidae	61,377	89,861	78,291	58,364	17,662	33,022
Scorpaenidae	32,512	32,676	37,416	24,072	11,656	15,533
Bothidae	20,761	24,007	16,346	7,171	4,775	7,445
Pleuronectidae	2,121	2,786	2,101	993	705	706
Other	7,247	13,964	16,207	8,644	11,241	12,204
Subtotal	304,629	324,268	330,055	325,345	264,426	377,440
Deep-sea pelagic fishes (mostly mesopelagic and bathypelagic)						
Myctophidae	34,620	42,625	60,136	49,590	67,373	52,584
Gonostomatidae	14,297	10,672	58,075	60,710	122,073	37,121
Bathylagidae	19,690	23,019	37,006	13,618	10,623	32,762
Other	5,662	7,556	8,277	6,755	5,961	5,073
Subtotal	74,269	83,872	163,494	130,673	206,030	127,540
Total—all categories	[1]378,898	408,140	493,549	456,018	470,456	504,980

[1] Totals for 1955 include multiple occupancies of pattern off Southern California during September and November, but exclude Norpac.

TABLE 2

PERCENTAGE CONTRIBUTION OF LARVAE OF THE MAJOR FAMILIES OF FISHES IN THE CALIFORNIA CURRENT REGION OFF CALIFORNIA AND BAJA CALIFORNIA DURING 1955–60

Family	Year					
	1955	1956	1957	1958	1959	1960
Epipelagic and bottom fishes						
Engraulidae	39.9	33.1	29.7	45.1	44.0	57.9
Clupeidae	3.7	3.9	2.1	2.7	1.3	1.8
Carangidae	3.5	2.0	4.1	1.4	1.0	1.1
Scorpaenidae	8.6	8.0	7.6	5.3	2.5	3.1
Gadidae	16.2	22.0	15.9	12.8	3.7	6.5
Scombridae	0.5	0.4	0.5	0.3	0.2	0.3
Bothidae	5.5	5.9	3.3	1.6	1.0	1.5
Pleuronectidae	0.6	0.7	0.4	0.2	0.1	0.1
Other	1.9	3.4	3.2	1.9	2.4	2.4
Subtotal	80.4	79.4	66.8	71.3	56.2	74.7
Deep-sea pelagic fishes (mostly mesopelagic and bathypelagic)						
Bathylagidae	5.2	5.6	7.5	3.0	2.3	6.5
Gonostomatidae	3.8	2.6	11.8	13.3	26.0	7.4
Myctophidae	9.1	10.5	12.2	10.9	14.3	10.4
Other	1.5	1.9	1.7	1.5	1.2	1.0
Subtotal	19.6	20.6	33.2	28.7	43.8	25.3
Total—all categories	100.0	100.0	100.0	100.0	100.0	100.0

Table 3 summarizes, by family, the contributions of all deep-sea pelagic fishes that enter significantly into the CalCOFI catches. Twenty families are included, plus the ordinal grouping of "eel leptocephali." Families that made significant contributions, in addition to the Myctophidae, Gonostomatidae, and Bathylagidae discussed above, include the Agrentinidae, Melamphaidae, Centrolophidae, Tetragonuridae, Stomiatidae, and Paralepididae. The "other" category in Table 3, although not large in number of specimens, contains larvae from at least as many families as those separately listed.

The relative abundance of different kinds of myctophid larvae in the California Current region during 1955–60 is summarized in Table 4. The tabulation is given by species for all commonly occurring larvae except *Hygophum* spp., which includes larvae of *H. atratum* and *H. reinhardti; although Hygophum* larvae can be identified to species, we have not done so routinely when identifying and enumerating larvae of this genus. Sixteen genera are represented in this tabulation, and 4 more of sporadic occurrence *(Benthosema, Centrobranchus, Electorna,* and *Lepidophanes)* are included in the "other" category. Hence, 20 genera of myctophids are represented in the collection of larval fishes from the California Current region. A number of these are common to abundant and three (*Triphoturus mexicanus, Stenobrachius leucopsarus,* and *Diogenichthys laternatus*) consistently rank among the top 12 kinds of larvae.

The myctophids in the California Current region belong to several faunal assemblages. *Stenobrachius leucopsarus* and *Tarletonbeania crenularis* are subarctic-temperate species which are at the southern end of their range in the CalCOFI area. *Diogenichthys laternatus* is a tropical lanternfish that is collected as far north as central Baja California in all years and off southern California in warmer-than-average years. *Ceratoscopelus townsendi* is a widely distributed, offshore oceanic form that occurs in the outer part of the CalCOFI station grid. All of these species have a much more extensive distribution than is encompassed in the CalCOFI surveys. The oceanic distribution of *Triphoturus mexicanus,* the most abundant myctophid in CalCOFI collections, is perhaps as completely encompassed as any by the CalCOFI surveys. Larvae of this species are abundant off Baja California and in the Gulf of California.

We have had a deep interest in lanternfish larvae of the California Current region since the initiation of the CalCOFI surveys some 18 years ago, and at long last Dr. H. Geoffrey Moser and I are in the midst of preparing descriptions of their early life history stages. Larval studies can make a definite contribution to the understanding of relationships among genera and species in some fish families; the myctophids are an outstanding example. There are good larval characters, at the generic level, for all genera that occur in the California Current region. The 20 genera off California and Baja California whose larvae we can identify, represent two-thirds of all genera currently recognized in this family. Consequently, the information we are accumulating on myctophids off California will aid in the identification of myctophid larvae from other areas and other oceans.

The gonostomatid light fishes are represented in the CalCOFI collection by five genera: *Vinciguerria,*

TABLE 3

RELATIVE ABUNDANCE OF LARVAE OF THE PRINCIPAL FAMILIES OF DEEP-SEA FISHES (MOSTLY MESOPELAGIC AND BATHYPELAGIC) IN THE CALIFORNIA CURRENT REGION OFF CALIFORNIA AND BAJA CALIFORNIA DURING 1955–60

(Standard haul summations)

Family	Year					
	1955	1956	1957	1958	1959	1960
Argentinidae	1,277	1,603	1,852	690	359	527
Bathylagidae	19,690	23,019	37,006	13,618	10,623	32,762
Gonostomatidae	14,297	10,672	58,075	60,710	122,073	37,121
Sternoptychidae	186	181	269	324	326	203
Astronesthidae	0	37	0	227	16	14
Chauliodontidae	254	350	195	285	241	210
Idiacanthidae	35	66	87	147	126	291
Melanostomiatidae	47	32	158	113	105	90
Malacosteidae	15	6	43	36	34	20
Stomiatidae	411	81	271	1,188	824	621
Myctophidae	34,620	42,625	60,136	49,590	67,373	52,584
Paralepididae	324	366	452	689	633	586
Scopelarchidae	113	89	199	170	335	227
Melamphaeidae	773	1,051	1,328	1,259	1,095	793
Eel leptocephali	16	68	134	247	255	52
Bregmacerotidae	36	0	706	218	52	104
Trachipteridae	76	84	98	107	34	94
Trichiuridae	110	389	332	97	311	365
Chiasmodontidae	97	46	222	280	240	133
Centrolophidae	1,386	898	768	431	405	407
Tetragonuridae	490	2,154	708	60	107	92
Other	16	55	455	187	463	244
Total	74,269	83,872	163,494	130,673	206,030	127,540

Cyclothone, Ichthyococcus, Diplophos, and (infrequently) *Danaphos* (Table 5). Most gonostomatid larvae—88.5 to 96.6% in 1955–60—belong to one species, *Vinciguerria lucetia;* it may be the most abundant fish in the temperate and tropical waters of the eastern Pacific Ocean. We have described the development of this species from egg to adult (Ahlstrom and Counts 1958). Two other species of *Vinciguerria*—*V. nimbaria* and *V. poweriae*—occur in offshore oceanic waters, and have been sampled on the few cruises when our coverage extended seaward beyond California Current waters into the oceanic water mass. We obtained excellent information on the distribution of these two species on the portion of the "Norpac" survey of the North Pacific Ocean made by CalCOFI vessels (between 20° N.–45° N. lat. and offshore to 150° W. long.), in 1955.

The abundance of larvae of *V. lucetia* is variable in the CalCOFI area, depending on water temperatures: The number collected ranged from 9,800 in 1956, a cold year, to 118,000 in 1959, a warm year. In the latter year, *Vinciguerria* made up 25% of all fish larvae and was outranked only by the northern anchovy. Yet we sampled only the fringe of the distribution of *Vinciguerria lucetia,* as will be evident when I discuss later the results of EASTROPAC I, the multi-vessel cruise of the eastern tropical Pacific.

Although five or possibly six species of *Cyclothone* are taken in the CalCOFI area, only two are common, *C. signata* and *C. acclinidens. Cyclothone* larvae are also more abundant during warmer-than-average years than during cold years—3,840 were taken in 1959 as compared to 810 in 1956.

The Bathylagidae is the third family of deep-sea pelagic fishes that is common in the CalCOFI collections. We take larvae of six species of bathylagid smelts, but only three are abundant (Table 5). The most abundant species, *Leuroglossus stilbius,* is taken throughout the length of the CalCOFI pattern, and also in the Gulf of California. It usually ranks about fifth in abundance, surpassed only by larvae of northern anchovy, Pacific hake, rockfish (*Sebastodes* spp.), and *Vinciguerria.* Most larvae of the deep-sea smelts are distributed below the thermocline—not in the upper mixed layer—and thus have a distribution similar to that of hake larvae. Larvae of *Bathylagus ochotensis* seldom rank higher than 15th. It is a subarctic form that has a widespread distribution in the North Pacific; we sample only the southern extent of its distribution. *Bathylagus wesethi* is a subtropical species that occurs between central California and southern Baja California; the CalCOFI station grid may encompass much of its distribution. The three less common species of Bathylagidae in the CalCOFI collections are *Bathylagus pacificus, B. milleri,* and *B. nigrigenys;* the first two are subarctic forms and the last is a tropical species that is sometimes taken in the CalCOFI area off southern Baja California.

Four species of argentinid smelts occur in the CalCOFI area—*Argentina sialis, Microstoma microstoma,* and two species of *Nansenia* (Table 5). Only *Argentina* has occurred in numbers large enough to rank among the top 25 kinds of larvae, and then only in some years.

I mentioned previously that the deep-sea pelagic fishes are more dominant in offshore waters than in

TABLE 4

RELATIVE ABUNDANCE OF LARVAE OF MYCTOPHID LANTERNFISHES IN THE CALIFORNIA CURRENT REGION OFF CALIFORNIA AND BAJA CALIFORNIA, 1955–60

(Standard haul summations)

Species	Year					
	1955	1956	1957	1958	1959	1960
Ceratoscopelus townsendi	446	221	2,598	1,446	4,457	1,564
Diaphus spp.	1,022	3,562	713	605	722	703
Diogenichthys atlanticus	699	747	780	641	634	704
Diogenichthys laternatus	4,774	3,158	11,603	7,020	6,425	3,678
Diogenichthys sp.[1]	21	24	235	157	496	506
Gonichthys tenuiculus	141	60	466	742	803	208
Hygophum spp.[2]	400	223	795	998	1,250	854
Lampadena urophaos	38	--	--	338	996	323
Lampanyctus regalis	95	82	124	92	197	58
Lampanyctus ritteri	1,986	1,924	2,789	3,127	2,424	1,990
Lampanyctus spp.[3]	487	310	732	989	1,369	1,140
Loweina rara	44	23	27	22	28	27
Myctophum nitidulum	53	88	122	230	400	148
Notolychnus valdiviae	8	12	0	2	12	54
Notoscopelus resplendens	100	4	156	119	524	331
Protomyctophum crockeri	1,824	1,852	1,415	1,824	2,045	1,979
Stenobrachius leucopsarus	7,453	15,125	16,808	11,880	7,224	11,977
Symbolophorus californiense	656	462	1,645	1,280	1,115	602
Tarletonbeania crenularis	999	3,352	1,570	526	777	1,730
Triphoturus mexicanus	13,160	10,802	16,207	16,604	33,871	22,106
Other[4]	214	594	1,351	948	1,604	1,902
Total	34,620	42,625	60,136	49,590	67,373	52,584

[1] Small specimens of *D. atlanticus* and *D. laternatus,* which cannot be identified to species with certainty.
[2] *Hygophum atratum* and *H. reinhardti* (combined).
[3] *Lampanyctus* spp. includes larvae of *L. idostigma* and several other species.
[4] Includes disintegrated specimens that could be identified with certainty only to the family level.

TABLE 5

RELATIVE ABUNDANCE OF LARVAE OF GONOSTOMATID LIGHTFISH AND OF DEEP-SEA SMELTS OF THE FAMILIES BATHLAGIDAE AND ARGENTINIDAE IN THE CALIFORNIA CURRENT REGION OFF CALIFORNIA AND BAJA CALIFORNIA DURING 1955–60

(Standard haul summations)

	Year					
	1955	1956	1957	1958	1959	1960
Family Gonostomatidae						
Vinciguerria lucetia	12,658	9,832	55,114	57,424	117,959	35,041
Cyclothone spp.	1,532	814	2,880	2,921	3,844	1,974
Ichthyococcus spp.	106	13	69	139	122	26
Diplophos	0	9	12	218	126	68
Other	1	4	0	8	22	12
Total	14,297	10,672	58,075	60,710	122,073	37,121
Family Bathylagidae						
Leuroglossus stilbius	15,114	18,620	29,506	4,859	7,597	29,795
Bathylagus ochotensis	1,301	2,231	1,078	1,550	545	1,671
Bathylagus wesethi	3,245	2,146	6,347	7,033	2,386	1,207
Other	30	22	75	176	95	89
Total	19,690	23,019	37,006	13,618	10,623	32,762
Family Argentinidae						
Argentina sialis	877	1,288	1,400	276	101	249
Microstoma microstoma	92	81	56	105	107	64
Nansenia spp.	308	234	396	309	151	214
Total	1,277	1,603	1,852	690	359	527

the California Current region. This dominance was most evident when we identified and counted the larvae taken on Norpac, the first comprehensive survey of the North Pacific Ocean made during August 1955. The CalCOFI agencies used four vessels on Norpac to cover the extensive area between 20° N. and 45° N. lat. and offshore to 150° W. long. Myctophids made up 46.7% of the larvae and gonostomatids 34.8%. *Vinciguerria* (three species) was the most abundant genus, contributing 24.4% of the larvae; *Ceratoscopelus townsendi* was the most abundant myctophid, contributing 11.2% of the larvae. Three other genera contributed over 5% of the total larvae: *Cyclothone* (10.0%), *Triphoturus* (9.5%), and *Diogenichthys* (5.5%). The dominance of the myctophids and gonostomatids is typical of offshore oceanic waters in other parts of the world, such as the eastern tropical Pacific and the Indian Ocean. When I examined collections of larvae from the International Indian Ocean Expedition at the Indian Ocean Biological Centre at Ernakulam, India (while appraising the potential of the larval fish collection there), I found that collections of fish larvae from the oceanic zone contained 47.6% myctophids and 30.5% gonostomatids — percentages similar to those found on Norpac.

I have examined the fish larvae obtained on the first EASTROPAC cruise, made by four vessels during February and March 1967. Myctophid larvae made up 47.2% of the larvae obtained, gonostomatid larvae (including the allied hatchetfish of the Sternoptychidae), 29.2%, and bathylagid larvae, 5.1%.

As mentioned above, myctophid larvae can be reliably identified to genus, even when the species composition is not completely known. Eighteen genera were commonly represented in the EASTROPAC collections. One species far outranked all others: *Diogenichthys laternatus* contributed 26.7% of the total larvae collected on EASTROPAC. It proved to be even more numerous than the larvae of the gonostomatid light fish, *Vinciguerria lucetia,* which made up 19.7%. Larvae of only two species of Bathylagidae were present in EASTROPAC collections—*Bathylagus nigrigenys* (3.1% of the total) and *Leuroglossus tranus* (2.0%).

I believe that I have shown that the deep-sea pelagic fishes are a very large resource, indeed. The fish larvae in all parts of oceanic province that I have investigated have been dominated by two families of deep-sea fishes—myctophids and gonostomatids. This vast oceanic province makes up at least 80%, and perhaps as much as 90% of the area of the oceans. The deep-sea pelagic fishes must represent a huge biomass.

Myctophids and gonostomatids fill an exceedingly important ecological role as forage fishes. They serve as a vital link between the zooplankton community and the larger predator fishes, including tunas and billfishes.

Can we harvest this resource directly? Perhaps, but I am not sanguine about the prospects. My reservations are based on several considerations. Foremost is the problem of fish size: most common myctophids and gonostomatids may be too small to be of commercial value. The two most abundant fishes in the eastern tropical Pacific, on the basis of their abundance as larvae—*Diogenichthys laternatus* and *Vinciguerria lucetia*—are only 1 to 2 inches (25 to 50 mm) long as mature adults. The myctophid that was taken most commonly (as juvenile and adult) in the micronekton collections made with the Blackburn micronekton net on EASTROPAC, *Notolychnus valdiviae,* is only an inch long at maturity. Most species of the gonostomatid *Cyclothone* are even less substantial than *Vinciguerria,* being thin and short. The majority of myctophids are larger as adults than the two discussed above; most species attain a length of approximately 2 to 4 inches (50 to 100 mm) and a few are relative monsters, growing to 6 or even 8 inches (150 to 200 mm) long. The bathylagid and argentinid smelts attain a somewhat larger average size than myctophids or gonostomatids. Most bathylagids, as adults, are comparable in size to anchovies, and *Argentina* and *Nansenia* grow as large as the sardine.

Another important limitation is the fact that adults of deep-sea pelagic fishes are indeed "deep"-sea fishes. Unlike their larvae, most myctophid lanternfishes occur at depths of 200 to 400 fathoms during daylight and may or may not move to shallower depths at night (Paxton 1967). These fishes also are most common in oceanic waters at a considerable distance from land.

Still another prime limitation to harvesting the deep-sea pelagic fishes is their manner of distribution. Adult gonostomatids and myctophids seldom occur in dense schools—although there may be exceptions, such as the schools of the myctophid *Benthosema panamense* that have occasionally been taken as bait by tuna fishermen, or the schools of the myctophid *Ceratoscopelus* that have been observed in the North Atlantic.

As the use of submersible vessels increases, we could rapidly increase our knowledge of the distribution of deep-sea fishes, which are commonly observed during dives. We also may learn how to concentrate the fish in quantities large enough to harvest them economically. These developments are for the future. For the present the deep-sea pelagic fishes will continue to be curiosities, rather than hors d'oeuvres.

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THE JACK MACKEREL (*TRACHURUS SYMMETRICUS*) RESOURCE OF THE EASTERN NORTH PACIFIC

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INTRODUCTION

The jack mackerel before 1947, was of minor commercial importance having to take a back seat to the better known, more profitable, and more abundant Pacific sardine (*Sardinops caeruleus*) and the more desirable Pacific mackerel (*Scomber japonicus*). During these years it was referred to as "horse mackerel" and had relatively little market appeal. Much of the catch between 1926 and 1946 was absorbed by the fresh fish markets and consisted primarily of jack mackerel taken from mixed sardine and Pacific mackerel schools. Landings were low, varying between 183 and 15,573 short tons. During the 1947–48 season, the industry, after being hit hard by poor sardine landings, turned to the jack mackerel as a substitute sardine and landed approximately 71,000 short tons. Jack mackerel have been a major contributor to California's commercial landings ever since (Figure 1).

In 1948, the U.S. Pure Food and Drug Administration authorized the use of the common name jack mackerel on all labeling. This name was expected to

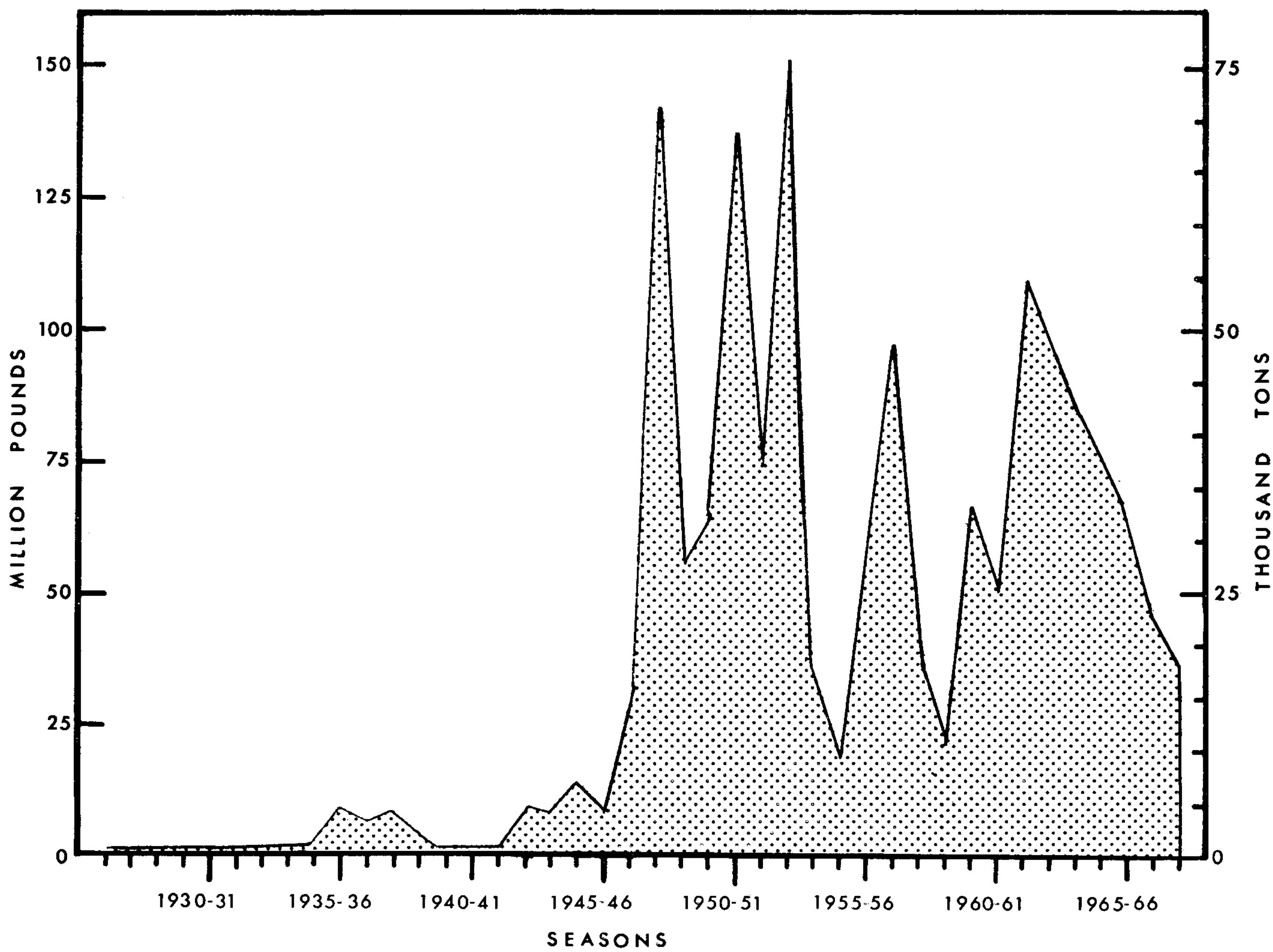

FIGURE 1. California landings of jack mackerel taken off California. The season extends from May of one year through April of the next.

have more consumer appeal than the original official name "horse mackerel".

The California Department of Fish and Game commenced routine length and age sampling of the commercial landings in 1947, the year the fishery first blossomed into being. Due to the apparent healthy condition of the resource and the need for emphasis on other fisheries these sample data have not been subjected to a complete analysis. We have recently completed the assignment of ages to the otoliths sampled and anticipate dedicating most of our effort in 1968 to writing a manuscript describing the fishery, its year-class composition and other factors affecting the yield.

The literature on the jack mackerel is somewhat scanty with the greatest part of it pertaining to: (i) taxonomy; (ii) egg and larva distribution and survival; (iii) yield per area from California waters; and (iv) reviews of the jack mackerel fishery in California and preliminary discussions of biological knowledge.

Accordingly, for this paper, I have called upon past work and much unpublished data from our files, including station data from pre-season albacore cruises and the previously mentioned length and age data.

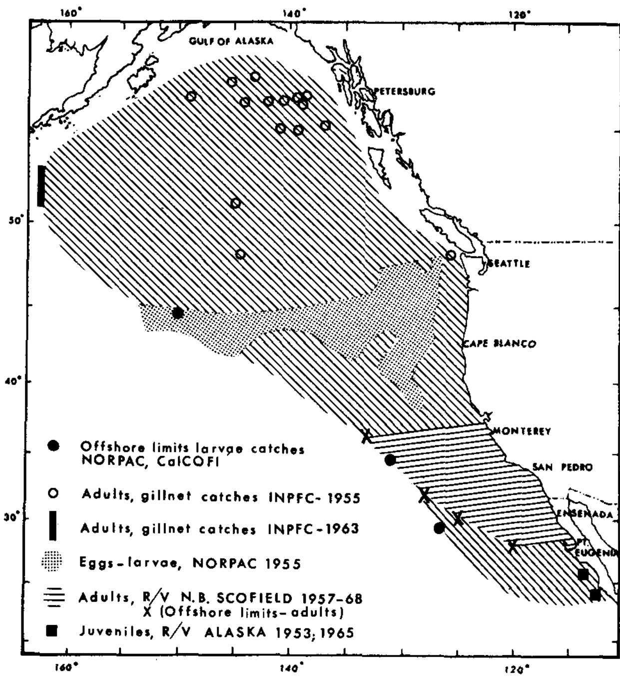

FIGURE 2. Generalized pattern depicting the range of jack mackerel in the eastern Pacific. This range represents the surface distribution resulting from records of adults, juveniles, and eggs and larvae as obtained by various Pacific coast research agencies (similar to Figure 2, Ahlstrom ms).

RANGE

The jack mackerel "population" represents a renewable resource of considerable range and magnitude. All available information indicates the distribution, as obtained primarily from surface observations, extends from the Gulf of Alaska in the north to Cape San Lucas, Baja California, Mexico in the south. Juveniles have been reported off Acapulco, the Revilla Gigedo Islands and the Gulf of Tehuantepec, although these may have been transported south in bait tanks of tuna boats (Fitch, 1956). Within this range lies an area of maximum density which extends from Point Conception to central Baja California.

The northern extension of the range has been well documented by the high seas sampling program of the International North Pacific Fisheries Commission (INPFC) (Figure 2). Significant numbers of large, adult jack mackerel were taken in a series of gill net sets during 1955 in the Gulf of Alaska as far north as lat. 57° 30′ N. (Powell and Peterson, 1957). The offshore extent in this northern area was extended in 1963 to long. 162° W. (Ahlstrom, ms; H. A. Larkins, U.S. Bureau of Commercial Fisheries, Seattle, pers. comm.). The sampling program covered offshore areas to long. 160° E. but no jack mackerel were taken.

One of the best sources for data on the range and center of abundance of pelagic populations in our area is the egg and larva survey conducted each year by the U.S. Bureau of Commercial Fisheries. Jack mackerel eggs and larvae are among the most abundant taken in plankton collections by the survey. The center of abundance of the spawning population is off southern California and Baja California between Point Conception and Cape San Quintin (Figure 3). Larvae have been taken up to 400 miles off the coast of southern California. The surveys have not always delimited the seaward extension of spawning; however, they appear to have encompassed the area of maximum abundance. In recent years this has been remedied somewhat by the addition of two station lines with a seaward extent of 600–700 miles.

Offshore pre-season albacore cruises by the California Department of Fish and Game are another source of information giving insight into the seaward extension of jack mackerel (Figure 4). These trips occur during May and June of each year. Each night, when weather permits, a light station is occupied for 2–4 hours. A variety of specimens are dip netted and observations made of organisms under the light. At many stations, large, old jack mackerel, up to 5 pounds in weight and 61 cm (24 in.) FL are soon attracted to the light. Usually most of the fish stay on the periphery of the lighted area except for occasional feeding forays upon other organisms attracted by the light. During 1968 one of the largest, sustained concentrations of adult jack mackerel attracted to the vessel occurred 150 miles off Ensenada, Mexico (William L. Craig, Calif. Dept. Fish and Game, pers. comm.). Craig estimated at least 2–3 tons to be present on the surface.

Since 1957 these pre-season albacore surveys have covered an area of approximately 350,000 square miles. Many of the night light stations have extended 900 miles offshore (Figure 4). Stations occupied be-

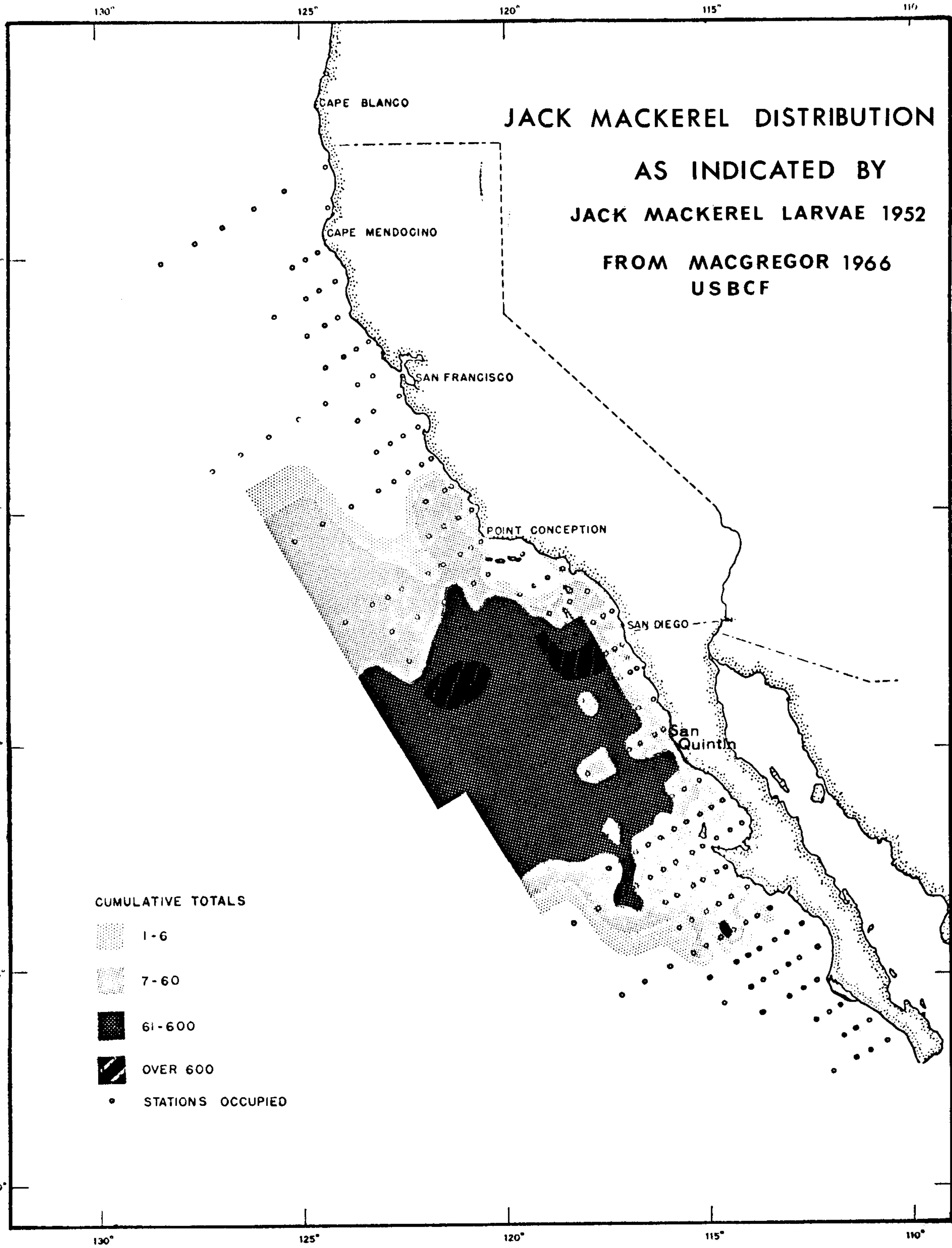

FIGURE 3. Distribution of jack mackerel larvae in 1952.

yond 500 miles did not result in jack mackerel observations or catches.

Department of Fish and Game pelagic fish sea survey cruises, 1950–53, utilizing dynamite as a killing and stunning device, are still another source of material for estimating distribution and relative abundance (Heimann, 1966). During these years a series of night light stations were occupied off California and Baja California. When fish were observed a charge of dynamite was thrown into the school and specimens floating on the surface were subsequently collected. Jack mackerel taken by this method ranged

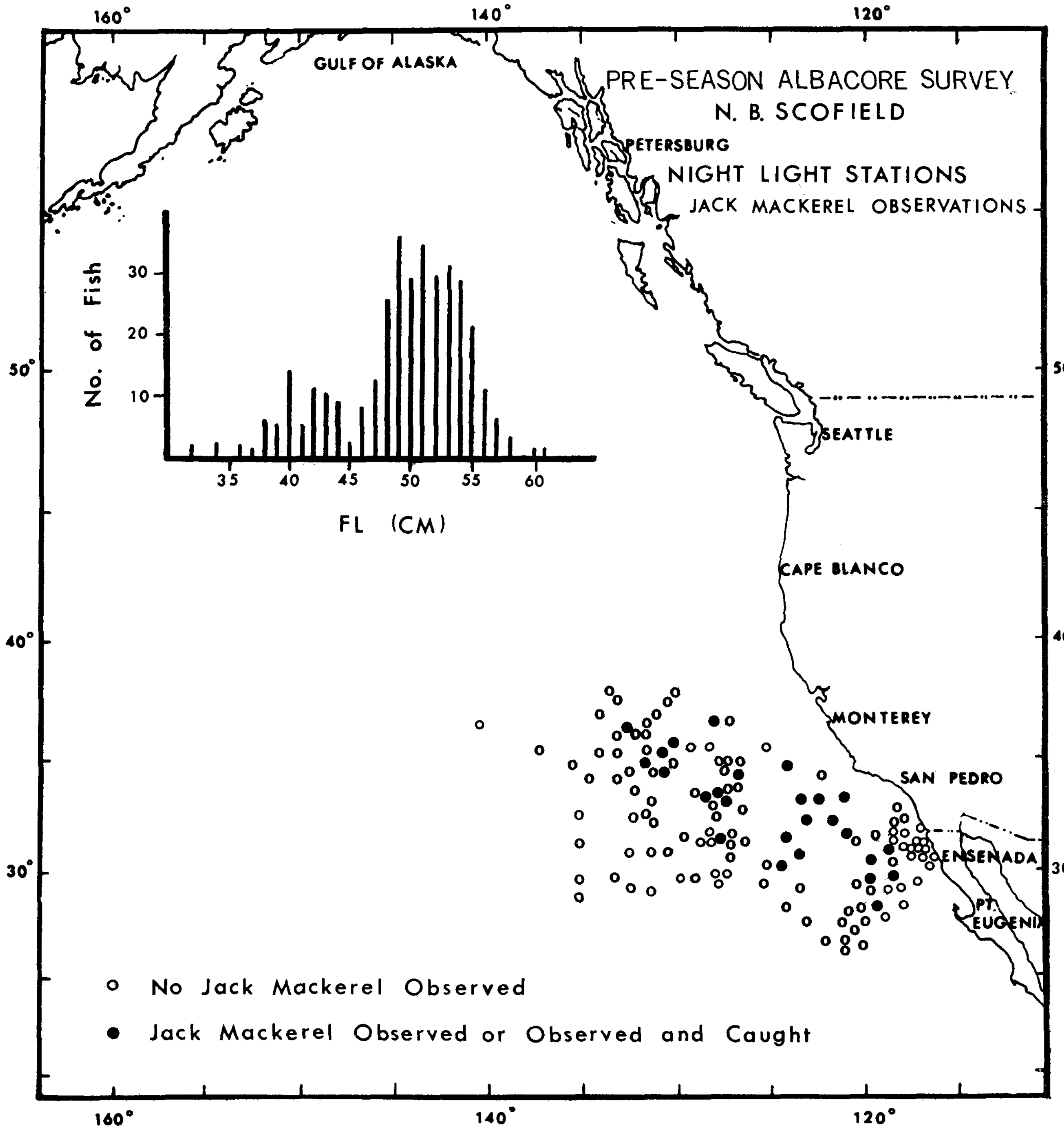

FIGURE 4. Distribution of adult jack mackerel off southern California and Baja California as depicted by successful night light stations made during the pre-season albacore surveys of the California Department of Fish and Game (from 1957 through 1968). The frequency diagram represents the numbers of fish by length taken on these cruises.

from 6–37 cm (2.4–14.6 inches) FL and consisted of juveniles, less than a year in age, and fish from 1–5 years of age. An index of abundance (Figure 5) was computed for each year and general area. This index consists of the percent frequency of occurrences of successful jack mackerel stations based on all stations occupied in a general area. The north-south distribution corresponds quite well with the 1952 larvae distribution.

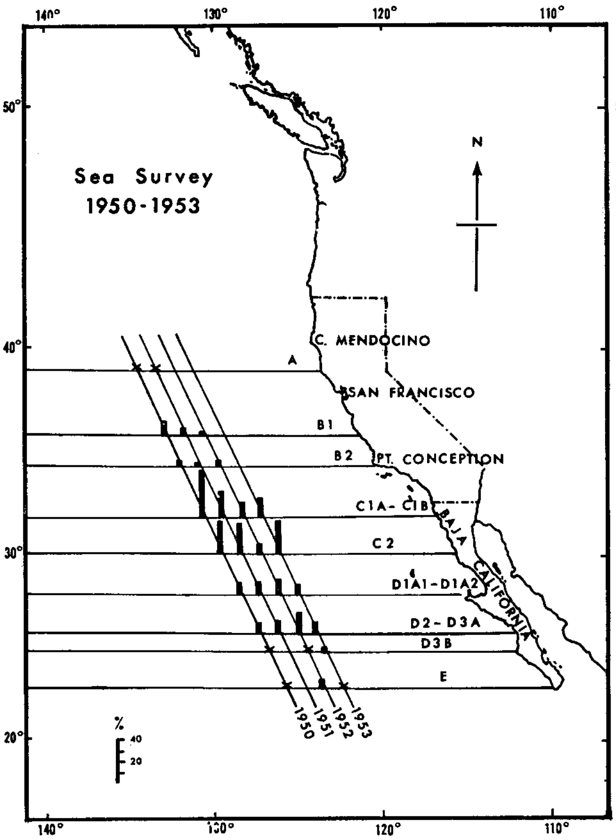

FIGURE 5. North-south distribution of jack mackerel as inferred from records of the R/V YELLOWFIN, 1950–53. Stations were run primarily to assess sardine young-of-year abundance and usually did not extend beyond 10 miles from shore. The bars represent the percent frequency of occurrence of successful jack mackerel stations as computed for all stations occupied in a general area.

A composite of all of the above distributional data takes on the general pattern as presented in Figure 2. It is interesting to note that the offshore extension of larvae, obtained by the CalCOFI surveys off southern California and northern Baja California, agrees quite well with the offshore extension of large adults as taken by the *N. B. Scofield* between 1957–1968. The 1963 catches of adult jack mackerel by the INPFC along long. 162° W. and between lat. 51–53° N. establishes the offshore distribution in this area quite well.

The occurrence of jack mackerel in the Gulf of Alaska appears to be related to the warming of surface waters with the progression of summer. Records of the INPFC suggest a seasonal range expansion of from a half to three-quarters of a million square miles in this region (Neave and Hanavan, 1960). Their data also suggest that the distance traveled by some fish may approximate 800 miles at a rate of 13–14 miles per day.

SIZES IN COMMERCIAL AND SPORT FISHERIES

The commercial fishery off southern California harvests fish between 15 and 38 cm (6 and 15 inches) FL. The fishery apparently harvests younger individuals from an inshore margin of a large, far ranging population occurring in the general range depicted in Figure 2.

Since 1953, the jack mackerel has contributed rather significantly to the sport catch. In that year 200,000 were taken; however, the catch has subsequently varied between 7,000 and 40,000 fish annually. The bulk of the jack mackerel caught by sportsmen in 1953 were in the size range of the offshore fish taken during the 1957–1968 *N. B. Scofield* albacore cruises (Figure 4).

MAGNITUDE OF RESOURCE

At the present time the magnitude of the jack mackerel resource is open to speculation. The offshore spawning range and distribution of adults has not been clearly delimited. Tagging has not been conducted and the Department's sea survey project has not been successful in locating jack mackerel schools. The present survey is confined to inshore areas and there are no pending plans to expand the survey so as to adequately cover the entire range of jack mackerel.

John S. MacGregor (1964) estimated there was an average biomass of 350,000 tons in the CalCOFI area during the years 1955–1957. His estimate was based on egg and larva surveys which did not cover the total spawning range of jack mackerel, and includes only spawning fish. Consequently, this estimate is probably low with respect to the total population.

Over the period covered by MacGregor and using his estimates it would appear that the southern California fishery harvested considerably less than 10% of the spawning fish in the CalCOFI area. Much of the 35,000 ton average annual landings by the commercial fishery, during these years, consisted of juvenile fish.

More recently, Elbert H. Ahlstrom presented an evaluation of the jack mackerel resource to the 1968 conference on The Future of the United States Fishing Industry held at the University of Washington on March 24–27. He estimated that the total resource in the eastern Pacific was between 2.1 to 4.8 million tons (based on an educated guess of the total population as $1\frac{1}{2}$ to 2 times that in the CalCOFI area). This represents a resource of considerable magnitude.

FISHERY

Seasons

Jack mackerel are caught on the southern California fishing grounds throughout the year. In the early days of the fishery, shortly after 1947, the monthly catches were simply related to the activity of the fleet searching for sardines and mackerel (Roedel, 1953). As a result, fleet activity was low during late winter and spring months, reflecting the close of the sardine season and the scarcity of Pacific mackerel in spring. Current monthly landings do not reflect the clear seasonal pattern evidenced in the early days of the fishery.

Landings

Jack mackerel landings in the southern California area have fluctuated widely (Figure 1). Many of these fluctuations are related to changing market demand and the resurgence of competing species such as Pacific mackerel and Pacific sardine. It is hypothesized that availability and vulnerability also played a part in these erratic catches; especially since the fishery was being prosecuted in a small part of a much larger biological range. A better insight into the true nature of these factors must await future study and analysis.

Areas

The southern California fleet catches jack mackerel from Point Conception to San Diego and offshore as far as San Nicolas Island and Tanner and Cortes Banks. The offshore distribution of these catches over the years has been related also to Pacific mackerel and sardine fishing. In 1961–64 Cortes Bank and other offshore regions produced 62% of the total jack mackerel catch of 145,167 tons (Figure 6). The sardine fishery was at a low level and scouting was pointed more in the direction of jack mackerel (Duffy, 1968).

I do not wish to imply that the yield per area of jack mackerel has at all times been related to sardine and mackerel scouting. The commercial fishery operates in a small part of the overall species range and movements of fish into and out of the limit of our fleet would certainly affect the yield per area.

Size, Age, Year-Class and Structure

Fish taken off southern California by the United States fishery and off Ensenada by the Mexican fishery are young fish between 15 and 38 cm (6 and 15 inches) FL. These fish are all less than 7 years-of-age. In recent years the catch has consisted primarily of 1, 2 and 3 year-old-fish.

Preliminary examination of unpublished length frequency and year-class data has shown that dominant year classes are evident in the fishery. Some of these carry through the fishery for periods up to 4 years, others less; some appear dominant for variable periods, disappear for extended periods and then reappear.

For example, the 1958 year-class first showed up as approximate one-year-olds in March 1959. It carried the fishery through 3 years, almost single-handedly most of the time, for total seasonal landings of 34,000 tons, 25,000 tons and 55,000 tons in 1959–60, 1960–61, and 1961–62 respectively.

Jack mackerel appear to remain inshore, where they are vulnerable to round haul gear, for 3–6 years. Apparently, as they grow older and larger, they become unavailable and inhabit the deeper offshore waters outside the range of the existing fisheries. Fish taken from these offshore areas have been aged to 25 and 30 years.

While processing our jack mackerel data it became evident that the size and age structure of the fish entering the catch has changed rather significantly since 1953. This change occurred after a series of years in which large catches were made averaging about 52,000 tons. The stock had not been fished significantly before 1947 (Figure 1) and during this series of years with large catches (1947–53) fish were generally large, most between 9 and 15 inches long and up to 6 and 7 years of age. Since that time the percentages of fish 4 years and older have decreased significantly to where they are now relatively rare in southern California catches.

SUMMARY

1. The jack mackerel "population" is extensive and ranges from the Gulf of Alaska in the north to Cape San Lucas in the south and up to 1,200 to 1,300 miles seaward. The offshore extent has not been positively delimited.
2. Known areas of greatest population density, consisting primarily of juveniles and young adults, occur between Pt. Conception, California and central Baja California, Mexico and up to 90 miles offshore.
3. Large, old fish up to 61 cm (24 inches) fork length and 30 years of age are abundant 180–500 miles off southern California and Baja California. Large, adult jack mackerel move into the surface waters of the Gulf of Alaska during the summer.
4. The present fisheries operate in a small portion of the overall range, harvesting juveniles and young adults off southern California and northern Baja California.
5. Initial examination of fishery year-class composition from 1947–67 shows the occurrence of dominant year-classes which enter the southern California fishery as 1-year-olds and continue dominant up to 4 years. Some year-classes appear dominant for variable periods, disappear for extended periods and then reappear.
6. One estimate of population size from egg and larva survey data indicates a spawning population of about 350,000 tons in the CalCOFI area. Another estimate places the total eastern Pacific population at 2.1 to 4.8 million tons.

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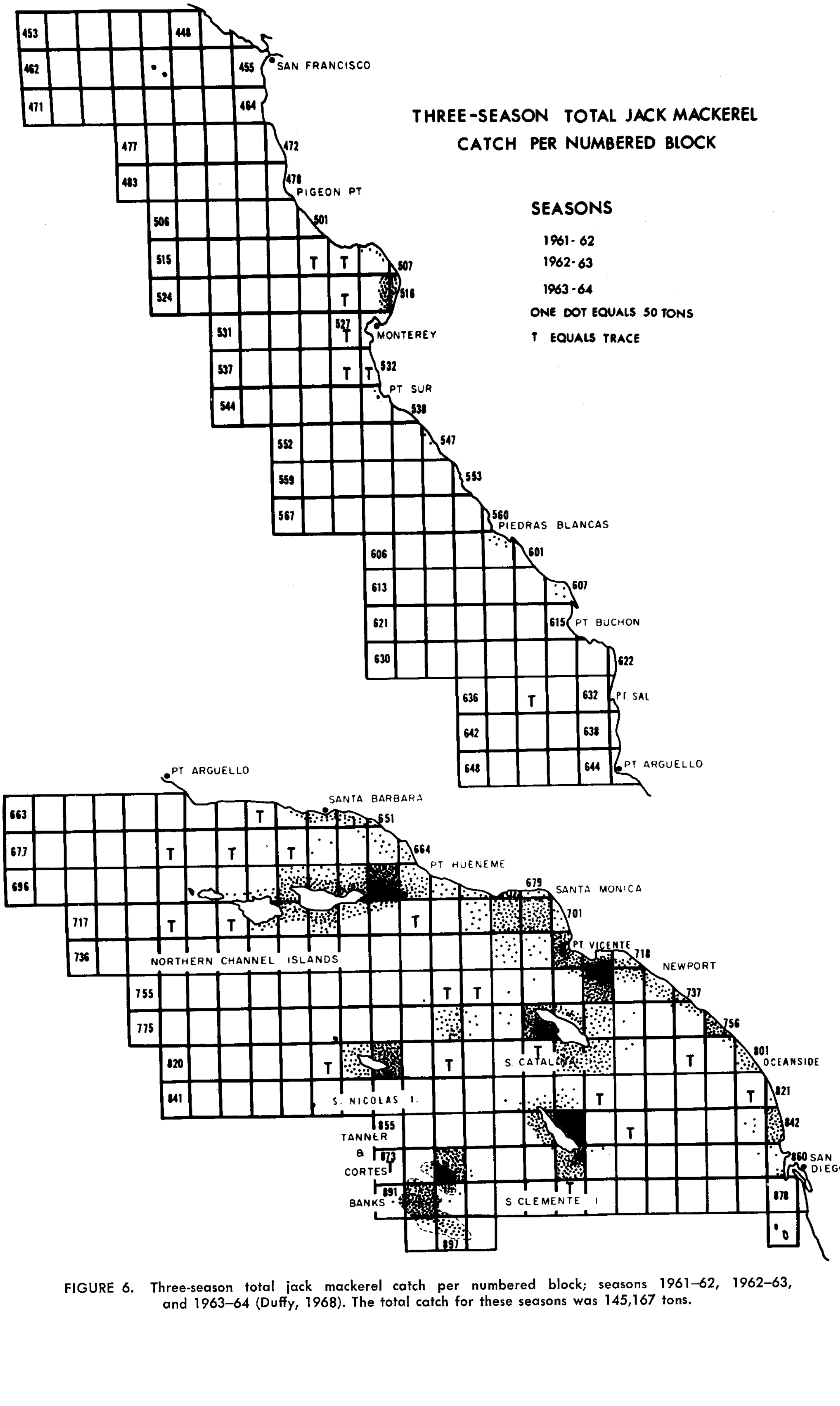

FIGURE 6. Three-season total jack mackerel catch per numbered block; seasons 1961–62, 1962–63, and 1963–64 (Duffy, 1968). The total catch for these seasons was 145,167 tons.

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Calif. Mar. Res. Comm., CalCOFI Rept., 13: 53–59, 1969

BOTTOMFISH RESOURCES OF THE CALIFORNIA CURRENT SYSTEM

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INTRODUCTION

Bottomfish resources as included in this report are the marine species of flatfish, roundfish, and shellfish traditionally caught in gear on or near the ocean bottom and used fresh or frozen. The principal species are soles, flounders, rockfishes, crabs, oysters, abalones, and shrimp (Table 1). Species of lesser commercial importance are lingcod, sablefish, and Pacific hake. Utilization of California's bottomfish resources occurs mainly off the central and northern coast.

In terms of pounds and dollars, the several bottomfish resources of California are being harvested to a yield of 67 million pounds and contribute approximately 24 million dollars to the economy of the State. Of this, more than half, 41 million pounds and about 14 million dollars, is from fin fisheries. The remainder, 26 million pounds and 10 million dollars is from shellfisheries.

The status of our knowledge of the bottomfish resources is very complete from the standpoint of total landings and time of harvest. From trawler logs we get very accurate records of location of catch and effort expended. However, for other fishing, information on harvest becomes progressively less detailed in regard to location of catch and effort expended. We know, for example how many pounds of crab were taken, but we cannot give location of gear more accurately than groups of Fish and Game blocks (30 x 60 miles) or say what the effort was more precisely than pounds per boat landing.

The status of our knowledge of facets of life history and population dynamics varies from very precise age growth relationships of the better known flatfish to statistical confusion for age composition of species of some areas.

The reasons for the wide gaps in our knowledge are not of ineptness and lack of interest on the part of researchers. They are of lack of application in terms of manpower and facilities for the job at which we only piddle here and there. What we know is valuable and is used for management recommendations. What we have not studied or have only begun to study is awesome in magnitude and is of great importance for progress in management.

TABLE 1
COMMON AND SCIENTIFIC NAMES

Common Name	Scientific Name
FISHES	
Bocaccio	*Sebastodes paucispinis*
Chilipepper	*Sebastodes goodei*
Flounder, arrowtooth	*Atheresthes stomias*
Flounder, starry	*Platichthys stellatus*
Halibut, California	*Paralichthys californicus*
Hake, Pacific	*Merluccius productus*
Lingcod	*Ophiodon elongatus*
Rockfish, canary	*Sebastodes pinninger*
Rockfish, shortspine channel	*Sebastodes alascanus*
Sablefish	*Anoplopoma fimbria*
Sole, Dover	*Microstomus pacificus*
Sole, English	*Parophrys vetulus*
Sole, petrale	*Eopsetta jordani*
Sole, rex	*Glyptocephalus zachirus*
CRUSTACEANS	
Crab, market	*Cancer magister*
Lobster, California spiny	*Panulirus interruptus*
Shrimp, ocean	*Pandalus jordani*
MOLLUSKS	
Abalone, pink	*Haliotis corrugata*
Abalone, red	*Haliotis rufescens*
Oyster, giant Pacific	*Crassostrea gigas*

FIN FISHERIES

The California trawl fleet fishes along the coast from southern California into waters off southern Oregon. (Figures 1, 2, 3 and 4) In northern and central California the trawling grounds extend from the three-mile limit to offshore depths of over 400 fathoms (372) m). Flatfish and roundfish are caught throughout this area but gear selectivity, fish abundance and distribution, bottom characteristics, and market demand for definite species influence the selection of fishing areas by trawler captains. The fish in greatest demand are Dover, English and petrale sole; and canary and shortspine channel rockfish. Southern California trawl grounds extend from three miles offshore to depths of about 200 fathoms (366 m). The fishing emphasis in this area is mainly for petrale and English sole; bocaccio and chilipepper rockfish; and animal food. Little effort is expended in deeper water for Dover sole.

The California trawl fleet landed 35.2 million pounds of bottomfish in 1966. This catch was 1 percent greater than the 34.8 million pounds of 1965 and 2 percent more than the 10-year average of 34.5 million.

Fishing effort of 54,098 trawling hours in 1966 exceeded by 3 percent the 1959–1965 mean annual effort of 52,598 hours. The size of the vessels, and the nets, cables, and winches with which they are equipped

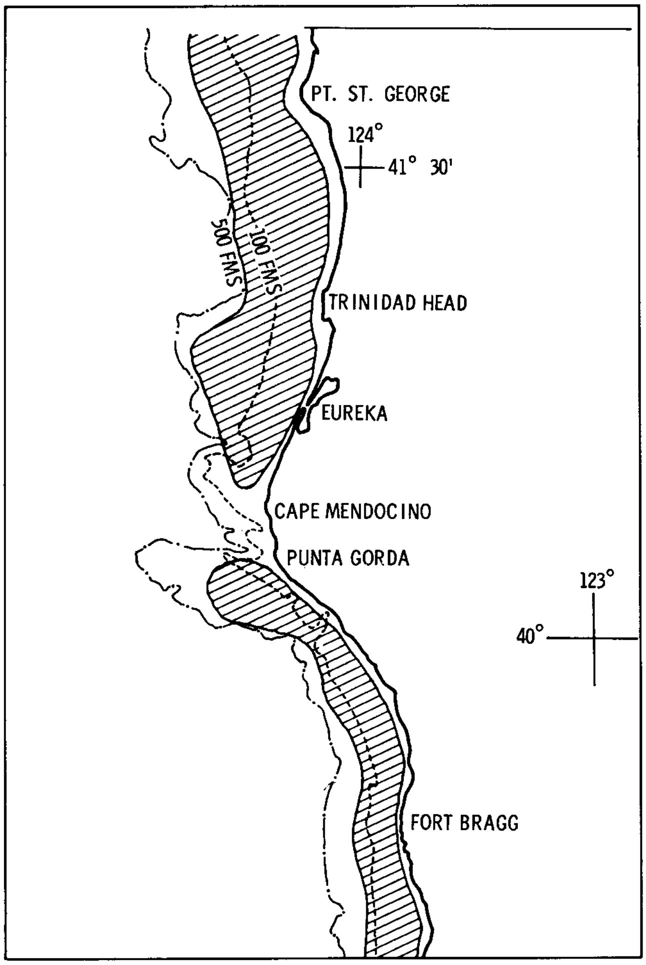

FIGURE 1. Northern California trawling grounds.

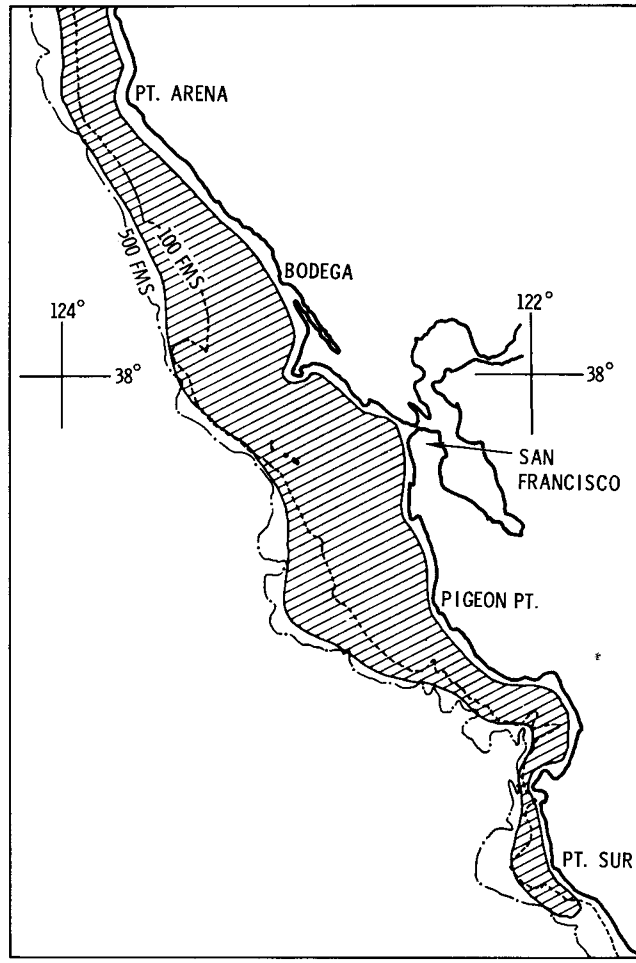

FIGURE 2. Central California trawling grounds.

limits fishing operations to waters of 500 fathoms (915 m) or less.

In 1966 there were slight decreases in catches of English sole, Dover sole, and lingcod, while petrale sole and rockfish landings increased 10 and 11 percent, respectively over 1965 totals (Table 2). Favorable marketing conditions prevailed throughout both years.

Flatfish

The annual harvest of the soles and flounders, has been about 25 million pounds during the past ten years (Table 2).

In 1967, market demand for flatfish declined and catch limits were imposed by dealers. Landings this year were also affected by price negotiations which caused a fleet tie-up in April. Nevertheless, preliminary data for the year show only a six percent decrease from comparable 1966 data. The market limits affected Dover sole more than other species and a 41 percent decline of 1.7 million pounds from that of 1966 occurred. However, increases in landings of English sole and petrale sole nearly offset the decline in the Dover sole catch. The increase in catch of these species was a consequence of severe Dover sole limits since trawl effort was diverted from deep water to inshore areas. Total 1967 landings of flatfish are expected to be slightly less than the 25.2 million pound catch of 1966.

The kinds of fluctuations in landings of flatfish species described for 1967 exemplify the conditions which have prevailed in the fishery for many years. The prospects for an enlarged fishery with greater production exist. However, the impetus for information needed on extent, distribution, and renewable capabilities of the flatfish populations is only now becoming acute because of greater interest in sources of protein from the sea and the exploitation of marine resources by foreign fleets off our coast. If increased demands for fish occur, the fleet will modernize and become capable of harvesting from more distant and deep grounds.

Dover sole stocks can support more utilization, particularly on the deeper trawlable grounds off central and southern California. Five million pounds of English sole can be taken with little added effort. Increased trawling off our southern coast would do the most for more adequate use of this species. Petrale sole are rather fully utilized. Expansion of fishing grounds will be necessary to raise production above

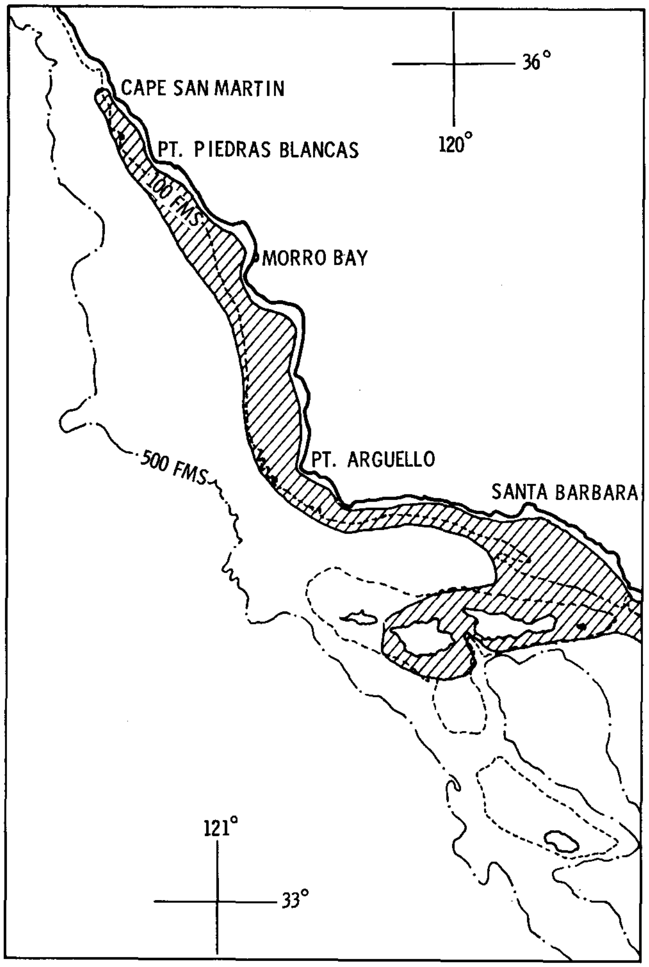

FIGURE 3. Southern California trawling grounds, northern portion.

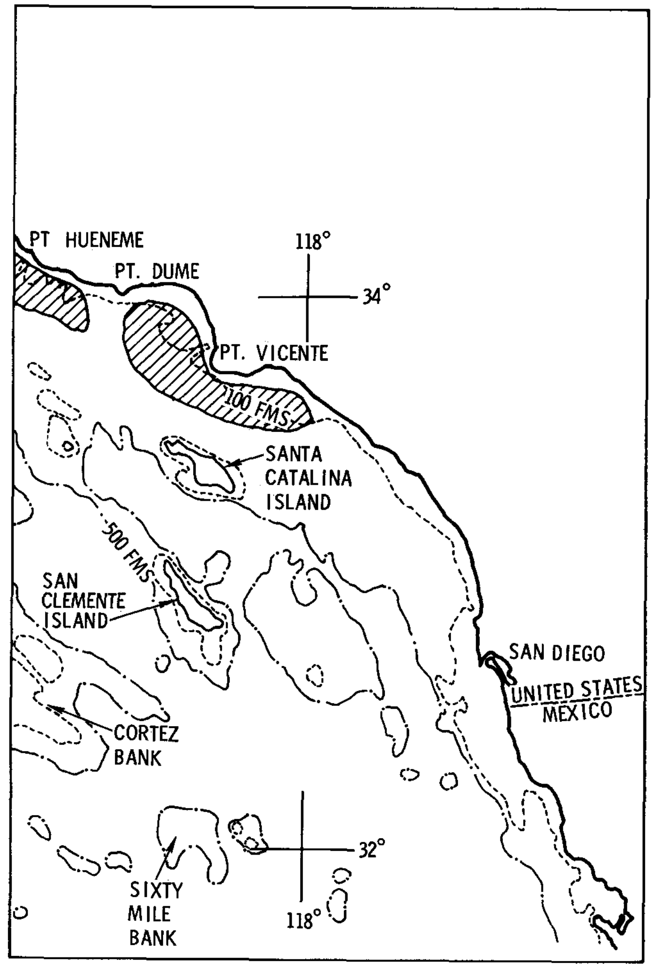

FIGURE 4. Southern California trawling grounds, southern portion.

TABLE 2
CALIFORNIA TRAWL LANDINGS
1956–1966
(Thousands of Pounds)

Species	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
English Sole	4,820	5,150	4,618	2,376	3,646	4,209	4,254	4,594	4,893	4,841
Rock Sole	1	1	--	3	1	--	1	2	--	--
Petrale Sole	3,454	3,155	2,632	2,475	3,391	3,038	3,317	2,699	2,659	2,925
Dover Sole	7,932	8,053	7,327	9,185	7,826	8,851	9,780	9,267	10,760	10,301
Rex Sole	1,234	1,423	1,443	1,107	1,209	1,408	1,565	1,409	1,491	1,635
Starry Flounder	500	466	1,043	248	296	298	461	370	324	284
Other Flatfish	1,856	1,214	1,657	1,908	934	1,160	1,312	1,384	1,224	1,319
Lingcod	1,239	1,358	1,153	1,099	1,163	819	857	673	618	586
Sablefish	1,268	1,415	1,703	2,133	1,340	1,690	1,660	1,618	1,880	2,077
Rockfish	14,280	14,632	12,240	11,732	8,912	7,757	9,807	6,785	7,673	8,499
Misc. Species	1,529	1,536	1,415	618	329	356	491	437	405	342
Animal Food	--	--	--	--	3,777	1,879	1,034	1,738	2,875	2,375
TOTAL	38,113	38,403	35,231	32,884	32,824	31,465	34,539	30,976	34,802	35,184

4 million pounds. Other flatfish such as rex sole, California halibut, sanddab, and starry flounder contribute a minor amount to the total landings but would yield more as effort for other species increased.

Roundfish

Prior to World War II rockfish landings had fluctuated between 2 and 8 million pounds in response to market demands. Stimulated by the World War II demand for sea food, landings increased to 13 million pounds in 1945. Following a post-war slump, total annual landings by trawl and longline gear increased to an all-time high of 18 million pounds in 1958. Since then the landings have dropped and are now at about 10 million pounds per year (Table 3).

TABLE 3

ANNUAL ROCKFISH LANDINGS, CALIFORNIA 1957–1966

Year	Pounds			
	Northern*	Central*	Southern*	Total
1957	3,794,601	8,289,084	4,007,594	16,091,279
1958	3,814,268	10,052,104	3,975,791	17,842,163
1959	3,333,682	9,620,352	2,327,248	15,281,282
1960	3,193,668	6,853,642	3,666,576	13,713,886
1961	2,117,410	5,449,776	3,263,576	10,830,762
1962	1,993,213	4,844,064	2,997,116	9,834,393
1963	3,373,251	4,825,308	3,550,901	11,749,460
1964	1,885,160	3,925,178	2,307,574	8,117,912
1965	2,524,174	4,194,621	2,673,629	9,392,424
1966	1,912,261	4,994,068	3,151,948	10,058,277

* Northern—from Oregon border south to Sonoma County.
* Central—includes Sonoma County south to San Luis Obispo County.
* Southern—includes San Luis Obispo County south to Mexican border.

The balloon trawl net, introduced in northern California in 1943, was the principal gear used for the highest landings. In previous years set longlines were the primary gear for rockfish. Catches by trawlers were incidental to flatfish. Longline fishing now accounts for about 15 percent of the commercial rockfish take. The most productive longline areas are at about 100 fathoms (183 m) between Pt. St. George and Trinidad Head, just south of Punta Gorda, off Fort Bragg, and from Pigeon Pt. to Pt. Sur. South of Santa Barbara county, possession of trawl nets in State waters was prohibited from 1925 to 1966. Therefore, setlines have been the primary gear for taking rockfish off southern California. The line fishing for rockfish has been about the islands of San Miguel, Santa Rosa, San Nicolas; on Cortez Bank, Sixty Mile Bank, and off San Diego. The use of trawl gear off the southern coast can result in an increase in landings, but the trawlable grounds are not extensive.

Increased effort in response to a greater market demand would result in a considerably greater harvest from all areas, and in all probability a sustained annual yield of 15 to 20 million pounds could be realized.

Better catches might also be made by adding large rollers on the lead line of nets to permit trawling over rough bottom, or by the use of large mid-water trawls not far off the bottom.

Because a large portion of the catch is listed by dealers simply as rockfish, we were prompted to sample for species composition of rockfish landed by trawlers at important California ports for the years 1962–1963. At ports from Santa Barbara to Fort Bragg, bocaccio and chilipepper are the most important rockfish, while at Eureka, canary rockfish and the shortspine channel rockfish are dominant. Statewide, bocaccio account for 44 percent of the rockfish landings. Chilipepper is second at 18 percent, and canary and shortspine channel rockfish follow at 11 and 6 percent respectively.

Sablefish. The peak in sablefish landings of over 6 million pounds occurred in 1945 concurrent with World War II demand for fisheries products and the use of fish livers for the production of vitamin A. Annual landings of recent years have averaged slightly more than 2 million pounds. However, landings have displayed an upward trend since the early sixties. Eureka, San Francisco, and Monterey are the main ports of landings which by 1960 were more from trawlers than longliners. Sablefish landings for 1966 totaled 3,215,939 pounds. This moderately harvested resource could withstand additional harvesting at a much higher level—at least 4 to 5 million pounds more each year.

Lingcod. Lingcod are caught with handlines and longlines as well as coincidental with sole and rockfish in trawl operations. The majority of landings are by trawl vessels which, since 1958, have accounted for nearly 80 percent of the landings. Lingcod occur at depths over 100 fathoms (183 m) but most are taken at about 60 fathoms (110 m). They occur along the entire coast but are more abundant off central and northern California.

Landings have fluctuated between 314,334 pounds in 1942 to over 2 million pounds in 1948. In recent years landings have displayed a declining trend with 797,710 pounds recorded for 1966. Since lingcod are incidental to catches of other trawl-caught fish and the number of longline boats has declined, the landing fluctuations do not express the condition of the resource. We believe the lingcod resource could withstand additional fishing pressure to yield 3 million pounds per year without adverse consequences.

Animal Food Fisheries

Since the inception of the animal food fishery in 1953, landings for this use have fluctuated between 932,000 and 4,007,000 pounds. Following the peak catch in 1960, landings dipped to 1 million pounds in 1963 because of price negotiations and the shift by the industry to other sources of raw material. In recent years landings have risen to nearly 3 million pounds.

Fish landed as animal food are generally the unmarketable portion of trawl catches which were formerly discarded at sea. These are principally small-size species and those species least desired by the fresh fish markets. Some of the small desirable market species, such as English sole, Dover sole, and sanddabs occur in landings for animal food, but they are not sought for this purpose. Sablefish, hake, arrowtooth flounder, and many small rockfish species occur in the landings (Table 4). At northern ports small sablefish predominate while hake become more numerous in landings to the south. In general there is a potential for enlargement of the fishery for animal food.

TABLE 4

COMPOSITION OF ANIMAL FOOD LANDINGS BY PERCENT

Species	1964	1965	1966
Sablefish	44.8	40.0	42.6
Pacific hake	15.9	25.5	10.3
Arrowtooth flounder	12.2	13.1	10.8
Rockfish	12.6	8.8	15.0
Dover sole	5.3	4.6	5.3
English sole	4.2	5.0	5.8
Other species	5.0	3.0	10.2

SHELLFISHERIES

Of the approximately 26 million pounds of shellfish landed in California annually the crab resource yields an average of 11 million pounds worth $1.7 million to fishermen (Table 5), while abalone bring $500 thousand to commercial fishermen for 4 million pounds. Shellfish culture provides 8 million pounds of oysters and about $300 thousand to the growers. Ocean shrimp and prawn yield 2 million pounds for which fishermen receive approximately $200 thousand each year, while the lobster fishery contributes 600 thousand pounds and $390 thousand. In addition, more than a million pounds of abalone, clams, and crabs are taken annually by sportsmen.

TABLE 5

AVERAGE ANNUAL SHELLFISH HARVEST

Resource	Weight in Pounds	Value to Fishermen
Abalone	4,000,000	$500,000
Crab	11,000,000	1,700,000
Lobster	600,000	390,000
Oyster	8,000,000	300,000
Shrimp	2,000,000	200,000
	25,600,000	$3,090,000

Expanded to represent their total contribution to the economy of the state, the nearly 26 million pounds landed are worth $16 million per year.

Crab

The fishery for the market crab in California is unique in that it is based on the harvest of one sex predominantly of one year class. Only male crabs with carapace width of $6\frac{1}{4}$ inches (15.875 cm) and greater are taken. Through the crab ranges the entire length of the California coast, its commercial abundance is from Morro Bay north over relatively shallow sandy areas, 75 fathoms (137 m) and less. The San Francisco-Bodega and the Eureka-Pt. St. George areas are the main crabbing grounds. The north coast leads in production with a long-term average of 7.4 million pounds, while the central coast fishery averages 3.1 million. Both areas have experienced wide fluctuations: 0.8 to 12.4 million pounds for north coast ports and 0.39 to 8.9 million pounds for central California (Table 6). Because the fishery is dependent on crabs predominantly $3\frac{1}{2}$ to 4 years of age, the fluctuations reflect year class abundance on the traditional crab grounds. We believe at least 90 percent of the legal sized portion of the resource is harvested each season. Our population estimates, based on pre-season random sampling, have been rather accurate. The reasons for the record low harvest (390 thousand lbs.) for the San Francisco area during the 1966–67 season are not known. However, we feel that the continually increasing fishing pressure has not been the cause. Variations in near shore ocean conditions are thought to be the most likely causes affecting larval survival and distribution. Data from our most recent research cruises reveal that a moderately strong year class will support a 2 million pound harvest from central California during the 1967–1968 season. A very abundant year class in the separate population off the north coast is expected to yield an all time high of 13 million pounds. The efficiency of the crabbing fleet and its coverage of the crabbing grounds and our post-season survey indicates the resource is completely utilized.

TABLE 6

CALIFORNIA MARKET CRAB LANDINGS IN THOUSANDS OF POUNDS 1956 to 1967

Season	Northern California	San Francisco	Monterey and Morro Bay
1956-57	9,980	8,919	380
1957-58	9,610	7,391	286
1958-59	12,378	5,014	394
1959-60	10,727	4,783	344
1960-61	10,043	2,255	99
1961-62	3,251	710	25
1962-63	900	1,331	11
1963-64	808	1,158	12
1964-65	3,979	760	10
1965-66	9,933	441	9
1966-67	10,200	390	10
	$\bar{x}$ = 7,437	$\bar{x}$ = 3,014	$\bar{x}$ = 144

Shrimp

Ocean shrimp were first determined to be present in beds off the California coast and in potential commercial abundance during research cruises of the *N. B. SCOFIELD* in 1950 and 1951. All these concentrations of shrimp have been on green mud bottoms at depths ranging from 40 to 120 fathoms (73 to 220 m).

Utilization of the shrimp began in 1952, landings increased and, in 1956 over one million pounds were harvested. The take of shrimp has been regulated to prevent a "boom and bust" fishery. The total landings each season relate closely to the quota set. The landings have been mainly from the largest bed off northern California—from Eureka to Brookings, Oregon. Last year this bed yielded 1.4 million pounds. The other beds are just north of Fort Bragg, off Bodega, and just south of Avila. The fishery has, during several seasons, landed slightly over 2 million pounds. We have reason to believe there will not be greater landings because the species is short-lived, the beds are small, very high natural mortalities occur, and fishing pressure is high. The two southernmost beds fluctuate widely in size from year to year, so much in fact that some years fishermen have not fished them. The highest take from these beds has been about 450 thousand pounds.

Lobster

Since the turn of the century, the California spiny lobster has been an important segment of the fresh fish catch. Total landings from California waters have varied from less than 200 thousand pounds in 1916 to over 900 thousand pounds in 1950. Since that time, landings have declined and the catch has stabilized at about 600 thousand pounds despite ever-increasing demands for lobsters, and both sport and commercial fishermen striving to increase their take.

The species, recorded from Monterey to Magdalena Bay, Baja California, is fished in California along the mainland from Point Conception south, around the offshore islands, and on some of the offshore banks. Deep water, separating these various areas, may act as a barrier to free intermixing of population segments.

Tagging studies and extensive surveys could delimit the populations and the extent of intermixing. If subpopulations exist, management of the resource must proceed on an area basis, not a range-wide basis.

Recognizing the need for information about spiny lobsters on which a sound management program can be based and in response to a Senate Resolution, we have proposed that shellfish studies be augmented to increase knowledge about the spiny lobster: its population size, life history, movements, and general ecology.

Oyster

Oyster production by several companies occurs in Humbolt, Tomales, Drakes, and Morro Bays with the greatest yield from Humboldt Bay. This culture is not meeting the market demand, but improved culture methods and use of more acres of bay waters could increase the yield manifold. The giant Pacific oysterm from Japan is the principal species grown. Oyster production in California is based on seed and shell stock planted, cultured, and harvested by several oyster growers. There have been wide fluctuations over the years due to commercial interest and effects of wars. However, at no time has the market demand been met. In 1951 and 1952 rebirth of the industry occurred and landings rose from a few hundred thousand pounds to 13.8 million in 1959. Shortages of seed in Japan in recent years resulted in a drop in California's production. The harvest is at about 8 million pounds. The area yielding the greatest portion of the harvest is Humboldt Bay. The east coast oyster and clams as well as scallops from Japan and oysters from Europe have yielded very encouraging results in hatching and culturing experiments. The use of hanging culture is being adopted by several California growers. This method providing additional production from areas too deep for conventional culture on tidal flats is now being used on a commercial scale in Humboldt and Drakes Bays.

During the past several years, there have been increasing reports of significant oyster mortalities on the Pacific Coast due to unknown causes. Heaviest mortalities have occurred in fast-growing Pacific oysters in areas where industrial pollution appears unlikely. Since no common causative factor is apparent, it is generally believed some disease or toxins are responsible. Our pathologists and our men monitoring pesticides in estuaries are investigating these problems to gain information to assure greater returns from shellfish culture.

Recent laboratory advances in marine biology have enabled biologists to hatch and raise marine shellfish larvae in the laboratory. Further research on the development of mass culture methods of clams, oysters, abalone shrimp, scallops, and crabs may open avenues to increase both the potential for food production and the recreational uses of California's coastal areas. Techniques developed and demonstrated in the Fish and Game Marine Culture Laboratory to be established at Pacific Grove may instill industry with sufficient confidence to utilize additional areas where natural larval set is poor.

Abalone

Abalone are intensively harvested from coastal waters from the Cambria area south and about the offshore islands. The red abalone is the principal species north of Point Conception and the pink abalone dominates the take from the Channel Islands and the southern coast of California. The long term average annual abalone harvest of 4 million pounds has been exceeded during the last few years (Table 7).

TABLE 7

CALIFORNIA ABALONE HARVEST IN THOUSANDS OF POUNDS 1964–1966

Species	1964	1965	1966
Red	2,370	2,491	2,656
Pink	1,612	2,071	2,163
Green	97	15	144
Total	4,079	4,577	4,963

The major fluctuations in abalone landings occurred in conjunction with World War II and again after the warm water years of 1957–1959 when kelp beds were reduced and pink abalone, because of food shortage, did not grow to legal size. Though both the red (in 1936) and pink (in 1952) resources have yielded high annual harvests of about 4 million pounds each; we do not believe a total harvest of 8 million pounds will occur; six million would more likely be the highest to be realized on a sustained basis.

SUMMARY

Bottomfish resources of California are species of flatfish, roundfish, and shellfish traditionally caught by gear on or near the ocean bottom. The principal species taken are soles, flounders, rockfishes, crabs, shrimp, abalone, and oysters. These resources are being harvested to a yield of over 60 million pounds per year. Of this, more than half is of fin fish; the remainder, from the shellfish resources.

The status of our knowledge about landings and areas of harvest is much more complete than our storehouse of data on life history and biological relationships pertaining to the organisms available for harvest.

The state of development of gear and size and power of the vessels engaged in harvesting bottomfish resources limits operations to 500 fathoms, and less. Living resources are available for harvest at greater depths, but it will not be until greater economic pressures occur that larger, better equipped vessels with greater harvesting capacities will take part in an American fishery beyond depths of 500 fathoms (915m) where flatfish and rockfish are the most available and desired species.

I believe that exploratory fishing and gear development can result in an increase in landings of offshore fishes while more efficient harvesting and application of new culture techniques can yield more from shellfisheries.

Calif. Mar. Res. Comm., CalCOFI Rept., 13: 60–62, 1969

PELAGIC INVERTEBRATE RESOURCES OF THE CALIFORNIA CURRENT

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I have been asked to discuss the pelagic invertebrate resources of the California Current, and this I will try to do, but I wish first of all to make one reservation: it is evident to me that none of these resources will have anything like the same economic importance as our potential pelagic fish resources, and if we cannot decide how to utilize these latter, then I'm not sure we should divert too much attention away from the problems of their utilization onto the problems of less important resources.

There appear to be three main possibilities in exploiting the pelagic invertebrates but I shall discuss only two of these: (i) that of expanding our small fishery for cephalopod molluscs, and (ii) that of starting a fishery for pelagic galatheid crabs, commonly called "red crabs." Discussion of the third possibility —that of utilizing planktonic copepods and euphausiids—I consider only an academic exercise at the moment, and even though mass occurrences of these sorts of animals are frequent in the California Current, I shall leave it to the future for their proper discussion.

Very much of what we know about the economically important cephalopods in the California Current derives from the work of Fields (1965), who studied the squid *(Loligo opalescens)* fishery, principally at Monterey. To see if there was any probability that this fishery could be expanded, it seemed to me appropriate to try to place it in a world-wide perspective; for this purpose I have surveyed summarily the literature, with the results that are set out in Tables 1 through 4.

These show, first of all, that while almost all nations which have any fishery at all catch at least a small amount of cephalopods, it is only Japan for which this forms a significant part of the total catch. It is also evident that cephalopods are more important in certain regions than in others: in the Mediterranean basin and adjoining parts of the Atlantic and in the Far East they are widely eaten; in the North Atlantic, the Scandinavians take significant amounts for use as bait in other fisheries. The migration of Far Eastern and Mediterranean peoples to other parts of the world has stimulated the establishment of cephalopod fisheries in places such as California.

Table 2 indicates some of the major features of the international trade in cephalopods; what is important is that a complicated trade network exists in the Far East, and that catches of Japanese vessels are purchased by some Mediterranean countries.

Table 3 shows that California even now dominates the U.S. catches; the Californian fishery, as Fields showed, originated in the Chinese fishing village in Monterey in about 1860, from which sun-dried squid entered the Far East trade. In about 1900 Italian fishermen introduced the lampara net into the fishery and took it over from the fishermen of Oriental origin. A peak was reached in 1932 with 5,500 tons of dried squid going into the Far East trade, which was closed to the U.S. in 1933. A second buildup occurred after World War II with the introduction of freezing and canning to the trade, but irregular, large-scale fluctuations of the fishery have been characteristic since then.

Table 4 surveys briefly the major squid resources of the world as they presently appear. The bulk of the Japanese landings is formed by *Todarodes pacificus;*

TABLE 1

THE APPROXIMATE WORLD LANDINGS OF CEPHALOPODS IN 1965, DERIVED FROM VARIOUS SOURCES, MAINLY FAO STATISTICS FOR THIS YEAR

Country	1965 catches (Thousand Tons)	
	Squids (*Ommastrephes, Loligo,* etc.)	Cuttlefish (*Sepia,* etc.)
Japan	472.5	26.9
Spain	19.1	17.2
Taiwan	8.8	5.4
Norway	8.5	--
United States (Pacific)	8.4	--
Canada (Atlantic)	8.3	--
Italy	6.6	12.6
France	3.9	--
Portugal	2.5	2.6
United States (Atlantic)	1.1	--
Hong Kong	1.0	0.4
Argentina	0.7	--
Peru	0.3	--
Ryukyu Islands	0.3	--
Venezuela	0.3	--
Iceland	0.2	--
Mexico	0.2	--
Yugoslavia	0.2	0.1
Australia	0.1	--
Belgium	0.1	--
Chile	0.1	--
England	0.1	--
Scotland	0.1	--
South Africa	0.1	--
Holland	<0.1	--
Korea	<0.1	--
Malaya	<0.1	1.2
Morocco	<0.1	1.0
St. Pierre	<0.1	--
Uruguay	<0.1	--
Wales	<0.1	--
Total	544.2	67.4
Grand total	----	611.6

TABLE 2

SOME IMPORTANT SECTIONS OF THE WORLD TRADE IN CEPHALOPODS, DERIVED FROM FAO STATISTICS AND FROM CLARKE, 1966

Product and country		Tons of cephalopods in thousands (excluding octopus)
	Dried, etc.	
Hong Kong →	Malaya	0.7
	Thailand	0.4
	Others	2.3
Japan →	Taiwan	0.1
	Hong Kong	0.1
	Singapore	0.1
S. Korea →	Taiwan	1.1
	Hong Kong	0.2
	Japan	4.2
	Singapore	0.5
	Thailand	0.3
	Others	0.5
	Total	10.5
	Fresh, frozen	
Japan →	Italy	6.9
	Portugal	2.1
	Others	1.3
	Total	10.3
	Total all products	20.8

TABLE 3

THE U.S. ACTIVITIES IN SQUID FISHERIES FOR 1965, BASED MAINLY ON STATISTICS COMPILED BY BUREAU OF COMMERCIAL FISHERIES

	Thousand Pounds
U.S. Landings (by areas)	
New England	840
Middle Atlantic	1,427
Chesapeake	255
South Atlantic	35
Gulf	54
Pacific	18,620
Hawaii	3
U.S. products	
Frozen, natural	5,963
Canned	12,419
U.S. Exports	
Frozen	--
Canned	4,510

TABLE 3 B

CALIFORNIA

Ports	No. of vessels	Thousand Pounds		Thousand Dollars
		lampara net	dipnet	
Monterey	14	8.8	0.1	202
Santa Barbara	6	1.9	0.1	18
San Pedro	35	7.4	0.3	86
Total	55	18.7		306

TABLE 4

THE SQUIDS THAT APPEAR MOST LIKELY TO BE OF COMMERCIAL IMPORTANCE IN THE WORLD FISHERIES, BASED VERY LARGELY ON DATA FROM CLARKE, 1966

Species	Range	Fishery
Todarodes pacificus	N. W. Pacific	Bulk of Japanese landings from N. Pacific.
T. sagittatus	Atlantic	Lightly utilized, largely for bait but some for human food.
Ommastrephes caroli and *O. pteropus*	Sub-tropical Atlantic	Some fished at Atlantic islands; latent oceanic fishery.
Illex illecebrosus	Atlantic	Bait fishery on Grand Banks and elsewhere.
Nototodarus gouldi	S. W. Pacific	Increasing but low utilization in Australia (Mediterranean immigrants).
Symplectoteuthis spp.	W. Indo-Pacific	Latent oceanic resource.
Dosidicus gigas	E. Pacific	Latent oceanic resource.
Loligo opalescens	California	Lightly utilized in coastal fishery.
Gonatus fabricius	California	Latent neritic resource.

the Atlantic counterpart, *T. sagittatus* is utilized largely for bait, and, though enormously abundant, has been said to be of poor flavor. *Illex illecebrosus* supports a large-scale bait fishery to the south of Newfoundland. The two species of *Ommastrephes* listed are extremely abundant in warmer parts of the Atlantic (e.g. at Madeira) and there form an important latent resource. Latent resources in the warmer parts of the eastern Pacific Ocean appear to be dominated by *Dosidicus gigas* which is at times very numerous in the offshore parts of the California Current and was, in fact utilized on one occasion in the 1930's by the California fishery (Clark and Phillips, 1936). This species appears to be the eastern Pacific counterpart, ecologically, of various species of *Ommastrephes* and *Symplectoteuthis*, and appears near the surface at night in oceanic regions, sometimes in vast numbers. The more neritic *Gonatus fabricius* may also form a latent resource in the California Current.

It is also quite evident that the population of *Loligo opalescens* could be fished to a far greater extent than it is at present; few of the many known regular spawning concentrations are utilized. If entry into new markets, or expansion of present markets, could be achieved, there is no doubt whatever that the latent resources of the California Current could be harvested at a much higher level of yield.

In general, cephalopod fisheries are prosecuted either by some form of multi-hook jig (hand or machine operated) or by various forms of round-haul nets; in both methods, night fishing, with concentration of squids by light, is normal. Such methods are well known and easily used by the California fishing community.

Let us turn now to the red or pelagic crabs, *Pleuroncodes planipes* of the California Current, where we are on less firm ground concerning the utility of the resources.

About five species of galatheids occur in massive concentrations, either as pelagic or benthic individuals, and one of these is our *Pleuroncodes planipes*. These forms are all typical of eutrophic regions of the ocean, where they often occur under conditions of very low dissolved oxygen. They are able to graze directly on blooms of phytoplankton, mainly large diatoms, and wherever they occur they figure largely in the diet of a wide range of large predators, from sea-birds to whales.

Off Chile, two of these species are harvested as an auxiliary catch by the shrimp boats when shrimp are not available; these species are *Pleuroncodes monodon* and *Cervimunida johni*, together known to the Chilean trade as "langostino." Starting in 1953 the langostino fishery has developed to its present level of landings in excess of 12 thousand tons per annum (Table 5).

TABLE 5

THE DEVELOPMENT OF THE CHILEAN LANGOSTINO FISHERY, BASED ON DATA SUPPLIED BY FAO, ROME (DONALD A. HANCOCK AND M. N. MISTAKIDIS, PERSONAL COMMUNICATION)

Year	Thousand Tons			
	Total catch	Consumed fresh	Canned	Frozen tails
1953	0.93	0.29	0.59	0.47
1954	2.64	0.85	1.20	0.58
1955	2.05	0.78	1.10	--
1956	5.71	1.61	3.57	--
1957	11.38	4.27	0.73	5.82
1958	12.83	5.37	0.22	6.33
1959	6.75	0.93	0.80	5.02
1960	8.12	1.22	0.83	6.02
1961	8.15	0.62	0.65	6.89
1962	7.99	0.36	0.94	6.69
1963	9.25	0.20	0.94	7.91
1964	10.67	0.68	0.94	9.03
1965	15.35	0.44	1.02	13.31
1966	13.37	0.39	0.78	12.18

What is striking about this fishery is that the crabs on which it is based are quite small, averaging a carapace length of 0.79–1.57 inches (20–40 mm) and a total net weight of 0.88 ounces (25 grams). The meat yield for tails is less than 10 percent. One wonders how such a fishery can be economic, but it evidently is, perhaps due to rather low labor costs.

Our California *Pleuroncodes planipes* differs from those species exploited off Chile in having both a benthic and pelagic phase instead of merely a benthic phase, and occurs in both phases in massive numbers. It has been shown (Longhurst, 1967) that the pelagic concentrations occur close to upwelling sites, and that their distribution is very sensitive to climatic variations and mass transport variations in the California Current.

The mean density of pelagic crabs in the southern part of the CalCOFI area in a normal year has been measured by Maurice Blackburn (personal communication) from a series of 5-foot net tows taken at standard CalCOFI stations. Extrapolated to a floating otter trawl with 326 ft^2 (30-m^2) mouth (a reasonable size for a small vessel) fished entirely randomly in this area, we get an estimate of about 0.25 ton per hour. Anybody who has observed *Pleuroncodes* swarms at sea knows how massive these are relative to the "background" densities of the animal, and it is obvious that selective fishing would raise this estimate by a factor of at least 10.

Pelagic *Pleuroncodes* are smaller than the langostinos exploited in Chile, so it is probable that a fishery would concentrate on the benthic phase, whose individuals are larger and are equivalent to those taken in the Chilean fishery. These benthic individuals occur in massive concentrations, mainly under upwelling areas and at depths corresponding to the depth of the oxygen minimum (Boyd, 1967).

The small amount of information which we have at hand suggests extremely high catch rates of the order of more than 25 tons per hour with a 10-m headrope (32.8 ft) demersal otter trawl. In fact, during a trawling survey for rockfish carried out a few years ago by the Bureau of Commercial Fisheries, it was found to be impracticable to trawl for fish at depths which benthic *Pleuroncodes* favored, because the net filled so rapidly and was torn by the weight of crabs (Herbert Perkins, personal communication). This supposition is also confirmed by the very recent reports from the Soviet factory trawlers, which took 5,000 tons of *Pleuroncodes* in an experimental fishery in 1967 off Baja California. It is presumed that these were reduced but we do not know for certain.

It appears quite evident, then, that there is a very large latent resource present, but it is much less clear what use can be made of it. If a satisfactory meal can be manufactured—perhaps of a specialty type, as for instance, an additive to trout food to give desirable flesh coloration and flavor—then it is probable that a fishery of local importance could be developed.

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HISTORY OF FISH POPULATIONS INFERRED FROM FISH SCALES IN ANAEROBIC SEDIMENTS OFF CALIFORNIA

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INTRODUCTION

Over the years the remains of many marine organisms along with land-derived detritus, fall to the floor of the ocean. There, if conditions are favorable, the sediment accumulates and so preserves a record of biologic and oceanographic events. In most regions this natural record is destroyed or distorted by the activity of large benthic animals. The burrowing and digestive actions of benthonic animals destroy fragile organic structures, promote bacterial decay and inorganic dissolution, stir the sediment, and destroy potential layering.

There are, however, exceptional situations where benthic animals are excluded and sediments are permitted to accumulate undisturbed. The factor responsible for the exclusion of macro-benthos is a continued anaerobic condition. Dissolved oxygen is mainly consumed in the decomposition of organic matter. Thus, besides other factors, a high productivity in the overlying waters is conducive to the formation of low-oxygen bottom water. Since the highest productivity occurs in regions of upwelling relatively close to shore, it is not surprising that the highest incidence of anaerobic sedimentation also occurs in these same regions. Off the west coast of North America there are several such areas (Figure 1). These are: the Santa Barbara Basin, the Santa Monica Basin, the San Pedro Basin, California (Emery, 1960); the Saanich Inlet, British Columbia (Gucluer and Gross, 1964); the basin north of Cabo San Lazaro, Baja California (d'Anglejan, 1965); and the Gulf of California (Revelle, 1939; Calvert, 1966).

Some elevated formations that are thought to have been deposited under conditions similar to those now present in these basins, have been examined. The Monterey shales, as an example, are highly stratified. Cleavage faces along bedding planes of these shales display an abundance of marine fish remains, and particularly a dense "peppering" of scales of pelagic fish. The sediments of the Santa Barbara Basin are strongly stratified, and the following discussion will be concerned principally with these materials.

SETTING OF THE SANTA BARBARA BASIN

The Santa Barbara Basin off Santa Barbara, California, has been studied in some detail. Situated inside Point Conception and receiving surface waters from a reverse arm of the main southward flow of the California Current System, the above sill depth portions of the basin are reasonably representative of the surrounding ocean. The surface waters are near the end of the well-defined intrusion of subarctic waters into the subtropical zone. To the south mixing with the Central water is rapid and by lat. 25° N. the mixed waters turn westward into the North Equatorial Current (Reid *et al.*, 1958). The Santa Barbara Basin thus lies in a position to be sensitive to major oceanographic and biologic events emanating from both the north and the south. The basin is also adjacent to and part of important spawning, growing, and fishing areas of several major pelagic fish species.

THE MICROPALEONTOLOGIC RECORD OF THE SANTA BARBARA BASIN

The biologic record within the sediments of the Santa Barbara Basin covers a wide range of ecologically- and economically-important organisms (Soutar, in press).

The ecologically-important organisms include species of Diatomacea, Radiolaria, planktonic Foraminifera, and pelagic Mollusca. Significant records of Coccolithophoridae and Dinoflagellitae most likely also exist. Much of the informational value of these taxa lies in their reflection of oceanic productivity, water masses and other oceanographic conditions.

The economically- and ecologically-important organisms include the major pelagic fish species of the California Current System. Bones, otoliths, and the scales of many species have been observed, and the scales of the Pacific sardine (*Sardinops caerulea*) the northern anchovy (*Engraulis mordax*), and the Pacific hake (*Merluccius productus*) are regularly encountered in the sediment (Soutar, 1967).

The truly unifying aspect of anaerobic sediments results from their ability to preserve in detail compositional changes in sediment reaching the bottom. At the latitude of the Santa Barbara Basin winter rains result in runoff from land, which produces a relatively dense layer of sediment. The summer sediment, composed mainly of diatom frustules, is less dense. The alternation of layers constitutes a varve and is in general thought to be equivalent to a single year. The alternation of sediment composition is not limited to gross features. Near-surface Radiolaria, which undergo a seasonal change in species composition, apparently show this change in the winter and summer sediment layers (Casey, pers. comm.).

Previous workers had considered the time record too incomplete for detailed paleo-ecologic study

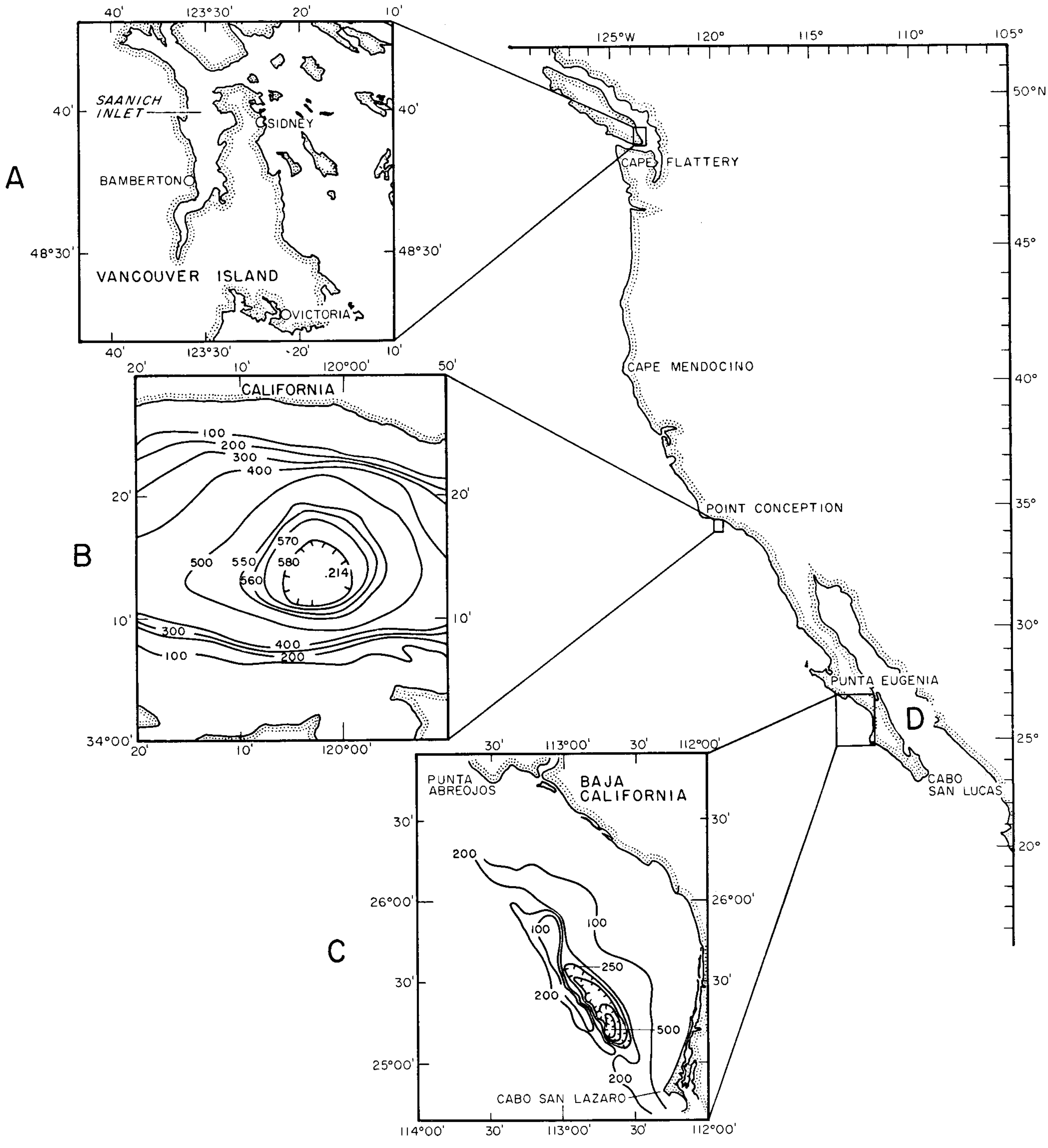

FIGURE 1. A. Saanich Inlet, British Columbia; B. Santa Barbara Basin, California. (The San Pedro and Santa Monica Basins lie just south of the Santa Barbara Basin.); C. Basin north of Cabo San Lazaro, Baja California; D. Gulf of California.

(Hulsemann and Emery, 1961). However, improved coring and observation techniques have subsequently shown quite complete sequences of varves and so revealed a remarkable time-biologic record (Soutar, in press). As an example, Figure 2 is a positive print of a radiograph of the top of core 230 from the Santa Barbara Basin. This core shows that the sediment varves extend up to the sediment-water interface.

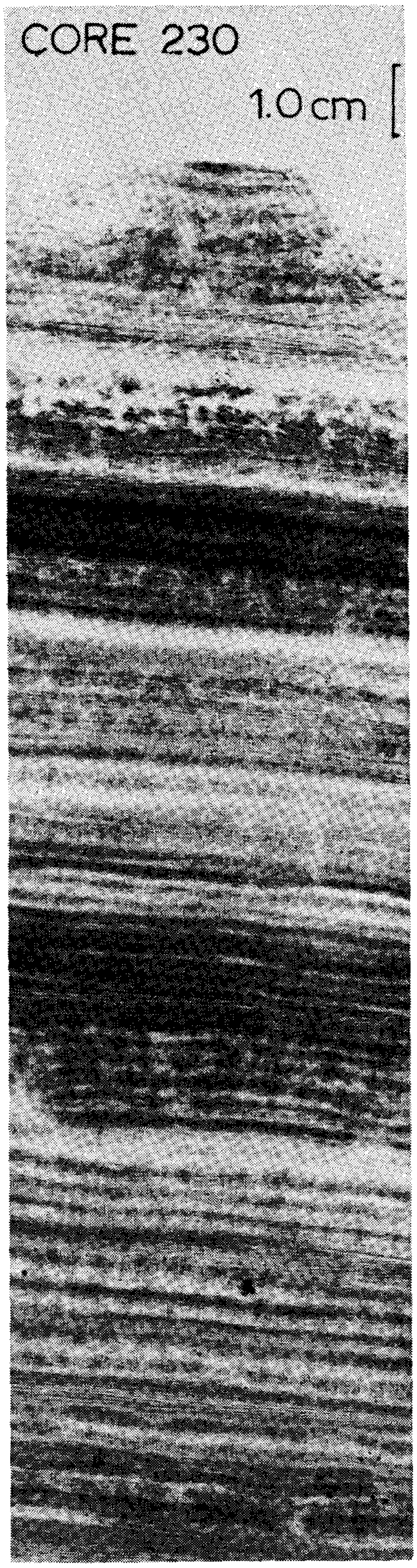

FIGURE 2. Santa Barbara Basin Core 230. Positive print of radiograph of core. Dark areas are the most dense and represent winter sedimentation. The lighter and less dense layers are mainly composed of diatoms and represent summer sedimentation. The layering extends to the water-sediment interface.

TREATMENT OF SEDIMENT SAMPLES

Core samples are subsampled at precise centimeter by centimeter intervals. The subsamples are disaggregated and wet screened into various size fractions from 500 to 25 microns. The basic data collected from the core subsamples is the number and sizes of the various inorganic and biologic components and the number of varves. A time series for each component may be constructed from these data. The high sedimentation rates within the Santa Barbara Basin now allow the construction of series with time intervals down to 10 years, and eventually, perhaps, to even finer time increments.

SANTA BARBARA BASIN, CORE 214

The specific sediment record that will be considered is that of Santa Barbara Basin, Core 214. This core is a 2.5 m (8.20 feet), 7.6 cm (3.0 inches) diameter fixed-piston core collected from the central basin area at lat. 34° 13.6′ N., long. 120° 01.7′ W. at a depth of 585 m (1,917 feet). This core is one of a series of complementary cores designed to extract a detailed and well-defined historical record from the basin.

The time series constructions for the Pacific sardine, the northern anchovy, the Pacific hake, the northern pteropod, *Limacina helicina,* and varve counts, are presented in Figure 3. The time interval is 10 years and in this figure is given as estimates of years before the year 2000 AD and of the year AD. The time series in Figure 3 shows a number of features, which are generally and qualitatively supported by data from all cores taken in the basin.

These are:

1) The occurrences of scales of the Pacific sardine are distinctly aggregated throughout the 1,850 year record. The clumps of scales are of varying intensities, the greatest occurring about 1,000 years ago. The most recent clump associated with the past sardine fishery is relatively moderate in intensity.

2) Northern anchovy scales decrease in occurrence from about 1,600 years ago to the present, but are always abundant.

3) The occurrences of Pacific hake scales continuously dominates the numbers of scales present but appears cyclical. This cyclic tendency is especially developed in the past 1000 years.

4) The combined fish group presents a relatively even distribution through time.

These same observations can be made on a set of cores taken three miles to the east (Soutar, 1967). This parallel set of observations suggest that on the size scale or core samples information pertinent to the entire basin has been preserved.

There are two main threads of information interwoven in the time series constructions of core 214. These are: information concerning the individual series of scales from a species and information on the interrelationships between the several series. Only the individual scale series will be considered here. The northern anchovy may be taken as an example. The scale-width-frequency-distribution of the scales of

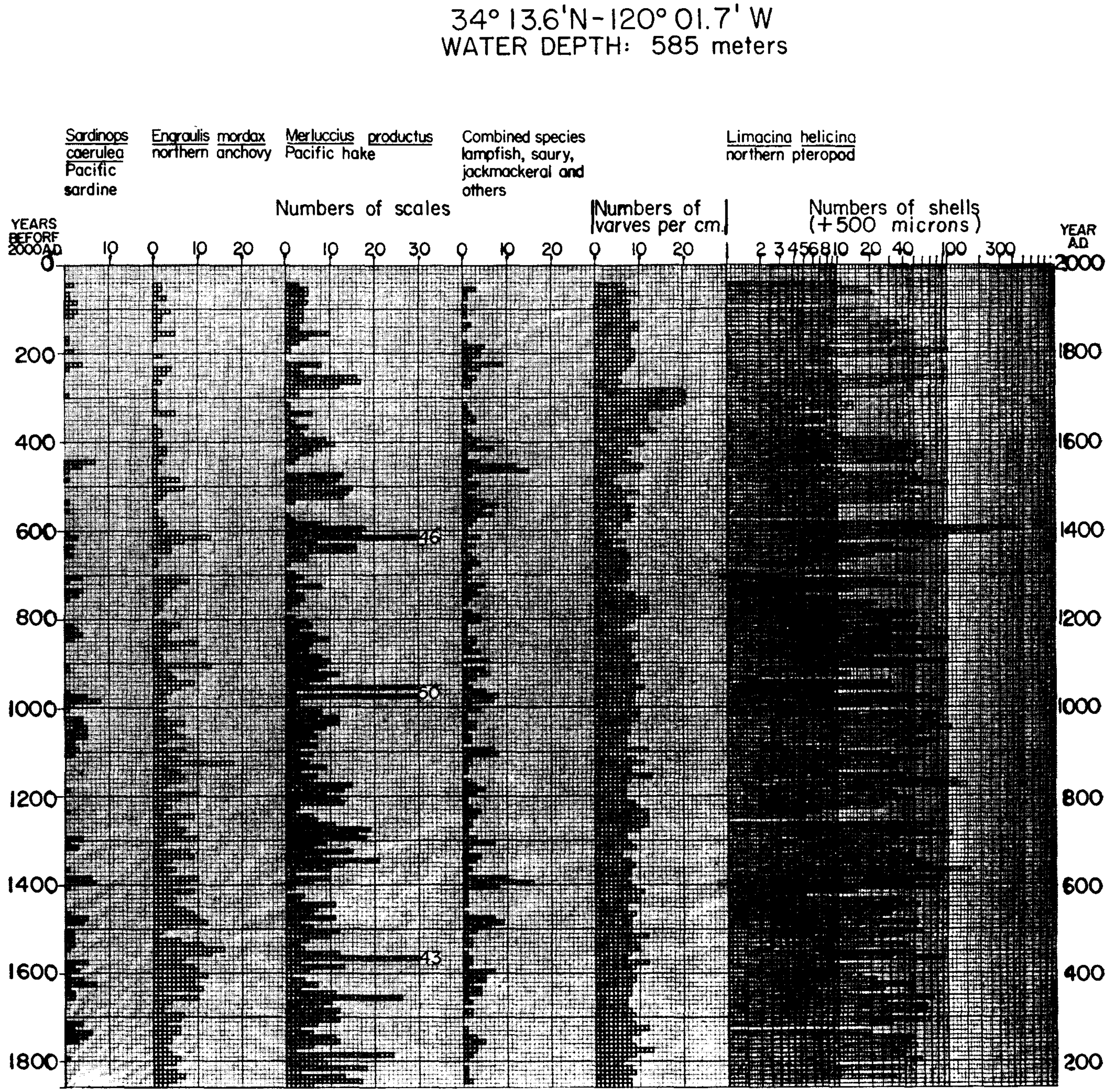

FIGURE 3. Santa Barbara Basin Core 214. Time series construction for the Pacific sardine, the northern anchovy, the Pacific hake, a combined fish species group, the northern pteropod *(Limacina helicina)*, and varve count.

this species for Santa Barbara Basin, core 214, is shown in Figure 4. The scale width may be used to estimate the length of the fish from which it originated. This transformation results in a derived length-frequency distribution (Figure 5). The peak of the distribution occurs at about 100 mm (3.94 inches), and limits the reliability of information to fish larger than 100 mm. Such a peaked distribution is characteristic of many sampling programs and the sediments appear to be no exception. For example, length-frequency distributions for fish taken from the fish surveys of the California Fish and Game Department, during 1950–1961 (Heimann, 1965–67) show a similar break at the 100 mm length. The derived length-frequency distribution can be regrouped into a derived age-frequency distribution by means of the growth curve of the northern anchovy, which relates length to age. The result of the regrouping in the case of the sediment data is given in Figure 6. The semi-log plot used in Figure 6 is a useful method of

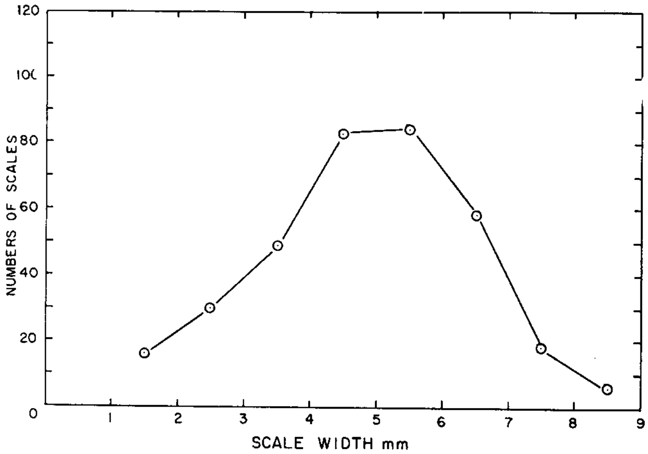

FIGURE 4. Northern anchovy, Santa Barbara Basin Core 214: scale width-frequency distribution. The scale width was chosen as it is a better preserved parameter of the scales in the sediments.

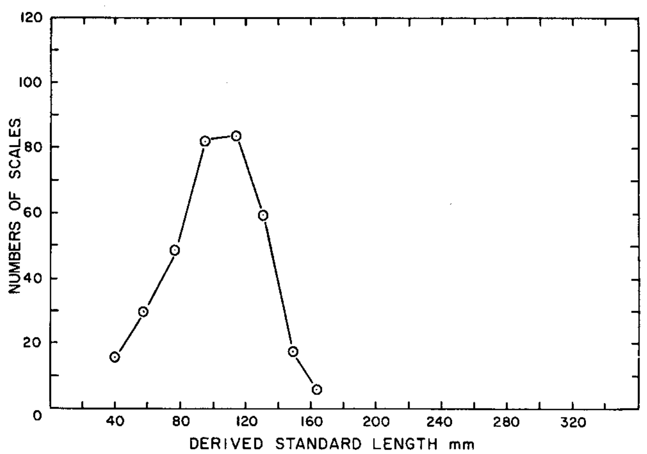

FIGURE 5. Northern anchovy, Santa Barbara Basin Core 214: derived standard length-frequency distribution.

presenting age-frequency distributions. The observed exponential decrease of fish of a single year class tends to a straight-line relation in such a plot. The slope of this line then contains a measure of survival. Furthermore, the mortality for a single year class is also an exponentially-decreasing function that has the same slope as the age-frequency distribution. This characteristic allows a direct comparison between sediment information and contemporary ecologic information. Included in Figure 6 is a summary plot of relative age-frequency taken from the 1953–1961 CalCOFI data reports. In general it can be seen that the sediment and the ecologic information agree.

The same kind of development can be made for the Pacific sardine and the Pacific hake. The agreement of the sediment and ecologic data in the case of the Pacific sardine seems quite good. The lack of ecologic information on the Pacific hake limits an assessment of the sediment information.

The minimum number of fish that sedimented scales represent may be estimated by dividing the total number of scales deposited over a given area by the number of scales per individual fish. Further-

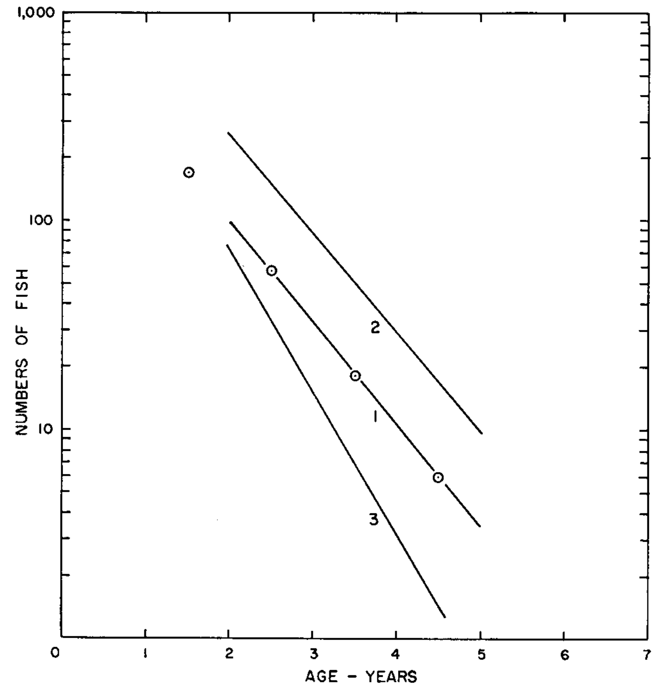

FIGURE 6. Northern anchovy, derived age-frequency distribution.
1. Derived* age-frequency distribution, Santa Barbara Basin Core 214; 2. Derived* age-frequency distribution, CalCOFI 1953–1961 data; 3. Age-frequency distribution, CalCOFI 1953–1961 data.
* Length to age transformation by growth curve.

more, the estimates of fish numbers may be limited to one year old and older fish by means of the age-frequency distribution (Figure 6).

If the estimates of minimum numbers of fish are thought of as estimates of yearly natural mortality, then an estimate of the number of living fish necessary to support the mortality may be attempted. Basically the method involves assuming that an average or steady-state population concentration and age-frequency distribution exists for a period of time. This allows a measure of an average minimum population level for that particular time period.

APPLICATION TO SANTA BARBARA, CORE 214

Minimum population levels per km^2 (0.386 sq. miles) for pelagic fish have been estimated for the area of the Santa Barbara Basin. A certain amount of subjectivity is involved in selecting time periods that will adequately portray the features of the sediment record. In the case of the Pacific sardine, the clumped distribution naturally defines periods of time. The average minimum [1] population levels for these periods are presented in Figure 7. The core record suggests that there have been 12 main occurrences of sardines over the past 1850 years. The average time between occurrences is 80 years with a range of 20 to 200 years and with a duration of occurrences of 20 to 150 years. The highest levels for the minimum population estimate are around 30,000 fish/km^2. The aver-

[1] Since all scales do not find their way to the bottom.

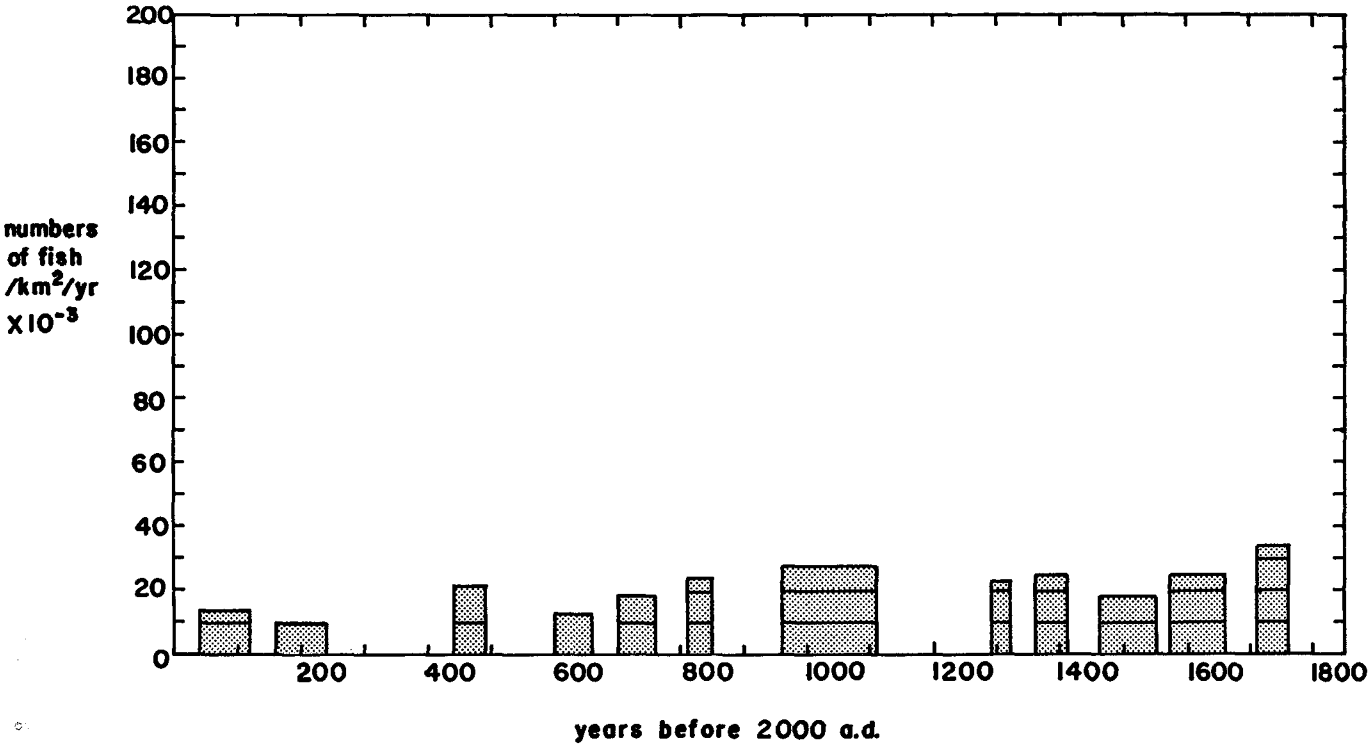

FIGURE 7. Santa Barbara Basin Core 214. Minimum population estimates for one year old and older Pacific sardine in periods of abundance. The average number of scales during each period of abundance was used to estimate the minimum population.

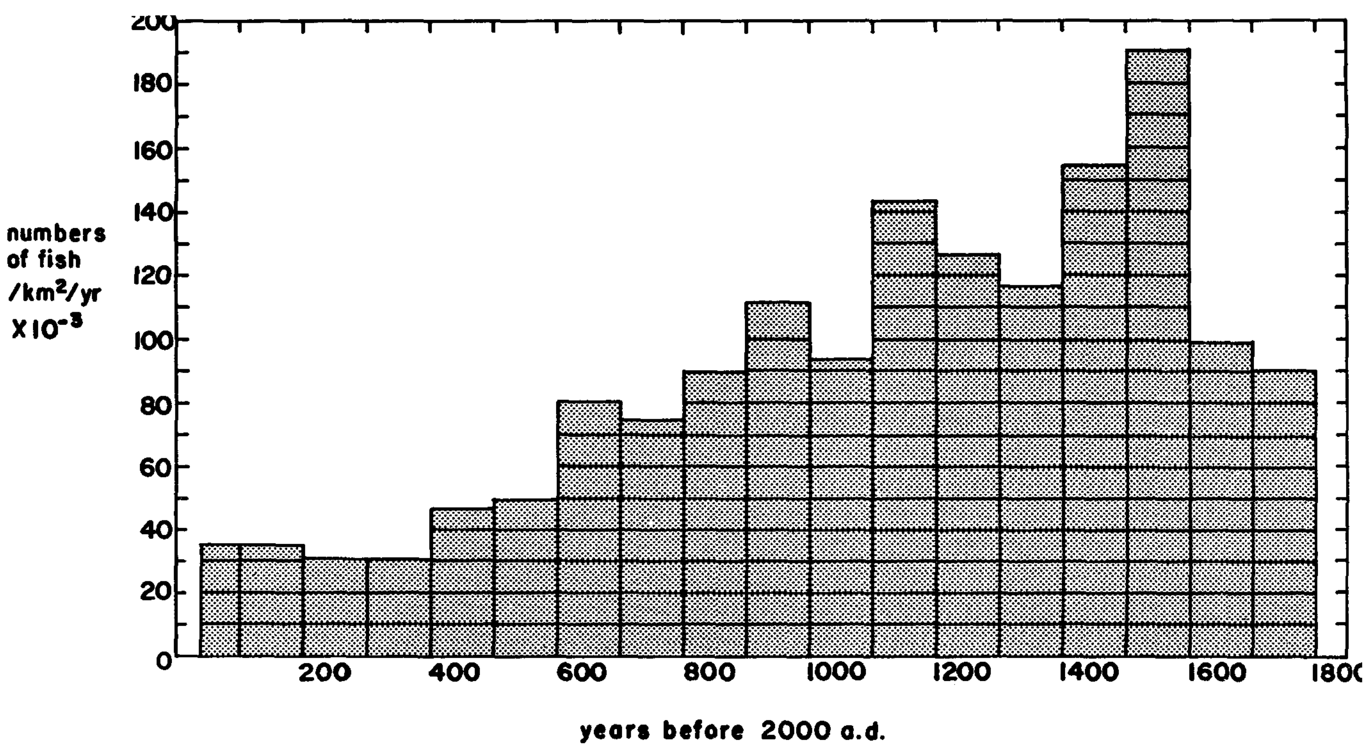

FIGURE 8. Santa Barbara Basin Core 214. Minimum population estimates of one year old and older northern anchovy for 100-year means. The mean number of scales for each century was used to derive the minimum population estimate.

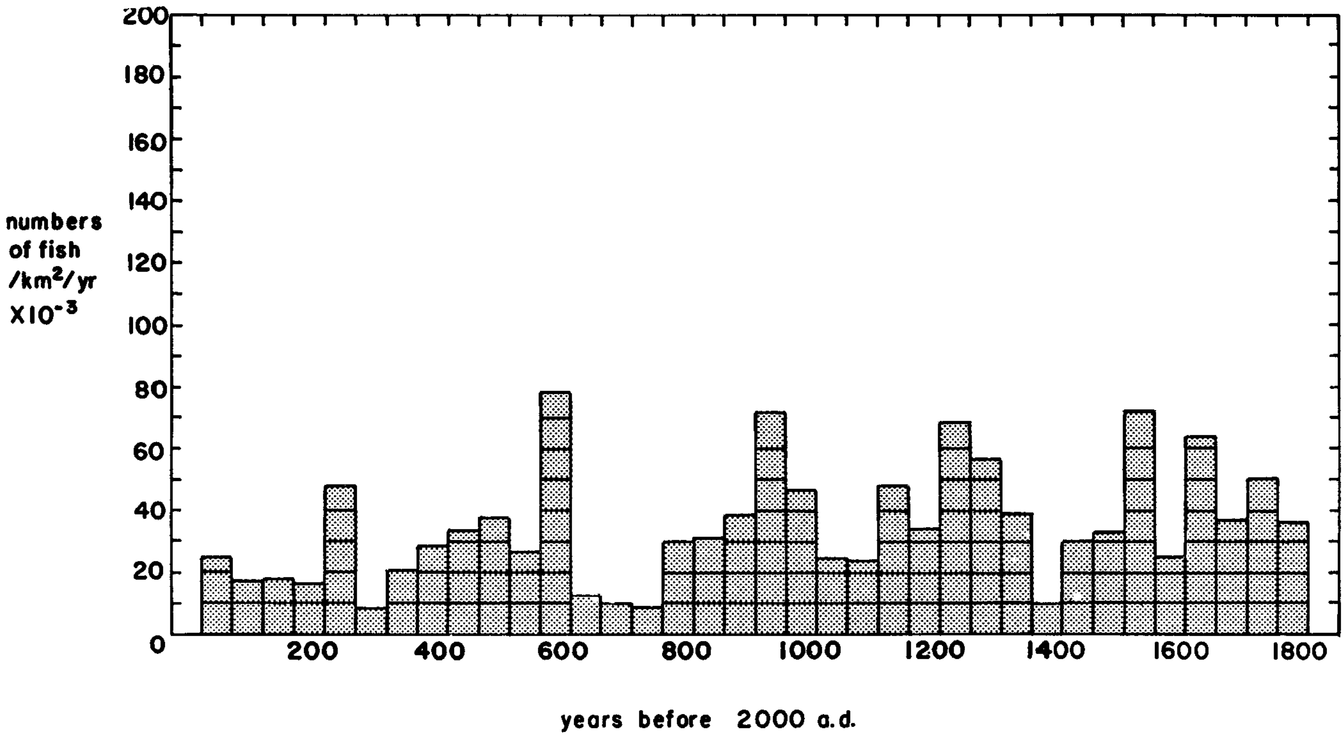

FIGURE 9. Santa Barbara Basin Core 214. Minimum population estimates of one year old and older Pacific hake for 50-year means. The mean number of scales for each 50-year period was used to derive the minimum population estimate.

age level associated with the past sardine fishery was about 15,000 fish/km^2.

The minimum population estimates based on 100-year intervals are presented for the northern anchovy in Figure 8. The average levels are considerably higher than in the case of the sardine; furthermore, there is a striking decrease from the level of about 180,000 fish/km^2 about 1,500 years ago to the recent level of around 35,000 fish/km^2.

The present estimated population of post-juvenile anchovies is 2 to 5 million tons over an area of perhaps 600,000 km^2. Hence an estimate of the present density of post-juvenile fish is 180,000 to 450.000 per km^2. Considering that only a fraction of the total scales produced reach the sediments the present day fish density is in reasonable accord with the above estimates from the sedimentary record.

In the case of the Pacific hake, 50-year intervals provide a somewhat better reflection of the distributional fluctuations shown in Figure 3. The levels, as shown in Figure 9, are intermediate between the sardine and the anchovy. The age-frequency information in the sediments for this species suggests an outward migration of fish 1 year old and older. This would conform with the observations of Best (1966) and would explain the relatively low minimum population levels of Figure 9.

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FOSSIL RECORDS OF CERTAIN SCHOOLING FISHES OF THE CALIFORNIA CURRENT SYSTEM

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Otoliths, vertebrae, teeth, and other fish remains are abundant in southern California Plio-Pleistocene deposits of marine origin, and in coastal Indian middens. Unfortunately, fossil and artifact recovery techniques employed by most paleontologists and archaeologists fail to reveal any but the largest fish remains, so not much has been known about the fish faunas that existed off our shores in the past. When recent experiments showed me how inadequate the "perusal-by-eye" technique is for recovering fossil otoliths (Fitch, 1966), and how poor the otolith yield and species content are when only coarse screenings are examined (Fitch, ms), I resampled numerous sites and subjected the fossiliferous matrix to more refined methods of washing, screening, and sorting.

As a result of these experiments, I have established a routine wherein field samples are screened through three sieves (2, 1, and 0.5 mm, U.S. Standard Sieve Series) that fit one into the other "piggy-back" style. After soaking my field sample in a tub of water, I place several handfuls of the saturated "dirt" solution into the top (largest mesh) sieve, submerge all three in a second tub of water to within one half inch of the top of the upper sieve, and filter the mixture by gently rotating and shaking the submerged screens. Before dumping the contents of each screen onto newspaper to dry, I clean the contained residue by rinsing it with water from a running hose.

When the sample is dry, I screen the coarsest material through $\frac{1}{4}$-inch (0.63 cm) mesh to remove large shells, rocks, bone fragments, and similar items. The residue retained by the $\frac{1}{4}$-inch (6.3 mm) screen can be checked by eye for the rare shark tooth or large otolith it might contain. I examine all remaining material by spreading a spoonful at a time in a flat dish with raised edges, and systematically searching through this residue with a pair of forceps while using a binocular miscroscope at six magnifications. By having washed the samples through three sieves, the particles are graded by size and the task of searching through the material under the microscope is greatly simplified.

Using these techniques of washing, screening and sorting, I have gleaned upwards of 100,000 otoliths, teeth and other fish remains from an assortment of Indian middens and Pleistocene and Pliocene deposits. To date, these remains have represented 167 species (23 elasmobranchs and 144 bony fishes), more than one-fourth of the marine fish fauna recorded from California during modern times. This statistic takes on even greater significance when one considers that otoliths of about 75 species of teleosts known to our waters are too small to be retained by 30 mesh screens (the finest mesh screen I use), and otoliths of possibly another 75 species are not likely to be found because these fishes are inhabitants of rocky substrate —a habitat type that is generally lacking in the fossil record. Then, too, many species have been noted only once or twice from our shores in more than a century of recorded history; unless they were considerably more abundant during earlier epochs, their recognizable remains are not likely to turn up in a ton or two of fossilized dirt.

Because fossil remains represent only death associations, they are not useful for making population estimates; however, finding the remains of a given species in a particular bed, horizon, or exposure is fairly good evidence the species was living in the area at the time of deposition—especially if it can be demonstrated that material in the bed has not arrived there from reworking of older deposits. Although radiologic dating techniques have improved greatly since carbon-14 measurements were first made, we still have not reached the stage where the geochronology of the Pleistocene (or older epochs) can be demonstrated in units smaller than 10,000 years. Regardless of this limitation, all information regarding fossil assemblages has application to modern-day problems, especially those involving ecology, evolution, dispersal, catastrophies, faunal anomalies, etc.

While this report deals generally with all fish remains I have found in Indian middens and Plio-Pleistocene deposits, specific details will be given for only six species: Pacific herring, *Clupea pallasi*; northern anchovy, *Engraulis mordax*; Pacific hake, *Merluccius productus*; Pacific sardine, *Sardinops caeruleus*; Pacific mackerel, *Scomber japonicus*; and jack mackerel, *Trachurus symmetricus*. These six species are schooling fishes, inhabit the California Current System, are of great economic importance or of potential importance, and all but one (*Merluccius*) can be caught abundantly with purse seine gear.

FISH REMAINS IN INDIAN MIDDENS

Although remains found in Indian middens do not constitute "true" fossils in a strict interpretation, they often are called "sub-fossils," and they usually offer our only link between present-day faunas and events, and those of the Pleistocene. In coastal California, many Indian middens cover a time span ranging from 300 to 7,000 years before the present (B.P.). Many of these sites are relatively undisturbed, and for remains found in these, radiocarbon dates furnish fairly accurate (± 100–250 years) information as to time of habitation.

Fish remains, especially otoliths, can arrive in a midden any of four ways, at least. Most, apparently are from food fishes the Indians caught and carried to the cooking or cleaning site. When the discarded remains of these fishes deteriorate, many otoliths, teeth, vertebrae, scales, and other hard parts remain relatively unchanged and become a permanent record in the midden. Remains of small prey species undoubtedly were discarded in the stomachs of fish, mammals, birds, and other fish-eating predators the Indians had harvested. The otoliths of these often can be recognized because they show some indication of digestive action, but so would otoliths from fish that had been eaten elsewhere by a scavenging gull and had passed through its digestive tract while it was foraging in the Indian garbage dump. Finally, some otoliths, shark teeth, stingray stings, and other items were prized by the Indians as ornaments, tools, weapons, etc., and these occasionally were lost, discarded or interred in their middens.

Of perhaps 20 publications reporting fish remains in California's coastal middens, only four (Follett, 1963a, 1963b, 1965; Fitch, 1967a) mention species of direct concern to this report. One of these sites, the Conejo Rock shelter in Ventura County (Ven-69) yielded 16 vertebrae identified as being from *Sardinops caeruleus* and 6 vertebrae from *Scomber japonicus* (Follett, 1965).

Two sites (LAn-52 and LAn-227), both in Los Angeles County, yielded remains only of *Scomber* from among my select six species. In the Arroyo Sequit midden (LAn-52) the recognized *Scomber* remains consisted of two dentary bones and 21 vertebrae (Follett, 1963a); whereas, at the Century Ranch site (LAn-227), they consisted of two vertebrae (Follett, 1963b). Fitch (1967a) reported an anchovy, *Engraulis mordax*, otolith from an Orange County excavation (Ora-190).

During the past several years, I have examined over 18,000 otoliths, plus an assortment of teeth, vertebrae, and miscellaneous fish remains from four coastal Indian middens (Table 1), and have identified more than 50 species from these middens that had been fed upon by the Indians or by some predator they had harvested. Perhaps 100 additional otoliths have been identified for various investigators who obtained them from other sites. One of these additional otoliths, collected by Carl L. Hubbs, Scripps Institution of Oceanography, at a La Jolla site, was from a jack mackerel, but none of the others represented a species of concern to this report.

Fish Remains from Ven-3

Ven-3, a Chumash Indian Village site at the ocean's edge in the city of Ventura, was partially excavated by a group of archaeologists in 1965. Their routine screening of 13 "standard" pits (each 1 by 2 by 0.7 m) and 2 control pits (each 1 by 1 by 0.7 m) yielded 7,357 otoliths from 10 species of fish and quantities of other fragments from several additional species. Eleven of these 15 pits were double-screened, which consisted of rescreening with ⅛-inch (3.2 mm) mesh the residue that passed through ¼-inch (6.3 mm) mesh. Since these "coarse" screens would miss the remains of many fish species, two small samples of midden material (perhaps totaling 0.5 m^3) were sent to me for processing by my three-sieve technique. The residue from these samples yielded 408 otoliths representing an additional 9 species, and

TABLE 1

NUMBERS OF OTOLITHS OF SELECT SPECIES IN INDIAN MIDDENS AND PLIO-PLEISTOCENE DEPOSITS OF SOUTHERN CALIFORNIA

	300–7,000?				100,000–2,000,000? Pleistocene							3,000,000–10,000,000? Pliocene		
	Indian Middens				PV Sand[1]			SP Sand[2]		Tms Pt Slt[3]		Lom Marl[4]	Pico Fm[4]	
Species	Ven 3	Ven 168	SBa 1	Ora 190	700 Blk	500 Blk	Del Rey	Ven Fwy	Mfl St	Tms Pt	Bts Rd	Mrl Cn	Npt Msa	Dntn LA
Engraulis mordax	30	14	64	1	8	7	262	70	80	4	2	49	6	23
Sardinops caeruleus	--	1	6	--	--	--	--	--	--	--	--	--	--	--
Merluccius productus	--	--	--	--	--	1	35	--	--	20	6	55	427	561
Trachurus symmetricus	--	--	--	--	--	--	3	--	3	1	1	46	24	31
Clupea pallasi	--	--	--	--	--	--	--	1	29	5	1	8	1	3
Scomber japonicus	--	--	--	--	--	--	--	--	--	--	--	15	3	4
Total otoliths (all species)	7,765	10,342	145	2	282	662	2,591	1,200	2,746	2,601	1,243	24,299	5,103	4,285
Total species (teleosts)	19	12	9	2	20	31	47	40	30	53	37	83	55	48

[1] Columns 5, 6, and 7 involve sites at: 500 block North Pacific Avenue, San Pedro; 700 block North Pacific Avenue, San Pedro; and Playa del Rey—representing Palos Verdes sand, late Pleistocene (warm oceanic temperatures and shallow depths).

[2] Columns 8 and 9 involve sites on the Ventura Freeway, Ventura; and at Miraflores Street, San Pedro—representing San Pedro sand, early Pleistocene (cold oceanic temperatures and shallow depths).

[3] Columns 10 and 11 involve sites at Timms Point, San Pedro; and on Bates Road, Santa Barbara County—representing Timms Point silt, early Pleistocene (cold oceanic temperatures and relatively deep water).

[4] Columns 12, 13, and 14 involve sites at: Miraleste Canyon, San Pedro; Newport Mesa, Orange County; and downtown Los Angeles—representing Lomita Marl and Pico Formation, Pliocene (cold oceanic temperatures and relatively deep water).

teeth of 7 more elasmobranchs. In all, remains of 45 fish species were identified from the Ven-3 site (Fitch, ms).

Although no otoliths of hake and Pacific mackerel were found, there were many jaw fragments and vertebrae from these two species, and lateral line scutes from *Trachurus symmetricus* were also present. All of the anchovy otoliths (Table 1) were among the 408 sagittae removed from the two special samples I processed. This extensive midden has been covered with asphalt and made into a parking lot since these investigations were carried out.

Fish Remains from Ven-168

Ven-168, a Chumash Village site beside the Ventura River 7 miles inland from the coast, was excavated intensively by archaeologists during 1967. Although 10,327 otoliths from eight species of bony fishes were found during the routine dig, 10,238 of these were from the white croaker, *Genyonemus lineatus*. The 231 fish teeth found at the same time were from 10 elasmobranchs and 3 additional teleosts. Since all of these remains had been retrieved with $\frac{1}{4}$- and $\frac{1}{8}$-inch mesh screens, a small sample of washed residue from a 30-mesh screen was sent to me for microscopic examination. This material was from a 3.6-foot (110 cm) deep control pit.

Because of time limitations, I examined residue from only 2 of the 11 subsamples sent me; these were from near mid-depth and the bottom of the control pit (30 to 40, and 100 to 110 cm levels). This material yielded otoliths of two additional teleosts and teeth of five additional elasmobranchs. Anchovy otoliths were at both levels, eight in material taken 11.81 to 15.75 inches (30 to 40 cm) beneath the surface, and six in the lowermost 3.94 inches (10 cm) of the midden. In addition, one broken sardine otolith turned up in the 30 to 40 cm stratum. All of these otoliths showed signs of erosion from digestive action, indicating they had been in the stomach of some predatory species caught by the Indians. Ven-168 was destroyed by freeway construction subsequent to these investigations.

Fish Remains from SBa-1

SBa-1 covers much of the top and sides of a hill overlooking the ocean at Rincon Point on the southern boundary of Santa Barbara county. In places, midden material is 8 to 10 feet (2.4 to 3.0 m) deep, indicating site occupancy of several thousand years. An archaeological group from UCLA was investigating this site during 1966 and 1967, and during this time I picked up about 200 pounds of midden dirt from their discard piles. There is no way to correlate the samples I obtained with any given depth. Broken mollusk shells were extremely abundant throughout the site, but fish remains were rather sparse in the material I examined, and presumably throughout this midden. The total otolith yield from the 200-pound field sample (145) represented only nine species, and 123 of these were from only two: *Engraulis mordax* (64) and *Genyonemus lineatus* (59). Six of the otoliths were from small sardines which apparently had been in the stomachs of predatory species, because all showed signs of digestive action. Teeth and vertebrae of an additional 12 to 15 kinds of teleosts and elasmobranchs were also found, but none was abundant. SBa-1 was almost completely destroyed (hauled away for fill dirt) during freeway construction in late 1967.

Fish Remains from ORA-190

Ora-190 is a small site about 2 miles southeast of Newport Bay and a similar distance inland from Corona del Mar in Orange County. The inhabitants of this site did not seem to be as marine oriented as were those of the three sites discussed previously. Very few objects of marine origin (e.g., mollusk shells) were found here during excavations in 1966 by members of the Pacific Coast Archaeological Society. I was supplied with a 6-inch square column of dirt from one of their excavation pits, and when I had finished washing, screening, and sorting this material, I had found identifiable remains from five elasmobranchs and six teleosts (Fitch, 1967a). One of the two otoliths I found was from an anchovy that appears to have arrived at the site in the stomach of some predator the Indians had carried there. The otolith was in the 6- to 12-inch (15.24 to 30.48 cm) horizon of a 30-inch (76.2 cm) deep pit, which was the maximum depth of Ora-190. This site appears destined to be covered by a housing tract in the not-too-distant future.

FISH REMAINS IN PLEISTOCENE DEPOSITS

Highly-fossiliferous marine Pleistocene deposits are constantly being exposed in southern California coastal localities through natural erosion as well as by housing and road construction, cut-and-fill projects, quarrying, tunneling, and a multitude of other digging activities of man. Many sites of historical interest are covered up or carried away each year, but concurrently many others are exposed for varying periods. The mollusks and foraminifera contained in long-exposed deposits usually have been investigated rather intensively, and many other groups of invertebrates have been the object of serious study, but fish remains, other than large shark and ray teeth, generally have been overlooked. In my studies, I have concentrated upon recovering fish remains, and toward this end, I have removed and examined a few pounds to possibly a ton of fossiliferous matrix from each of a dozen or more Pleistocene outcrops in southern California.

Geologists and paleontologists generally agree that our youngest marine Pleistocene is the lowest of a dozen terraces that can be seen in any profile study of Palos Verdes hill which lies between San Pedro and Redondo Beach, and at numerous other coastal and insular localities. This terrace corresponds to deposits that have been termed Palos Verdes sand and an age of 95,000 to 130,000 years B.P. recently has been determined for these sediments by Fanale and Schaeffer (1967) who also assign an age of 330,000 to 420,000 to the oldest (12th) terrace in this series. These 12 terraces comprise the late Pleistocene in southern California.

Two early Pleistocene deposits (San Pedro sand and Timms Point silt) apparently complete the marine Pleistocene in the Los Angeles area, and the San Pedro sand is unanimously accepted as being the younger of the two. No ages have been determined for either, however.

I have found otoliths from four of the six species this report is concerned about, but remains of *Sardinops* and *Scomber* are absent in the Pleistocene, in-sofar as it has been sampled (Table 1).

Fish Remains from the Palos Verdes Sand

The Palos Verdes sand represents a lengthy period when the ocean waters that bathed our shores were considerably warmer than they are at present. Many of the mollusks reported from these beds are locally extinct southern forms, and six of the fishes that left their remains have not been taken north of about Cedros Island or Magdalena Bay during modern times, and still others rarely are seen off California even during several years of warmer than average water temperature (Radovich, 1961).

Three of 12 exposures of Palos Verdes sand that I have examined have yielded recognizable remains, mostly otoliths and teeth, from 57 species of teleosts and 18 elasmobranchs. A few of these have been from lanternfishes, macrourids, and other offshore-living species, but most of the fishes represent assemblages that normally are found in depths no greater than 10 to 12 fathoms (18.3 to 22 m) over sandy or sandy-mud bottoms (Fitch 1964, 1966). Otoliths of *Engraulis mordax* were abundant at Playa del Rey, and were present at two San Pedro sites I sampled (500 and 700 blocks, North Pacific Avenue). The Playa del Rey deposit also yielded otoliths from *Merluccius* and *Trachurus*, but except for a single hake otolith, these two species were absent at San Pedro (Table 1). The deposit in the 700 block, North Pacific Avenue, San Pedro, was both exposed and hauled away during construction of the access to the Vincent Thomas Bridge, while the deposit two blocks south of there and on the opposite side of Pacific Avenue is no longer accessible because it undermines private property. Fossiliferous material can still be found at the Playa del Rey site, but fossils have been excavated at this locality for nearly four decades and the exposure is badly depleted.

Fish Remains from the San Pedro Sand

The fish remains I have recovered from two widely separated deposits of San Pedro sand represent a fauna such as one would encounter north of Point Conception today. Two of the species found in these deposits (night smelt, *Spirinchus starksi*, and Pacific tomcod, *Microgadus proximus*) have not been noted south of Point Conception during modern times, and several others have centers of distribution well to the north of the two sites that I sampled.

One of these exposures at the base of a cliff in the 600 block, Miraflores Street, San Pedro, yielded identifiable remains of 10 elasmobranchs and 30 teleosts (Fitch, 1967b). *Engraulis*, *Clupea*, and *Trachurus* otoliths were among the 2,746 sagittae that I found, but there was no evidence of *Merluccius*, *Sardinops*, or *Scomber*. The other deposit I sampled (1.1 miles upcoast from the Ventura River in a freeway cut) yielded fair numbers of *Engraulis* otoliths and one from *Clupea*, but none from the other four species being considered here (Table 1). The 1,200 otoliths from this deposit represented 40 species; an additional 3 species were identified from teeth. In all, 55 species (45 teleosts and 10 elasmobranchs) were identified from the two sites.

The Miraflores Street deposit at San Pedro is doomed by the impending extension of the Harbor Freeway during 1968, but the exposure of San Pedro sand in the freeway cut near Ventura should be accessible for many years to come.

Fish Remains from the Timms Point Silt

The type locality for the Timms Point silt at San Pedro has been extensively sampled for mollusks, foraminifera, and a few other groups, but the only published report of teleost remains from this deposit is a plate showing six fish otoliths in a publication on foraminifera (Bagg, 1912). My investigations of Timms Point silt at the type locality have yielded otoliths, teeth and other remains representing 53 species of bony fishes and 9 of elasmobranchs (Fitch, 1968), while an exposure in a road cut on Bates Road near its juncture with state highway 150 in Santa Barbara County has turned up an additional 18 species of teleosts. Only 30 of the 2,370 otoliths from the Timms Point (San Pedro) site were from fishes of concern to this report, but these were from four species: *Clupea*, *Engraulis*, *Merluccius*, and *Trachurus*. The Bates Road deposit yielded otoliths from the same four species, but in even smaller numbers (Table 1).

The many remains from lanternfishes, melamphaids, and deep-water scorpaenids are indicative of deposition at depths of 400 to 600 feet (122 to 183 m) or more, and the locally-extinct northern forms (*Ammodytes hexapterus*, *Atheresthes stomias*, *Lyconectes aleutensis*, *Malacocottus zonurus*, *Microgadus proximus*, and *Theragra chalcogramma*) are reasonably good proof that ocean temperatures were a great deal colder than today at the same latitude.

Most outcrops of Timms Point silt in the San Pedro area have been buried under houses, streets, etc., and behind retaining walls, but the Bates Road deposit and some near Newport Beach should be accessible for additional sampling for a number of years.

FISH REMAINS IN PLIOCENE DEPOSITS

Historically, the Lomita marl has been reported as the oldest marine Pleistocene in southern California (Valentine, 1961; Woodring, Bramlette, and Kew, 1946; and others), and many contemporary invertebrate paleontologists who are familar with the formation accept this viewpoint (Warren Addicott, pers. commun.). Additionally, it has been argued that the basal part of the Villafranchian Stage of Europe (lateral equivalent of the Calabrian Stage which is basal Pleistocene) has an older radiometric age determination (3.3 million years B.P.) than the estimate of 3.04 million years B.P. reported for the Lomita marl by Obradovich (1965).

My work with fossil fish otoliths, and intensive sampling of the Lomita marl by personnel from the Los Angeles County Museum of Natural History since 1964 have provided substantial evidence that the Lomita marl is in fact the youngest marine Pliocene unit in southern California (Kanakoff and McLean, 1966; Kanakoff, pers. commun.; Fitch, unpubl. data). The younger age estimate for the Lomita marl (compared to the age that has been assigned the basal Pleistocene of Europe) could have resulted from a vagary of the relatively unproven radiometric techniques involved. Duplicate tests on a given piece of material often have yielded age estimates that are at greater variance than the 300,000 years in the present case. No age estimates are available for either the Pico formation, or the San Diego formation, two other well-known components of the southern California marine Pliocene.

Fish remains were abundant in all Pliocene deposits that I examined, and the species these represent, with one exception, are still extant. I have found otoliths of five of the six species of concern to this report, but not one *Sardinops* sagitta is represented among the nearly 34,000 Pliocene otoliths I have identified from three deposits (Table 1).

FISH REMAINS IN PLIOCENE DEPOSITS

Although one of the best known (historically) Lomita marl deposits (Hilltop Quarry, San Pedro) was covered by a housing project in the early 1940's, an exposure in the bottom of a canyon just north of there has yielded the richest fossil fish fauna known to the Pliocene of North America. The 24,299 otoliths I have recovered from this site represent a minimum of 82 species (Table 1), while more than 15 kinds of elasmobranchs are identifiable among the 575 shark, skate, and ray teeth. Possibly one ton of fossiliferous matrix was washed, screened, and sorted to obtain these remains.

The fish fauna is comprised of many mesopelagics, a few bathypelagics and a half-dozen kinds of locally extinct northern forms, in addition to an assortment of species that is typical of 20- to 50-fathom (36.6 to 91.5 m) depths at the latitude of San Pedro today. The several thousand lanternfish (family Myctophidae) otoliths I found here are from at least 11 species, but the most abundant single species among the more than 82 kinds of teleosts was *Physiculus rastrelliger* (2,424 otoliths), a deep-water, bottom-dwelling morid (family Moridae).

This deposit has been exposed for more than two years, but the canyon 100 yards west of the site is being filled, and a similar fate apparently is in store for the remainder of the canyon in the not-too-distant future.

Fish Remains from the Pico Formation

A deposit uncovered in 1967 during housing construction on the mesa south of upper Newport Bay appears to represent the Pico formation, but this assumption is based upon the fish fauna and may not hold up when additional evidence has been carefully examined. Approximately 500 pounds of fossiliferous matrix I dug at this site yielded over 5,100 otoliths and 1,200 elasmobranch teeth. These remains represented more than 70 species (55 teleosts), but except for *Merluccius productus* (427 otoliths), sagittae of the six species of concern to this report were not abundant (Table 1). As with the Lomita marl deposit, otoliths of *Physiculus* (1,387) were more numerous than those of any other single species.

Material from one other bed of the fossiliferous Pico formation was examined and yielded quantities of teleost otoliths (4,285) and a small collection of elasmobranch teeth (182). This material was salvaged during excavation of a sub-basement for a multi-storied building in downtown Los Angeles. *Merluccius* otoliths (561) comprised more than 13 percent of the total yield (Table 1), but unlike the Newport Mesa deposit not many *Physiculus* sagittae (33) were present.

SPECIES ACCOUNTS

The sagittae of the six species covered in this report are easy to distinguish from all other species including their closest relatives, once one knows what characters are diagnostic and whether certain observed differences are valid. Generally, the configuration of the sulcus (the groove, channel, imprint, or pitted area on the inner face of each sagitta) in conjunction with one or more other features will serve to identify the otolith to family (e.g., the typically-shaped two-part sulcus, cockscomb-like arrangement of spines along the ventral margin, and broadly-oval outline in lateral aspect will distinguish engraulid otoliths). Once an otolith has been recognized at the family level, numerous other features are important in distinguishing genera and species, but one must study lengthy series of otoliths before he can evaluate the variability he observes, and make accurate identifications.

In order to assist various investigators concerned with food-habit, age, and other studies wherein otoliths may be encountered or utilized, I have prepared a dichotomous key, which in conjunction with the figures (Figure 1a through h) should permit rapid identification of native (the introduced *Alosa* and *Dorosoma* are not included) engraulid and clupeid genera regardless of their state of digestion or fragmentation.

Key to Otoliths of Californian Engraulid and Clupeid Genera

1. A series of short spines radiating from ventral margin of otolith; dorsal and ventral contours strongly arched, otolith oval in broad outline; rostrum (anteriorly projecting "nose-piece" ventral to sulcus) short, comprising one-fourth or less of total otolith length ______________Engraulidae, 2
   Ventral margin of otolith incised but never spinose; dorsal and ventral contours straight (parallel), or nearly so; rostrum long, comprising one-

third or more of total otolith length ____________ __________________________________Clupeidae, 4

2. Otolith more than twice as long as high, highest point posterior to center of otolith; anterodorsal margin concave; posterior termination relatively sharp, never evenly rounded __________ *Engraulis*
Otolith less than twice as long as high, highest point at mid-length; anterodorsal margin convex; posterior end evenly rounded ________________ 3
3. Antirostrum (anteriorly projecting portion above sulcus) distinct, sharply pointed; rostrum pointed; ostium (mouth or front part of sulcus) more than one-half as high as otolith at that point ____________________________ *Cetengraulis*
Antirostrum indistinct or absent; rostrum rounded; ostium about one-third as high as otolith at that point ______________________ *Anchoa*
4. Sulcus extending to posterior margin of otolith slightly above centerline; posterior end of otolith notched where cauda (tail or posterior part of sulcus) reaches margin ___________________ *Clupea*
Sulcus fails to reach posterior margin of otolith, turning slightly downward in those genera where it almost reaches end of otolith, never terminating above center-line; posterior end of otolith never notched, although profile invaginated or concave below center-line in some genera _____________ 5
5. Sulcus straight for entire length, cauda terminating well inside posterior rim which is evenly rounded ____________________________________ 6
Sulcus curves slightly downward posteriorly, terminating just inside margin; posterior end with an overhanging bulge above cauda, never evenly rounded ________________________________ 7
6. Rostrum equal to height of otolith; antirostrum about twice as long as post-caudal field (area between end of cauda and posterior rim of otolith) _______________________________ *Opisthonema*
Rostrum short, about one-half as long as otolith height; antirostrum as long as post-caudal field, or nearly so __________________________*Harengula*
7. Rostrum long, equal to nearly one-half length of otolith; antirostrum distinct; dorsal and ventral margins of otolith nearly parallel, dorsal margin smooth or nearly so; overhanging postero-dorsal bulge tapering to a rounded point _____*Sardinops*
Rostrum short, equal to about one-third of otolith length; antirostrum indistinct; dorsal margin sloping upward posteriorly, usually deeply notched above end of ostium (mouth or anterior part of sulcus); postero-dorsal bulge broadly and evenly rounded ____________________________*Etrumeus*

Scombrid sagittae have been discussed and illustrated by Fitch and Craig (1964), who found it is impossible to confuse otoliths of *Scomber* with those of any other fish. The otoliths of *Merluccius* (Figure 3f) are equally distinctive, but those of *Trachurus* could be mistaken for *Decapterus* except for one unvarying character—the angle of flexure of the cauda. In *Trachurus,* the cauda bends downward near its posterior extremity at a 45° angle, whereas in *Decapterus* it bends at a 90° angle. This is especially apparent in an examination of the ventral rim of the cauda (Figure 2). No other carangid otolith (of the nine other species noted from California) resembles the sagittae of *Trachurus* and *Decapterus* sufficiently to create a problem.

Anchovies

Otoliths of *Engraulis mordax* were present in every Indian midden (4), Pleistocene (7), and Pliocene (3) deposit that I investigated during the past several years (Table 1). They comprised as much as 44 percent of the total otolith yield in one Indian midden (SBa-1), 10 percent in one Pleistocene deposit (Playa del Rey), and one-half of one percent in one Pliocene deposit (Pico formation).

Beds of Palos Verdes sand and San Pedro sand represent deposition in shallow water, the former (P. V. sand) during a period when ocean temperatures were considerably warmer off southern California than at present, and the latter (S.P. sand) when ocean temperatures were colder. On the other hand, Timms Point silt fossils reflect deposition in relatively deep water (±600 feet) during a time when ocean temperatures were colder than normal.

The three Pliocene deposits (Table 1) were laid down at depths and temperatures similar to those of the Timms Point silt.

Obviously, *Engraulis* has been present off our coast during warm as well as cold periods, and in both shallow and deep areas for upwards of 12 million years, at least.

Herring and Sardines

Clupea otoliths were present in all of the Pleistocene and Pliocene sites that represented deposition during periods when ocean temperatures were colder than at present. They were not found in the deposits that reflected warm oceanic conditions (Table 1), and none was recovered from the four Indian middens examined.

No *Sardinops* otoliths were found in any Pleistocene or Pliocene deposit regardless of depth or temperature, but two of the four Indian middens that I investigated yielded recognizable fragments of sardine otoliths (Table 1, Figure 3c). All seven of these otoliths were from small fish (yearlings or younger), none was entire, and all were somewhat eroded as if they had been in the digestive tracts of predators the Indians had caught. Follett (1965) identified 16 vertebrae recovered at a Ventura County site (Ven-69) as having come from *Sardinops caeruleus.*

Pacific Mackerel

No Pacific mackerel otoliths were found in any of the Pleistocene exposures that I investigated regardless of depth or temperature at the time of deposition, but all three Pliocene deposits yielded their sagittae (Table 1). Otoliths that are indistinguishable from those of *S. japonicus* are present in Miocene deposits near Bakersfield (±25 million years old), so Pacific mackerel are not "new" to our coast. Absence of their remains in Pleistocene deposits could reflect a reduced population during that period, but there is no proof that this was the case.

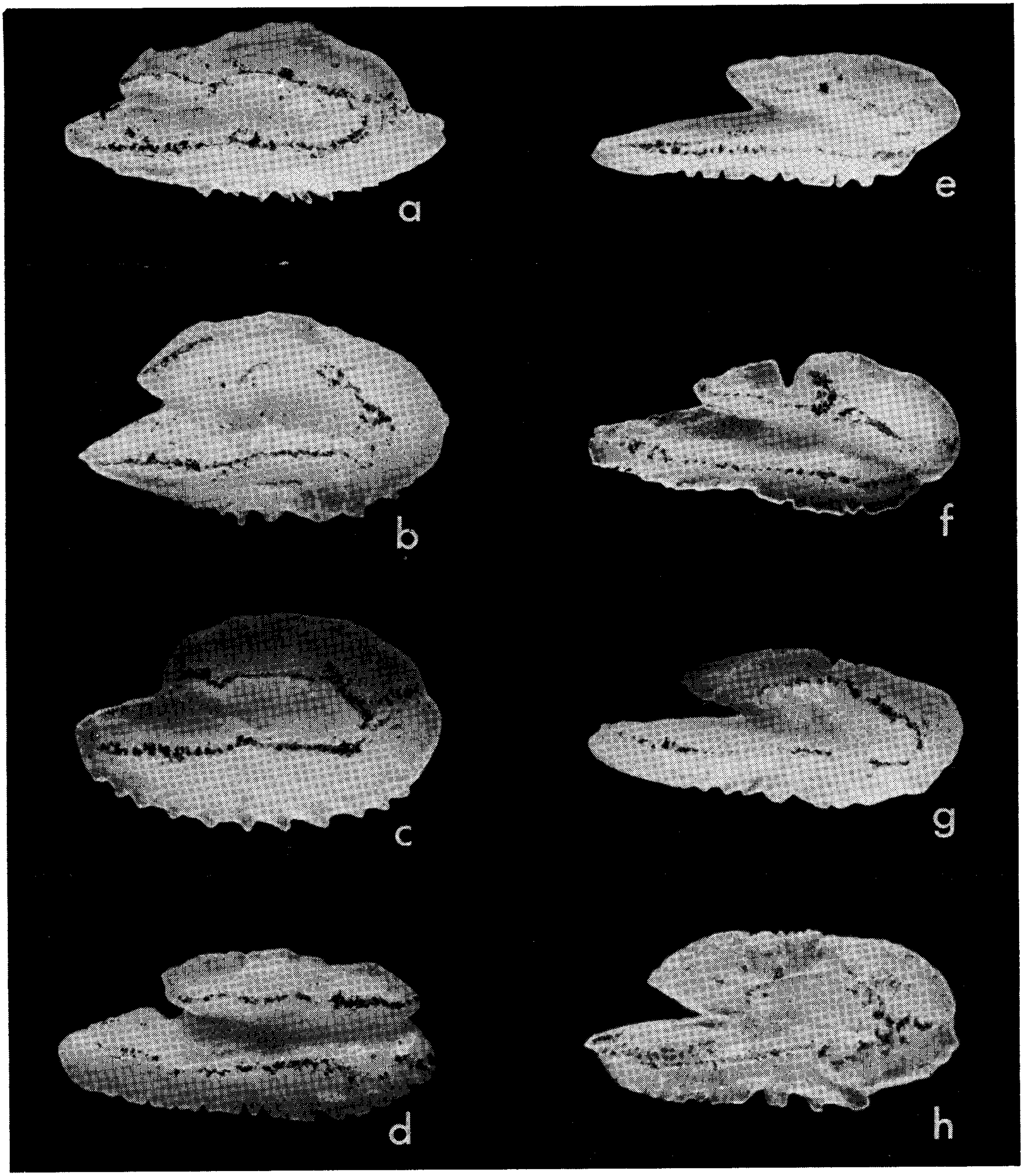

FIGURE 1. Right sagittae from adults of native genera of Californian engraulids and clupeids. The sulcus of each otolith has been highlighted by rubbing a pencil across the raised margins. Otolith lengths and heights (in mm) are given in parentheses. The eight species figured are: a. *Engraulis mordax* (4.5 x 2.1), b. *Centengraulis mysticetus* (4.2 x 2.4), c. *Anchoa compressa* (4.2 x 2.4), d. *Clupea pallasi* (4.6 x 2.0), e. *Sardinops caeruleus* (4.5 x 1.6), f. *Etrumeus teres* (4.4 x 1.9), g. *Opisthonema medirastre* (4.5 x 1.9), h. *Harengula thrissina* (2.5 x 1.2). *Photographs by Jack W. Schott.*

No *Scomber* otoliths have been recovered from Indian middens either, but Follett (1963a, 1963b, 1965) has identified vertebrae and dentary bones in three middens as having come from *S. japonicus,* and I have seen many Pacific mackerel vertebrae and jaw fragments in midden material I have examined. Possibly, *Scomber* otoliths require a more intricate combination of favorable conditions before fossilization can occur. If this is the case, and such conditions were not met during the Pleistocene, no amount of searching would turn up a Pacific mackerel otolith, even if dense schools had existed off our coast.

None of the fossil *Scomber* otoliths has been entire; only posterior ends have been recovered (Figure 3d).

Jack Mackerel

Although *Trachurus* sagittae resemble those of *Decapterus* in general outline and configuration, the two can be separated accurately by the degree of flexure of the cauda (Figure 2). Six of the seven coldwater deposits that I investigated (three of four Pleistocene and all three Pliocene) yielded *Trachurus* otoliths, but they were present in only one of the three warm-water sites (Playa del Rey, Table 1).

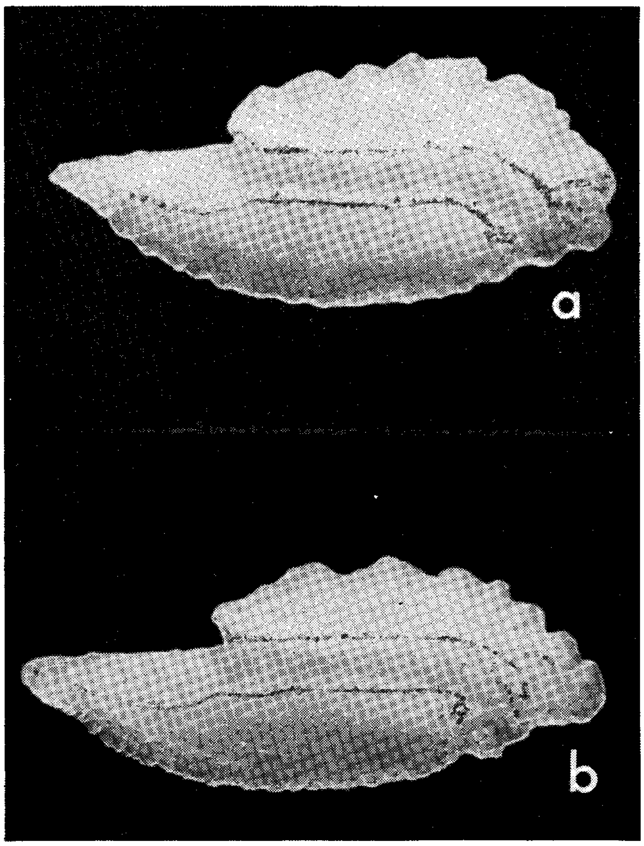

FIGURE 2. Right sagittae from similar sized *Trachurus symmetricus* (a), and *Decapterus hypodus* (b). Otolith lengths and heights (in mm) are: 6.0 x 2.5, and 7.5 x 3.0, respectively. The sulcus of each has been highlighted by rubbing a pencil across the raised margins. *Photographs by Jack W. Schott.*

No jack mackerel otoliths were found in the four Indian middens reported upon here, but other *Trachurus* remains (e.g., posterior lateral line scutes) were noted, and a single sagitta has been found in a coastal midden at La Jolla.

Hake

Merluccius sagittae were not found in either of the San Pedro sand deposits that I investigated, and these were the only outcrops representing cold temperatures and shallow (possibly nearshore) depths at time of deposition (Table 1). Hake otoliths were present in all other Pleistocene deposits that yielded 500 or more otoliths (two shallow water warm deposits and two deep water cold localities), and were in all three Pliocene exposures, being very abundant in two of the three. Very few of the hake otoliths were from large fish, perhaps 90 percent representing fish-of-the-year.

Hake jaw fragments and vertebrae were plentiful in the Ven-3 Indian midden and were present at SBa-1, but no otoliths were found at any of the four sites investigated.

DISCUSSION

Indian middens and fossil deposits offer a nearly continuous record of the fish faunas that have existed off our shores during the most recent 125 million years of the earth's history. The species that were present between the Cretaceous and Miocene are mostly extinct, but many of these were the ancestors of present-day stocks. On the other hand, Pliocene and Pleistocene deposits in California have yielded otoliths from 144 species of teleosts, and all but one of these are living off our shores today.

Unfortunately, science has not progressed to the point that an exact date can be affixed to each fossil horizon regarding its time of deposition. There are few areas where geologists and paleontologists have not mastered the geochronology, but they have not been able to correlate with any degree of certainty a given bed in one locality with a given bed in another locality 500 or 1,000 miles away. When dating techniques have reached the stage of perfection that fossil deposits at Arcata can be matched with those at San Francisco, San Pedro, and San Diego, intricate details of paleoecology will be within reach of the inquisitive mind. Information on paleotemperatures, fish distributions, life history, predation, catastrophic events, etc. can be gleaned from fossil otoliths (Devereux, 1967; Fitch, 1964, 1967b) and used in conjunction with knowledge of today's happenings to help explain long- and short-term trends. Obviously, a complete history of *Sardinops* in time and space would permit speculation as to its future potential, and such questions as to whether it has been displaced by the anchovy, whether it was ever very important except during the 1930's etc., would no longer be academic.

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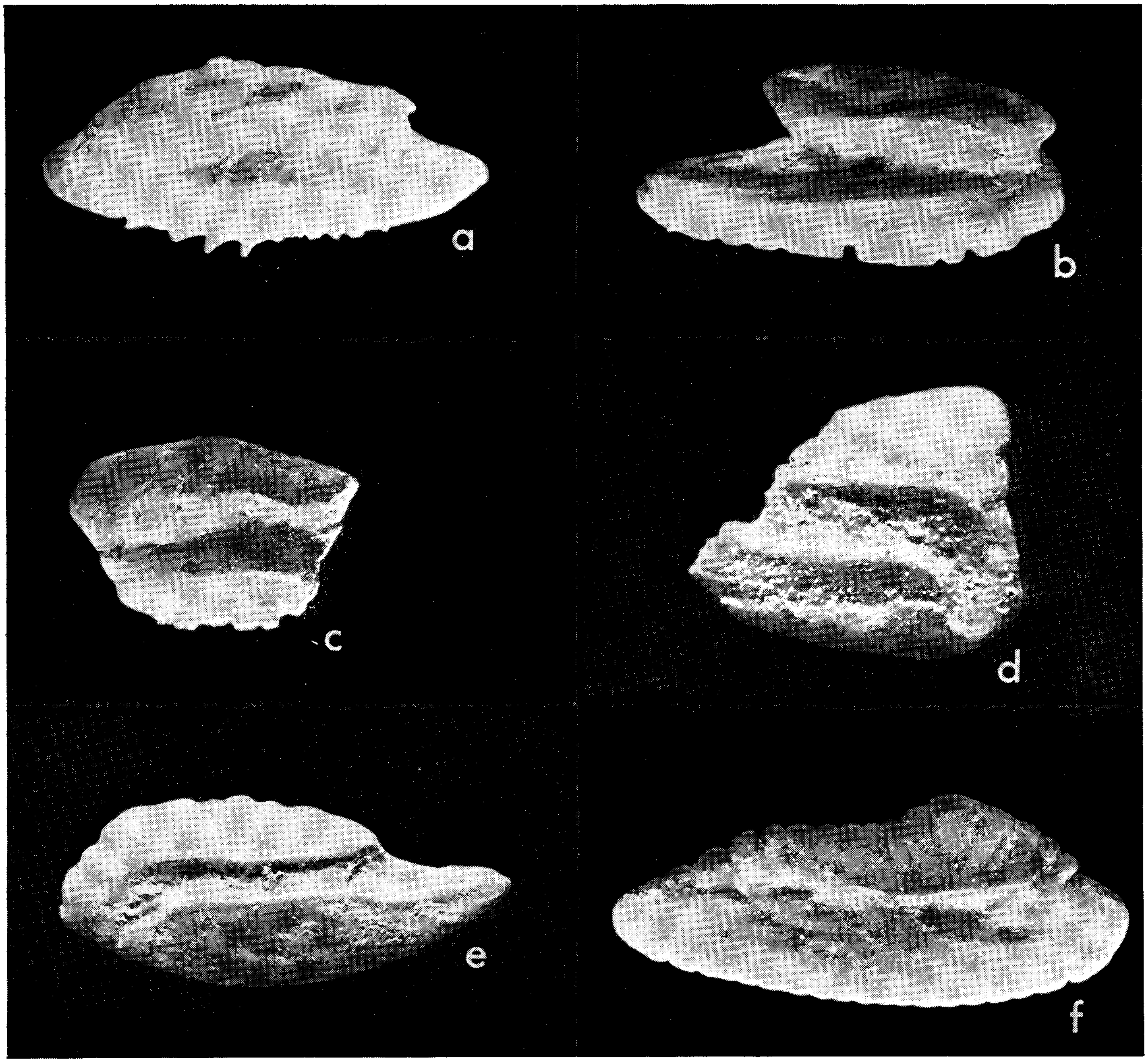

FIGURE 3. Sagittae of certain schooling fishes recovered from an Indian midden and various southern Cailfornia Pleistocene and Pliocene deposits. Only posterior portions of *Sardinops* and *Scomber* otoliths have been recovered, but otoliths of the other four species are often entire. Lengths are given for each figured otolith or fragment, and notation is made as to whether it is a left or right sagitta. The six species are: a. *Engraulis mordax,* 3.9 mm, l., Ventura Freeway, early Pleistocene; b. *Clupea pallasi,* 3.7 mm, r., Miraleste Canyon, Pliocene; c. *Sardinops caeruleus,* 2.0 mm, l., SBa-1 Indian midden; d. *Scomber japonicus,* 1.7 mm, r., Newport Mesa, Pliocene; e. *Trachurus symmetricus,* 4.8 mm, l., Newport Mesa, Pliocene; f. *Merluccius productus,* 6.2 mm., l., Newport Mesa, Pliocene. *Photographs by Jack W. Schott.*

viduals have been helpful in an assortment of ways: Warren O. Addicott, U.S. Geological Survey, Menlo Park, offered helpful comments for improving the manuscript; Richard A. Fitch washed, screened, and sorted the bulk of the fossiliferous matrix from these sites; Mrs. Roberta Greenwood, Pacific Palisades, supplied information, otoliths, and dirt from several Indian middens; George P. Kanakoff, Los Angeles County Museum of Natural History, gave me otoliths and fossiliferous matrix from many Pleistocene and Pliocene deposits; and Jack W. Schott, San Pedro, took the excellent otolith photographs.

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A PERSPECTIVE OF A MULTI-SPECIES FISHERY

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This perspective takes the viewpoint that the fishery resources of the California Current region offer a base for a large multi-species fishery, examines the nature of this base, explores the advantages of multi-species over single-species fisheries, discusses some of the problems required to be solved, and suggests the direction research might take to contribute to the solution of the problems.

The quantity of living material any part of the ocean can support depends primarily on its content of essential nutrient salts and on the radiant energy it receives from the sun. Thanks to the relatively high content of nutrients in the subarctic water brought southward in the California Current, some in solution and some bound in the tissues of the plankton, and the additional dissolved nutrient salts brought up from the depths in the locally upwelled water, the basic biological productivity in the waters off the California coast is relatively high. Here is the base for support of an unusually large quantity of resource species such as the pelagic Pacific sardine, *Sardinops caeruleus* (Girard); northern anchovy *Engraulis mordax* (Girard); jack mackerel, *Trachurus symmetricus* (Ayres); Pacific mackerel, *Scomber japonicus* (Houttuyn); Pacific saury, *Cololabis saira* (Brevoort); and the hemipelagic Pacific hake, *Merluccius productus* (Ayres); and squid, *Loligo opalescens* (Berry).

The waters off the California coast, with their chemical and biological content, can be viewed as an ecological system, in which basic productivity oscillates as the inputs of nutrient salts and of solar energy pulse with the season and are irregularly disturbed when the weather deviates from the normal, or climate average, for short and long periods of days, weeks, or years. This will cause deviations from basic productivity appropriate to the normal "underwater climate" of the region and set up oscillations in the biomass the region contains. Just as the weather oscillates with limited amplitude about its climatic average, we can expect the biomass to oscillate with limited amplitude about an equilibrium level appropriate to the underwater climatic pattern. Taking this viewpoint, we may postulate an inherent though imperfect stability in the quantity of living matter supported by the waters off the California coast.

In contrast to the postulated relative stability of the total quantity of living matter (biomass) we may expect less stability in the species composition of the biomass. Each species has its own set of optimal environmental conditions and its own seasonality in spawning and feeding. The seasonality is especially marked among those having an annual reproductive cycle, as do most of our resource species. Accordingly each can be expected to respond differently than the others to even a moderate oscillation in the physical or chemical environment. A set of environmental conditions unfavorable to reproduction, larval survival, or growth of one species may be favorable to one or more of the other species. Furthermore, the several species occupying the same habitat interact with each other as predators, prey or competitors.

As the combined result of species-specific physical and chemical environmental requirements and of interactions among species, a disfavored species may be reduced substantially while one or more of the others increase substantially in population and biomass.

If, during such an alteration of relative numbers and biomass among the species, the basic biological productivity of their common habitat has remained relatively stable, limitation of foodstuff will place a bound on the increase of any one or more favored species. Thus the individual species can oscillate widely while the aggregate biomass oscillates only moderately.

This view is offered as a hypothesis of the nature of processes in an ecological system in the absence of fishing pressure. As such the hypothesis cannot be tested. However, Andrew Soutar's studies of historical variations of scales of pelagic fishes deposited in sediments and reported in this symposium tend to support the belief that the abundance of certain of the pelagic fishes fluctuated very widely long before fishing pressures could have significantly affected abundance. Whether or not such sediments could also yield an index of total biomass remains to be discovered.

That environmentally caused fluctuations in the abundance of particular species do occur is shown by the history of the sardine. This story has been well-documented by the scientists of CalCOFI and their predecessors over a period of nearly 50 years. Most obvious and incontrovertible is the evidence that the numbers of sardines surviving through infancy to reach commercial size from each year's spawning season vary widely. Poor survival resulting in small year classes occurs more often than good survival producing large year classes. More often than not, several small year classes occur in succession. The more small year classes in succession that fail to offset annual adult mortality, the more the adult population declines.

That this statement can be made without equivocation is owing to the foresight of N. B. Scofield and Will F. Thompson, who recognized the need ". . . to establish a logical and adequate system of observation of the important fisheries of the state. . . ."[1] Thanks to this recognition, systematic observation of the sardine fishery began in the season of 1919–20.[2]

Early in the system of observation, when fishing effort could not be measured because processors imposed limits on the size of catch they would accept from the fishing vessels, and before a technique for determining age from scales or otoliths was developed, the fishery was systematically sampled for size composition of the fish in the catch. By following the progression of modal groups in length-frequency distributions of the landings sampled during the period 1919–33, it is possible to identify the incidence of small year classes as contrasted with large ones. From Clark (1939, Figures 4 and 5) it is readily seen that the sequences of small year classes intervening between large year classes were 2 or 3 years in length and averaged 2.5 years. This evidence comes from the length composition of the fish in catches landed during 1919–33. Age composition during this period is lacking because techniques of determining age had not been developed at that time. We now know that sardines first enter the commercial catch in substantial numbers at age 2 and can conclude that the year classes recognized by length composition during 1919–33 reflected the variations in infant survival during 1917–31.

In contrast are the longer sequences of small year classes between large ones after 1931. Thanks to the advances in research during the 1930's, the information on year-class size is more explicit from 1930 onward. The development by Clark (1939) of a measure of fishing effort, and by Walford and Mosher (1943) of a technique for determining age from scales and otoliths, provided the means for computing apparent relative abundance and relative year-class size from collections of samples from the sardine catch from 1932 onward. On the other hand, large fluctuations in year-class size, apparently unrelated to size of spawning stock and almost certainly governed by environmental variations from year to year, coupled with considerable year-to-year variations in catchability, proved to be unsurmountable obstacles to the successful application of the simple density-dependent model of population dynamics of 30 years ago. The recent study on the sardine population problem by Murphy (1966) circumvented the obstacles. He estimated sardine population sizes for the period 1932–59 by using the nearly 30-year-long series of data on catch, effort, and age composition, together with independent estimates of total population size afforded by the tag and recapture experiment of the 1930's (Clark and Janssen, 1945) and by the sardine egg and larval surveys of the 1950's (Ahlstrom, 1966). Pertinent to this perspective are his estimates of year-class size and population biomass. These data are reproduced graphically in Figure 1. In 1933–37 there was a 5-year sequence of small year classes. Depending on whether the 1940 class is considered large or small, the next sequence of small year classes occurred between 1939 or 1940 and 1946, and was 6 or 7 years long. Thus the period of successive small year classes averaged over twice as long in 1932–49 as in 1917–31.

After 1948 the sequences of small year classes were shorter. Following 1948 came a 2-year sequence and, following 1952, a 3-year sequence of small year classes. According to Murphy (1966) the fishery drew mainly on the northern subpopulation until about 1950 and thereafter mainly on the southern subpopulation. The latter occupies the waters off Baja California, Mexico, and extends northward into waters off southern California a variable distance, but probably not beyond Santa Barbara. Murphy found it necessary to analyze separately the segment of data following 1949. This requirement complicates the interpretation of events following 1949 and I shall not attempt it.

These ratings of year classes are relative. Those rated as "small" are small relative only to the adjacent "large" year classes. Alternatively, ratings can be regarded as being based on deviations from the trend of absolute year-class size. Although Figure 1 includes no trend line, it can readily be seen that year-class size showed a strong downward trend after the large year classes of 1938 and 1939. The year classes rated as small would lie below the trend line whereas those rated as large would lie above it. This method of rating is intended to distinguish the spawning years of unfavorable environmental conditions from those of favorable environmental conditions for survival of the young. For considering absolute year-class size, it is necessary to turn to the record of biomass.

Figure 1 makes it impressive that two years following the onset of each sequence of small year classes the biomass of the sardine population declines. The new year class, if small when recruited into the fishery at age 2, was not adequate to fully replace the mortality suffered annually by the sardine population. If followed by another small year class, the biomass continued to decline. From the peak of biomass preceding a sequence of small year classes to the following lowest point in biomass for the first four small year-class sequences enumerated above, the total declines in population biomass were 67, 81, 43 and 70 percent in successive cycles. The first decline, reducing the stock to one-third of its previous biomass, still left a stock sufficient to produce the two large 1938 and 1939 classes. Apparently this condition did not hold after the severe decline of 81 percent. For examination of conditions surrounding this decline we may turn to the record of fishing effort in relation to biomass and catch.

The record (Figure 2) gives evidence not only on the fluctuations in year-class size but also on the total effect of these fluctuations under light and under heavy fishing pressure. When the data given by Murphy (1966) are plotted as a time series, it is readily

[1] This quotation is taken from the foreword to Fish and Game of Calif. Fish Bull. No. 11, 1926, entitled The California Sardine, by the Staff of the California State Fisheries Laboratory.

[2] Throughout most of its history the fishing season has extended from midsummer of one year to late winter of the next. In the following pages, each season is designated by the year in which it started.

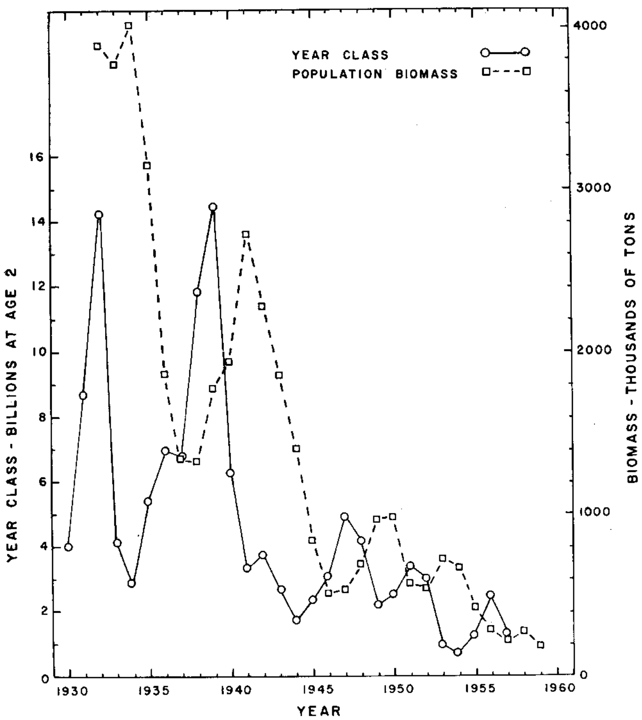

FIGURE 1. Year-class size and population biomass of the sardine population of the west coast of North America, exclusive of the Gulf of California. Data drawn from Murphy (1966, Tables 14 and 15, pp. 41 and 46).

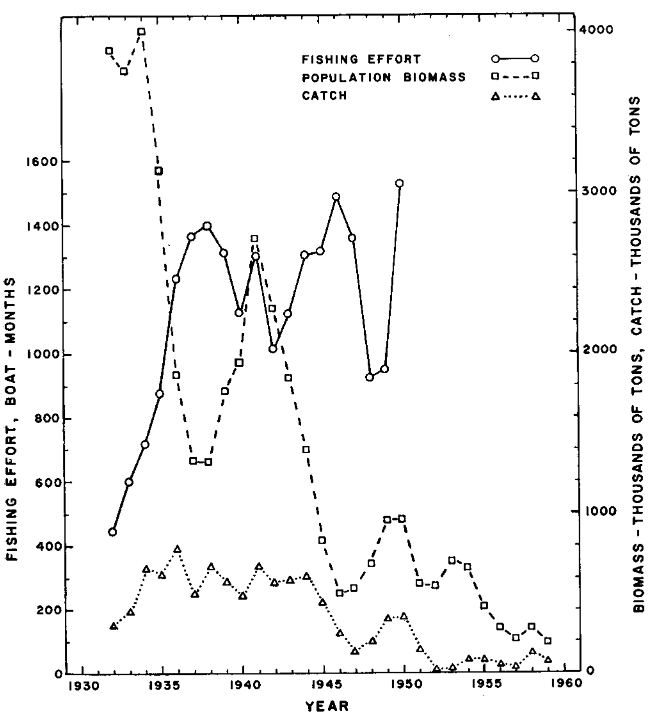

FIGURE 2. Total catch, fishing effort and population biomass of the sardine population of the west coast of North America, exclusive of the Gulf of California. Data drawn from Murphy (1966, Tables 1, 10 and 14, pp. 4, 5, 37 and 46).

seen that the fishery was still in its growth stage in 1932, and that the fishing effort nearly tripled between 1932 and 1936. During this growth period the population biomass, averaging 3,700 thousand tons, was high; the effort, averaging 650 boat-months was low; and the annual catch, averaging 500 thousand tons, was only 14 percent of the biomass. In 1936, the end of the growth period of the fishery, when the effort had reached nearly 1,200 boat-months, the level about which it was to fluctuate for a number of ensuing years, the population was already in a decline due to the diminished recruitment during 1935–39 from the 1933–37 sequence of small year class. The combined effect of poor recruitment, natural mortality, and an annual catch averaging about 600 thousand tons brought the biomass down to 1,300 thousand tons. At this level the population was still able to produce the two large year classes of 1938 and 1939, which were even a little larger than the large year classes of 1931 and 1932 produced by the 4-million-ton population of those two years (Figure 1).

The outcome of the next cycle of events was far different. The fishery had grown to a size sufficient to exert an effort of about 1,200 boat-months. This general level, with some fluctuation, was sustained throughout the cycle. The recruitment from the large 1938 and 1939-classes restored the population to the 2,700-thousand-ton level. But under the substantial catch mortality imposed by the high fishing effort, the ensuing recruitment from the 1941–46 sequence of small year classes replenished the stock so inadequately that the biomass fell to 700,000 tons before the next large year classes of 1947 and 1948 were recruited to the population in 1949 and 1950. By the time the second, third, and fourth in the 6-year sequence of small year classes were being recruited to the population in 1945, 1946, and 1947, the vigorous fishing during these 3 years averaged nearly 1,400 boat-months and was taking an annual average of 430 thousand tons from the population in the fishery area. This catch amounted to 49 percent of the population biomass. The 1947 and 1948 year classes, though rated as large relative to the adjacent year class, were so small and fished so vigorously that their recruitment in 1949 and 1950 raised the population biomass only to 970 thousand tons. These two year classes came from the spawnings of 1947 and 1948, when the population biomass averaged 600,000 tons.

From this sequence of events it is obvious that the great decline of the sardine population between 1941 and 1946 took place when (i) there had been a long sequence of 6 or 7 years when the environment had been continuously unfavorable for survival of year classes to the age of recruitment in large numbers, and (ii) the fishery was catching an annual tonnage amounting to 25 to 50 percent of the population biomass, taking the larger percentages in the years when the biomass was sinking toward its lowest levels.

For purposes of this perspective, the events after 1948 are germane only as evidence that the sardine population in waters off California has not recovered from the severe decline in the middle 1940's. With some fluctuation, the sardine catch of the California fleet has dwindled almost continuously until in 1966 only a few tons were landed for processing. These fish were incidental to catches of mackerel with which they were mixed. In 1967 California imposed a moratorium on sardine fishing for delivery to processors. They are still fished for bait in California, and the Baja California fleet still delivers sardines to processing plants there.

Thus the events in the California sardine fishery give an example of a species disfavored by relatively unfavorable environmental conditions during its early life history through two sets of successive years. Each set produced a large fluctuation in population size. Following the first set, under relatively light fishing pressure, the population was still large enough to produce, when favorable environmental conditions ensued through 2 years, year classes fully as large as formerly. Following the second, somewhat longer set of unfavorable years, under heavy fishing pressure, the sardine population seems to have lost its capacity for producing really large year classes. Instead, the combination of unfavorable environment and heavy fishing appears to have set off an irreversible downward trend. How has the ecological system of the California Current region responded to the extreme dimunition of a once major component in the system?

That the sardine probably was a major component in the ecological system of the California Current region in the early 1930's has been documented by Murphy (1966). Using energy-requirement data furnished by Dr. Reuben Lasker, the energy contained per-unit wet-weight in the plankton, the average zooplankton content of the water off California and Baja California in 1952 as reported by U. S. Fish and Wildlife Service (1953), and the quantity of zooplankton in the waters flowing from the north in the California Current and the quantity outflowing at the south, Murphy estimated that the sardine population alone, at its level of about 4 million tons in the early 1930's would have required for its growth and activity about 2.5 standing crops of zooplankton. The turnover rate of plankton in the California Current region has not been measured. Murphy (1966) gave his opinion that ". . . it is no greater than five times per year. . . ." Because neither the sardine nor the plankton is distributed evenly or randomly throughout the waters under consideration, it is probable the schools of sardines continuously consumed well over half of the standing crop of plankton wherever they aggregated for feeding in the early 1930's.

When the sardine population was reduced to one-twentieth of its former size in the late 1950's and withdrawn to the southern end of its range, it became a trivial consumer of plankton everywhere north of southern California. This change released a tremendous food mass for the support of any zooplankton-feeding pelagic species occupying the practically vacated area.

Evidence now exists that the anchovy was the species that benefited most from the bounteous food supply left unconsumed by the decimated sardine population. It is not known how large the anchovy population was when the sardine population was at its high size of 4 million tons. A thorough egg and larva survey of the waters off southern California in 1939 showed anchovy and sardine larvae to be about equally abundant, but the area surveyed was too small a portion of the habitat of both species to provide a dependable estimate of the whole population of either species. It was not until after the war-interrupted civilian fishery-oceanography programs could get under way again in 1949 that fish egg and larva surveys were resumed. These surveys were designed to discover the environmental requirements causing the year-class size of the sardine to fluctuate as widely as they had been observed to do up to that time. As yet they have not been successful in accomplishing this purpose.

Yet they have accomplished an equally significant purpose—that of furnishing year-by-year estimates of the size of spawning populations of the sardine; and when the scientists of CalCOFI decided to broaden their efforts, estimates were made also of the spawning populations of other important fish species of the California Current region from San Francisco to the southern tip of Baja California. As result of these surveys and the analyses of samples of eggs and larvae by Dr. Elbert H. Ahlstrom and his staff, it is now known that the numbers of anchovy larvae in the survey area increased spectacularly from 1951, the year of the first definitive survey, until in 1962 they were nearly 20-fold more numerous than in 1951 (see Messersmith, Baxter and Roedel, this symposium). They appear to have remained at about this high level since 1959. Translated to quantity of parental anchovy biomass by means of data from fecundity studies by MacGregor (1968) and by comparison with sardine biomass and larvae (Ahlstrom, 1966), the anchovy spawning biomass since 1962 has equalled or exceeded that of the 4 million tons of sardine biomass of the early 1930's.

Parenthetically, it also may be surmised that the anchovy biomass may be substantially larger than this estimate. The CalCOFI surveys extended northward only to the waters off San Francisco whereas the anchovy ranges northward in substantial but unestimated numbers into waters off the coasts of Oregon and Washington. One may conjecture that the waters off Vancouver Island and northward the anchovy may be replaced as the major plankton-feeding clupeoid by the Pacific herring (*Clupea pallasi* Valenciennes).

The 50-year history of the sardine population and fishery based upon it, and the much shorter history of the anchovy population as it has been revealed by the estimates of larval abundance have been reviewed in some detail because the events recorded by these histories have generated the ideas leading to the concept of a multi-species fishery. Before I proceed to the advantages and problems associated with a multi-species fishery, I shall examine the concept of the maximum sustainable yield in the light of these histories.

Murphy (1966, pp. 68–69) estimated that during the period 1932–49 the sardine population size ". . .

for a maximum sustained yield was 975,000 tons, and the yield was 470,600 tons annually. . . ."; and pointed out that "During the 1937–1945 period when the population was near that expected to yield the maximum catch, i.e., 1,000,000 tons, the actual annual harvest was 570,000 tons. This suggests that the population was 'overharvested' by about 20 percent. . . ."

It appears, however, that during most of this period the stock was well above the 1,000,000-ton level, dipping below it only in 1945; it thus could provide a yield in the order of 100,000 tons greater than 470,000 tons during those years without driving the stock below the size needed to produce a large year class, whenever environmental conditions were favorable for good survival. On the premise that it is socio-economically impractical to curtail suddenly, perhaps severely, a fishery which supports many people in both the fishing and processing industry, the concept of a fixed maximum sustainable yield is sound and Murphy's estimate is valid, provided of course that the future will never have an even longer sequence of small year classes; and provided also that the sacrifice of large amounts of yield of a single species is really the best use that can be made of the potentials of the ecological system of which the single species is a part.

If we can hypothesize, as has been done at the outset of this perspective, that the productivity in the California Current area fluctuates much less than the sizes of year classes of a single species, and if a socio-economic condition can be created within which the various species can be fished, processed and sold in proportion to their ascendency in the ecological system, then it should be possible to harvest yields continuously equal to or exceeding those of the heyday of the sardine fishery. That is to say, a multi-species fishery, processing industry, and marketing system offers the probability of full and prudent use of the fishery resources in the waters off California, and perhaps a total yield much larger than any one species is capable of supporting.

This approach would not be abandoning the principle of maximum sustainable yield, whether it be measured in tons or in dollars, or in one or the other of these plus the value of recreational satisfaction. Instead, it expands this principle from its focus on a single species to embrace the aggregate of harvestable species supported by the ecological system being fished.

For instance, by hindsight we can see in Figure 1 that the mediocre year class of 1940, succeeded by the small year class of 1941, portended a decline, perhaps severe, of the sardine population. If this sequence could have been foreseen and if a substantial portion of the fishing effort could have been shifted from the sardine to other species, the sardine decline would have been lessened and perhaps halted while the population was still at a size capable of producing large year classes such as those of 1932, 1938, and 1939. This view, though conjectural, illustrates the type of adjustments that might be made in a multi-species fishery managed under the multi-species concepts.

A shift toward spreading the fishery over more species did take place in the past, but it was too little, too late, and not in accordance with the concept of maximizing the yield of a multi-species resource. In the late 1940's, as the sardine and Pacific mackerel landings failed to supply the demand for canning, the acceptance of jack mackerel and anchovy for this purpose increased. By 1952, eight years after the sardine population had lost its capability of producing a year class large enough to sustain the population, the landings of each of these four species converged at a level that averaged about 30,000 tons per year or 121,000 tons for all four species during the period 1952–57 (Anderson and Power, 1955–57; Power, 1958–59). A combination of foreign competition in the canned fish market from the post-war resurgence of the Japanese and South African sardine and mackerel fisheries, lack of consumer acceptance of the anchovy pack, and California regulation against the processing of fish for meal and oil soon drove the processing demand down until in 1965, the latest year for which final statistics are available, the California landings of all four species totaled less than 41,000 tons (Lyles, 1967).[3]

This set of events is mentioned here only because, on the surface, it might appear as if there had existed, at the fishing and processing level, a multi-species fishery industry. Indeed, in a loosely defined sense this was one, but it lacked the most essential attribute set forth in this perspective. If it were not so lengthy, the multi-species fishery concept would be better named "the management of a fishery for achieving maximum sustainable yield of a multi-species resource," or better yet, the "management of a fishery for achieving the optimal utilization of a multi-species resource considering commercial and recreational values."

It is true also that these events following the decline of the sardine and mackerel emphasize the economic impact of fishery management concerned with the ultimate product, e.g., canned fish versus fish meal and oil, rather than the sustainable yield of the resource.

Let us turn now to a more comprehensive consideration of the problems needing solution for establishment of a successful multi-species fishing industry based on the pelagic and hemipelagic fishery resources of the California Current region. These problems exist at the research level, the fishing level, the processing level, and the fishery-management level.

At the research level the problem is to achieve an understanding of processes operating in the ecological system that is adequate to provide foresight of events such as have been observed by hindsight as related above. This is to say that the scientists in CalCOFI

[3] In 1967, according to preliminary statistics, the California landings for canning purposes of the four species totaled only about 21,000 tons. In addition, about 30,000 tons of anchovy were landed for reduction to fish meal and oil. The terms under which this fishing was permitted apparently were discouraging to fishermen and processors at existing world price levels for meal and oil. At the time the symposium was held it was already evident that the anchovy fishing effort in the 1967–1968 season would be inconsequential.

need to develop the capability of reliably forecasting long-term, middle-term, and short-term trends and events.

For the long term, this capability has been partially achieved in the assessment if the interaction between sardine and anchovy populations. It remains to be demonstrated how reliable the assessment is. CalCOFI has proposed a cautious test of its reliability, but various complications of socio-economic nature have so far prevented the test from being performed. Since this difficulty is perhaps the main reason for this symposium and its various aspects have been and are to be discussed by other participants, I shall not dwell upon it. It will be more useful to take a viewpoint broader than just the interrelation between the two species.

That the anchovy has replaced the sardine, an event which I believe to be well substantiated, implies that the biological productivity of California Current region fluctuates much less than do some of the individual members within the biological community, as I hypothesized at the outset. But we have practically no quantitative measure of the amplitude or the periods of these oscillations in productivity. It would be logical to add productivity to the items to be observed in future survey programs. Carbon 14 suggests itself, but is expensive in ship time and manpower. Perhaps it would be simpler and cheaper to go to the first trophic level and measure chlorophyll or something proportional to it. Ultimately, once the relationships are established, it might be most efficient to rely on agents that govern nutrient input and thermal energy, such as vertical and horizontal advection and influx of radiation. These processes may be measured in the near future for a number of other purposes—not just the fishery application.

In the long term and verging on the middle term are several questions raised by the historical record.

First, why do small sardine year classes occur in sequences; and why were the sequences shorter before than after 1931?

Why was year-class size inversely correlated with parental biomass in the middle term as documented by MacGregor (1964) and visually apparent in Figure 1, and yet positively correlated in long-term trend? Murphy (1966) examined this apparent contradiction in great detail and concluded (p. 51) ". . . that the average resilience of the population is a great deal less than the 90 thousand eggs produced per female might suggest, and that really large year classes are not to be expected from small spawning stocks. . . ." Although this statement probably is true, it begs the question of what processes are involved. I tend to be haunted by the sedimentary record that suggests relatively long upward and downward trends in sardine abundance, which suggest in turn that there may be similar long trends in environmental suitability for the sardine in contemporary times.

As nearly as one can tell from the record, the increase of the anchovy population did not keep pace with the decline of the sardine population. In 1946 the sardine was reduced to one-eighth of its size in the early 1930's, but the anchovy population did not reach a size rivalling that until about 1958. What caused such a lag? One could invoke the answer given by Murphy for the sardine, i.e., that a really small anchovy population cannot produce a really large year class, but again the statement says nothing of the processes involved.

This series of questions all point to the master question: What are the environmental survival requirements for bringing the young stages of the sardine, the anchovy, and each of the other important pelagic species through their respective early life histories in numbers that can be called a large year class? What do we need to measure, or what assortment of things do we need to measure in our surveys if we are to forecast good recruitment to the fishable stock of the several species? Do these recruitments become evident far enough ahead for the manager, the processor, and the fisherman to adopt a strategy in each of their several affairs that will be appropriate for maximum yields from an assortment of species and provide assurance against jeopardizing subsequent yields of any species in this assortment?

Attempts to answer questions of this type with respect to one species, the sardine, have so far eluded earnest, persistent, and expensive at-sea observations. It appears that we simply do not know what condition, or what set of conditions, to measure. It seems we should add to the survey effort, controlled laboratory experiments in which various physical, chemical, and biological environmental conditions of the kind and range of variation likely to be encountered at sea are imposed singly and in combination until the optimal condition or set of conditions is discovered and the various degrees of suboptimal conditions are evaluated.

Turning now to forecasting in the middle term which in my terminology means forecasts in advance of each forthcoming season, we are concerned not only with fishery management decisions but also with the economic necessity of improving the efficiency of fishing and processing. Achieving such forecasting capability is already being explored by research vessel surveys employing echosounding and echoranging, supplemented with species identification by actual catches of the schools producing the signatures on the sounder or sonar display. As these techniques become perfected, it should be possible for the management system, if made sufficiently flexible, to prescribe the tonnages to be taken of each of the several species appropriate to their pre-ascertained abundance. Foresight and flexible management would permit the fisherman to prepare the appropriate gear and the processor to tool up for handling the anticipated landings, and lay forward-looking marketing plans.

The short-range, within-season, forecasts are needed to increase the efficiency of fishing operations sufficiently for our catches to become competitive with foreign-produced fishery products. All of the latter are produced in economies that have lower costs of manpower, equipment, and supplies than are prevalent in this country's economy. Presently the California local purse seine fleet probably spends three-fourths or more of its time hunting for schools and one-fourth or less catching them. Only a small decrease of hunting time in favor of an increase in catching time could make the difference between profit or loss in the fishing operation. Needed here is foreknowledge as to when and where aggregates of fishable schools are more probable than elsewhere. Research needs to be directed toward attaining this foresight.

To take advantage of the forecasting capability resulting from survey and research, the fisherman needs to provide himself with the gear and skills to catch most efficiently the several pelagic and hemipelagic species in proportion to the quantities appropriate to their prospective abundance. This not only calls for the appropriate purse seines, but also midwater or bottom trawls for such species as hake or squid, or possibly even completely novel methods of fishing.

The processor, in turn, may be alerted on a day-to-day basis to prepare for handling the amounts in the various proportions of the several species expected to be landed during the several days ahead.

Upon the fishery management under a truly multi-species fishery rests the burden of utilizing the forecasts to frame regulations appropriate to the expected relative abundances of the several species in a forthcoming season and perhaps adjusting these regulations according to events within the season.

All of these manipulations depend on (i) reliable forecasts—a responsibility of the fishery research organizations—and (ii) a regulation system that can respond to the strongly fluctuating abundances of the several pelagic and hemipelagic species of the California Current region and also permit their processing to the forms marketable in competition with foreign product—whether they be canned goods, fish-protein concentrate, fish meal and oil, or some other product not yet conceived of.

In summary, this perspective hypothesizes that the fishery resources of the California Current could yield a larger tonnage on a sustained basis than ever before realized, if the resources are researched, fished, and managed as a multi-species resource. Because the resource would be sustained at the optimal level, oscillating only moderately as the productivity of the ecological system oscillates, recreational values would be preserved. To realize these benefits, serious economic problems must be solved. A major contribution to their solution would be the attainment, through research, of forecasting capability in the long term, middle term, and short term so that the fisherman, the processor, and the resource manager could plan ahead and adopt strategy and tactics that would maximize the efficiency and reduce costs of fishery operations and maximize the yield without jeopardizing the resource. Finally, the sociological portion of the socio-economic problem calls for better communication among scientists, fishery administrators, commercial fishermen, fish processors, and recreational fishermen. As I understand it, this symposium represents an experiment in providing one kind of communication channel among five groups.

I appreciate the opportunity of participating in this experiment.

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THE STATE'S INVOLVEMENT IN MARITIME AND OCEAN RESOURCES DEVELOPMENT

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I consider it a privilege to be here and address this group. Phil Roedel once commented on how difficult it is to get the broad perspective properly communicated to the oceanographic community. I had to agree, because quite frankly in my own instance, having been exposed to this broad perspective for many years, I still had no idea what CalCOFI (California Cooperative Oceanic Fisheries Investigations) was. However, it didn't take me very long since I was placed in the position of having to accomplish an overview of what was going on in California. I attended a Marine Research Committee (MRC) meeting and a CalCOFI meeting, and soon found that I wasn't the only one who had problems. Thanks again to the efforts of Phil Roedel, and others, I then made it my business to become more intimately informed on what CalCOFI was really accomplishing and what it was designed for.

It has been my good fortune through the years to have made the acquaintance of most of you, either in the course of my survey in depth of the national oceanographic structure in 1963, under the sponsorship of the Honorable Bob Wilson, Congressman from San Diego, or in connection with my association with the Ocean Research Institute of La Jolla.

In my current assignment as the Oceanic Advisor to the Governor, I am getting an overview of our total marine activity not only in this state but in the western coastal states, Mexico and Canada too since they contribute to the total Pacific basin marine community programs.

In this connection, my assignment to the Governor's staff wasn't by any particular design. I had never met the Governor when he was campaigning, but one of the members of his staff called me one day and asked if I would help with a program. Anyway it is interesting for me to go back and look over my original discussions with that staff in 1966, and very frankly I pointed out three very important things that you're dealing with: i) The confrontation between sport and commercial fishermen, ii) The confrontation between this country and foreign fisheries, and iii) That search as I might I could find no programs wherein the scientific community and economic evaluators had gotten together to establish some economic formulas by which you might sensibly approach these things.

I was then and I am now continually confronted by this cost effectiveness approach to fisheries. I might add that had we used the cost effectiveness system (I am not entirely against it I want to point out) but had we used it in the agricultural areas historically, we would not have what we term in California now, agri-business instead of agriculture.

I am not an oceanographer, nor am I an expert on fisheries, my function as the liaison between the Governor's Advisory Commission on Ocean Resources (GACOR) and the recently created Interagency Council on Ocean Resources (ICOR) requires that I be fairly well informed of all on-going programs not only in the State but in the areas referred to above and the Federal Government as well. Fortunately, I do have access to virtually all of the world's published literature as it is received by the Oceanic Library and Information Center from over 50 countries. This involves the review of well over 1,600 journals, magazines, special reports and individual studies with a gross number of ocean-oriented articles numbering approximately 70,000 annually. There are nearly 7,000 authors who have been identified as producing worthwhile articles, of this number a major portion are either residing in California or have had their training in this State.

Therefore, we must assume that one of our most valuable export items is that of oceanic know-how, an export that is impossible to be reflected in an economic formula upon which our gross national product is reported. In spite of the general impression, the news media to the contrary, Governor Reagan is deeply concerned about the necessity of supporting our discipline-oriented educational facilities related to the future requirements for the dynamic development of our ocean resources. We have under study right now the requirements not only for graduate students but also the need for marine technicians. Every agency of the State government that has ocean-oriented activities within it, is being directed to participate in the production of a comprehensive ocean area plan. The 1967 Legislature with concurrence of this Administration enacted the Marine Resources Conservation and Development Act of 1967 and this carries a mandate to the Governor to prepare such a plan and submit it to the 1969 Legislature.

In the meantime we are engaged in making an inventory of every on-going ocean-oriented project within the State. This will be accomplished by creating a unique planning, programming and budgeting system for the purpose of identification and analysis. Once the initial stage of this system is accomplished then recommendations from qualified persons will be sought for establishing priorities for legislative emphasis, funding, and allocation of our resources; natural, equipment, funds, and manpower. I have never been able to become enthused about planning until I had a fair idea of what we were talking about, hopefully our system will provide a working inventory.

I do not go along with the theory that once you have a planning, programming, and budgeting system that you immediately begin to apply cost effectiveness to everything that you do. In my opinion, the status of our fisheries in this country is one that you can relate to our agriculture as it was some 30–40 years ago. It is almost incredible the number of Congressional resolutions that are dealing now with studies of estuaries, studies of fisheries, things that will hopefully assist in developing some new or better approach to our maritime knowledge and to our posture in the International community.

We could make a lot of facetious remarks about the ineptness of some of our legislative bodies, but quite seriously, I become more impressed every year as I deal with this subject, with the know-how of a number of our Congressmen and Senators, with the desire on the part of our legislators to become better informed, but I am also almost startled by the lack of communication between people who have the need to communicate and the need to have a better understanding of their problems.

About a month ago I made a trip to Eureka, Fort Bragg and Crescent City, with Congressman Dan Clauson and I spent most of my time in individual discussions with fishermen in sport and commercial areas, boat riggers and with people who are really out there working with their hands. I was quite surprised to have them invariably say, "you are the first person who has ever taken the time to sit down and go through our shop and really see what we're confronted with." Well, that isn't entirely true, because I happen to know that a good many people from our Fish and Game Department call there. But I do admit that I am in a little different position and I can perhaps make a little different type of inquiry than has been done before. Last Friday I flew to Crescent City with Lt. Gov. Finch who is Chairman of ICOR, and I can assure you that he takes the opportunity every time he is in one of these coastal communities, to meet with ocean industry people, and listen to their discussions and I think this will all pay dividends.

In Eureka about six local fishermen and a couple of people from nearby Humboldt State College met for the first time. The fishermen were complaining about the lack of information. One man made this statement, "I'm 30 years of age and starting in the fisheries business. I am going to make it my career." I remember he mentioned black cod and saying, "I don't know why I got into that, I don't know very much about it. Where would I find something about it?" Sitting in the meeting was a young fisheries professor from Humboldt State, how qualified I don't know, but I am sure there will be benefits from those two getting together.

Now, changing quickly to a subject which I think is vitally important. I can say for the first time that there is an economic study going on and going on in depth. It is being conducted by Prof. S. V. Wantrup, College of Agricultural Sciences, University of California who is a member of the Governor's Advisory Commission on Ocean Resources.

We have had many letters from fisheries experts who are encouraging us to go at this program in depth, and I have noted from Phil Roedel's initial address to you that the CalCOFI Committee has recognized that you must take further steps toward communicating the results of your scientific studies, get them into the hands of the public, get them into the hands of the legislators, get them into the hands of the sociologists, and the economists, and, by the way, to the banking institutions.

I am sure that most of you know that approximately one-third of our international monetary deficit, which is in the billions, is related to the imports of fisheries products. Now, I don't know the cure, but I can assure you that the same kind of approach has to be taken in the fisheries business as has historically been taken in the agricultural business. You cannot take the kinds of actions that are taken now on a piecemeal basis and hope to improve our international deficit situation. I do believe that if we can enhance the economic development of the fishing industry these deficits can be overcome. It is a great industry, and not one in which people should hesitate to participate. I do not agree with the people who say young men will not go into fisheries. I have already seen and I have already met and I have already had discussions with young men who would like to make fisheries their career and have already made that decision.

I think we have to improve our inter-communication in these various areas and this is one of my functions in this administration. We are not trying to give you people the idea that we are going to solve all your problems. I would say that one of our projects was to get some incentive programs going, and if you recall the only tax relief bill that passed the 1967 Legislature, and was approved by the Governor, was the one related to commercial fishing and research vessels. Even though there was a pretty serious battle over that and the county assessors fought us right down the line, it has been done. That may be an indication of our interest.

I do believe there are other tax incentive ideas that can be developed that can help the fishing industry. But this is out of the pure research area and into the socio-economic area.

It is my opinion that CalCOFI can be an organization that can carry on and perhaps expand its influence, into legislative areas and into economic and financial areas without diluting the fine scientific approaches that have already been so ably followed.

In closing, I would like to compliment those responsible for the way in which you have developed this particular CalCOFI program. I have contended for the past several years that those of us interested in the ocean, most of us with very special interests, have failed to get the working level segment of the public sufficiently involved. Your program will very definitely contribute to a better understanding among all concerned with the future planning for a more intelligent and practical approach to our complex ocean problems. It is truly a privilege to be here.

DISCUSSION

ISAACS: One extremely important aspect of these fisheries, particularly the confrontation you speak of, sports versus commercial, is perhaps getting somebody like Wantrup to work on the problems of real comparison of these two uses in some rational way. To date, economics has always been brought in by the coat tails . . . but there is more to life than just the economics and it seems to me there are more fundamental ways perhaps of making these comparisons.

Wantrup is working on commercial fisheries right now; the recent project you mentioned. Wouldn't it be wise to set up a more rational defensible sort of comparison between these uses so they can at least be reduced to numbers?

GILLENWATERS: You are entirely correct. This is a kind of a break-through with Wantrup. I told the National Commission I was getting pretty badly put out with the Federal system because they continue to grant funds for research projects on specific species or specific piece of shoreline, or specific dredging program, but I have yet to see a grant which has written down the results of that research into some economic study, other than this catch phrase "cost effectiveness". I would like to point out that the nearshore waters have a total value, less shipping, of $1,286,413,000 to California. Of that, $450 million is tourist expenditure, $316 million boating expenditures, $107 million sports fishing, $10 million SCUBA diving, $3.8 million surfing, $313 thousand boat fares and $23 million fishing industry.

That $23 million, if you multiply it out, means more to our gross national product in terms of benefits to California, than $23 million.

It is my observation, and I haven't had a chance to evaluate it, but I hope that our own California Fish and Game Commission will drop this business of how much the sports fishermen pay in, so much for lines and so much for this. I know they are confronted with this when they go to the Legislature, but I think that with a better understanding of the contribution to the GNP that perhaps we can make a better case for a better understanding of the scientific results.

I also think that with the economic formulas being developed we will get a better understanding of conservation. Now again, I have to admit I am placed in a very unusual situation. I am getting, for the first time, an overview, and if I were to plot a course of my opinion it would look like the mountain road coming up here from the valley. Two or three years ago I had a very definite fixation that there should be a wet NASA. I helped draft the bill. I admit Congressman Wilson and myself weren't too enthusiastic that that was the proper way to do it, but we did feel we'd stir up the natives, and we did. The Bureau of Commercial Fisheries, the Navy and the Department of Commerce, got busy showing everybody how good they were, and everybody got a little bit better.

I proposed to the National Commission that we forget about maintaining these commissions a long time, but put a death sentence on them and they must expire at a certain time and that in lieu thereof we create a Federal planning authority with some muscle on it so that 3–4 years from now you could have a separate marine department when you learn more.

Within the State, I presume I am going to end up recommending a somewhat similar thing, but my path of opinion changes constantly. You talk about a woman changing her mind! I have changed my mind so many times, as I become exposed to these problems, that I almost dislike to make a public speech because I am going to have to eat some of it a couple of years from now and I know it. But at least, we are now getting the sore spots exposed.

I will definitely take your suggestion and will put more pressure on some type of economic formula that will take it into consideration.

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VIEWS CONCERNING USE OF THE LIVING RESOURCES OF THE CALIFORNIA CURRENT

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I have been asked to express the views of the Bureau of Commercial Fisheries concerning the legal, economic, sociological and technological problems impeding the best use of the living resources of the California Current and how they can be resolved. The impediments are generally rather well known. It is their resolution which presents the challenge.

A major objective of the programs of the Bureau of Commercial Fisheries is to seek the resolution of problems which handicap the economic well-being of the domestic fishing industry and hinder the best use of the fishery resources. Success of Bureau research and service programs, however, depends on close collaboration and cooperation with other parties, especially State agencies.

Pertinent to the present discussion is that regulation of fishing in the United States, aside from that done under treaty with other nations, is done under State laws rather than Federal statutes. As a result, the States have major influence or control over the development and utilization of the nation's fishery resources. Bureau influence is largely advisory and, depending on the policy of the States, its role is active or passive in the development and rational utilization of the aquatic living resources.

To a considerable degree, varying with the situation, State and Federal fishery programs are both complementary and interdependent. It is common, for example, for the Bureau to provide research information of vital importance to a State and for State policy and regulations to affect sharply the degree to which Bureau goals can be attained. The interdependence of State and Bureau programs means that team work is essential and that a vigorous State agency is important to the Bureau and vice versa.

IDENTIFICATION OF THE PROBLEMS

The title of the present session of this symposium categorizes the problems which are impeding the best use of the living resources of the California Current as legal, economic, sociological and technological. I will treat the legal and sociological problems as one category and the economic and technological problems similarly. In each instance the pair is so closely related.

It is also convenient to categorize the principal fisheries which operate in the Calfironia Current because they have quite different characteristics and problems. I would identify three, the "tuna" fisheries which take the tropical and temperate tunas; the "wetfish" fisheries which harvest mackerels, anchovies and bonito; and the "bottomfish" fisheries which harvest, though not exclusively, species taken by trawling.

Californians generally do not think of the tropical tunas as a resource of the California Current, probably because they occur in its southern extension off Baja California and rarely in commercial quantities off southern California. I have included them not only because they support California's most important fishery, but because the long-range tuna fleet's experience in overcoming economic difficulties has been more successful than that of other elements of the California fishing fleet. I especially wish to mention things that the tropical fleet has done to place itself in the more enviable situation.

A major factor preventing the rational use, including expansion, of U.S. fisheries, lies in regulations existing at the State level. Tabulations exist in various recent publications which indicate that California has a share of prohibitions against efficient fishing and better utilization of the resources available to the several users. This group is well aware of the restrictions on the kinds of commodities into which fish may be manufactured. You are well acquainted with the restrictive quotas applied to the anchovy fishery with respect to the total quota and the geographical quotas. You also know that there are prohibitions against certain gears and the capture of certain species for commercial use.

The objective of too many regulations, unfortunately, has not been to maintain the fish populations at levels which permit maximum sustainable yield and to assist in their efficient and equitable harvest. Rather, the origin has been sociological and has resulted too often from conflicts between and among users of the resources—conflicts between sport and commercial fishermen, among sportsmen and among commercial fishermen. Regulations which have that basis permit neither maximum use of our fishery resources nor their efficient harvest, and they inevitably discriminate against some users.

In that connection, it is encouraging that a number of recommendations have been made recently for a policy for the management of the marine fishery resources which, if adopted, should go far to remove legal and sociological barriers which impede the best use of California's living resources of the sea. The recommendations which are similar, appear in *California and Use of the Ocean* (University of California, Institute of Marine Resources, IMR Reference

65-21, October 1965) and *California Fish and Wildlife Plan* (California Office of State Printing, Volume 1, Summary January 1966) and *Proceedings of the Governor's Advisory Commission on Ocean Resources.* References for the recommendation made by GACOR are provided in *Compilation of Recommendations of the Governor's Advisory Commission on Ocean Resources* (December 20, 1966, State Office of Planning, Department of Finance). Although the separate recommendations differ slightly, essentially they urge that the marine resources be managed to attain the optimum sustainable yield while encouraging efficient harvest. They recommend that where recreational interests are involved, priority should be given to reasonable and legitimate demands of recreation and that the commercial fishery should be encouraged to use any harvestable surplus. Implementation of that policy would be appropriate for the situation in California. It would go far to eliminate conflicts among users of the resources and thereby automatically contribute to the efficiency of commercial fishing.

Implementation of a management policy like that described would make it much easier to tackle the major economic problem which has long confronted California fishermen—the competition from imported fishery products from other states and foreign countries. At least 50 percent of the fresh and frozen fish and perhaps 80 percent of the fish meal utilized in California are imported. Whereas present requirements for these products exceed the landings, local catches are delivered in a manner and at prices as to limit their sale. The fact that California fishermen must pay higher prices for vessels, gear, salaries, boat repairs and insurance is largely responsible for their higher production costs.

Much more attention must be given, now and in the future, to means of lowering the cost of catching fish and improving the quality of the landings if California fishermen are to compete successfully and to increase their share of markets in California and elsewhere. The key to accomplishment in this area is the application of technological advances. An array of technological improvements are required. Among them are improvements to existing vessels and gear, new types of vessels and gear, improved practices of handling and holding of fish at sea, improved processing techniques and new products. The application of ocean research results to improve fishing strategy also has its place.

The introduction of improved technology in the fishing industry obviously requires money. Except for the tuna fisheries, investment capital has not been attracted to our fisheries for many years and fishermen generally have had difficulty obtaining loans to outfit, repair and replace their vessels. The situation described has been particularly critical for the wetfish fleet based in San Pedro. The plight of the wetfish fishermen stems from the competition from imports but it is compounded by the small quota of anchovies for reduction purposes. Were the quota higher, volume of production conceivably would reduce unit production costs.

Beyond the application of technological advances and the need for capital, marketing of the catch is yet another problem in some fisheries of the California Current. There appears to be a need for vigorous marketing programs to expand the market available to the bottomfish producers, especially in northern California where vessels are on limits and unable to fish full-time. It would seem that well directed activity in this area might recover specialized markets now held by foreign products.

Comparison of events in the tuna fisheries with those in the wetfish fisheries and the bottomfish fisheries over the past decade attest to the contribution of technological advances and investment capital. The comparison is not entirely fair, however. Tuna is a high-priced fish; domestic demand for the catch exists; conflict among harvesters is minimum; and regulations are either not needed or based solely on the principle of maximum sustainable yield. Recovery of the tuna fishery from near disaster in the late 1950's caused by foreign competition is well known. Improvement in their situation resulted from the introduction of the purse seine power block which permitted conversion from bait fishing to seining and also the introduction of new vessels of advanced design. Today, this fishery probably is in the best economic condition of any large group of fishermen in the United States.

I should say the observations about the economic condition of the tropical tuna fishery are not meant to imply that tuna fishermen are without problems. They have many but, so far, the majority has demonstrated the ability to adjust to changing conditions and to make a profit.

Except for the tuna fisheries, California fishermen generally have been free of international problems which inevitably occur when more than one nation harvests the same resource. I will not get into the international problems of the tropical tuna fisheries but will mention that foreign harvesting of resources off California has begun. The degree of future impingement by other nations will depend to a large extent on whether California is adequately harvesting its resources. If it does and can prove it, foreign impingements can be controlled. Success here depends on the State's ability, together with the Federal Government through the Bureau, to establish a defensible position regarding the optimum harvest of the living resources occurring off its shores.

SOLUTION OF THE PROBLEMS

The fundamental step towards resolving the problems impeding the best use of the living resources of the California Current is adoption and implementation of a management policy like that previously cited. I refer to the management of the resources to obtain the maximum sustainable yield, with appropriate consideration to the interests of both commercial and sport fishermen in harvesting the resource.

It is clear to those of us in the Bureau, in the California Department of Fish and Game and the Scripps Institution of Oceanography who have been engaged jointly in CalCOFI that the necessary scientific information is available for the State to manage the major resources in accordance with the policy described. Unfortunately, this situation does not appear to be generally well known to those outside this circle.

Since the capability to carry on a more enlightened system of management of the resources does exist and the impediment to its adoption perhaps may lie in conflicts among users, more effort needs to be spent preparing and disseminating popular material on the results of the scientific research which has been accomplished. It is important to remind ourselves that conflicts often arise not only due to lack of scientific facts but also due to the lack of presentation of known facts in an intelligible fashion. Certainly more effort is needed in extension activities of various kinds, and it is required on a continuing basis.

If a better job were done informing the public of research and management results, many of the conflicts we have grown accustomed to would not arise. It is safe to say that if the facts about our resources were better known squabbles between sportsmen and commercial fishermen and within each group, would subside to the point that fishermen might realize that they have more in common than they have to quarrel about. They would find that fluctuations in the resources are caused by such things as competition among the species and changes in the environment as well as by man and that it is possible to control the man's activities in a rational manner.

Besides maintaining fishery populations at levels which permit maximum sustainable harvest, regulations should be designed to encourage fishing efficiency. Harvesting efficiency is the key to successful competition with foreign fishermen because of our higher living standard. Historically, regulatory practices have often outlawed newly developed and more efficient gear or vessels in favor of old established units. Harvesting efficiency cannot be promoted if fishermen cannot take advantage of technological advances.

Aside from providing the basis for the rational use of the living resources, there are other important ways in which information resulting from fishery research or fishery oceanography can assist harvesting efficiency. The few areas which I will mention fall within the capabilities of the Bureau's Fishery-Oceanography Center at La Jolla and its Ocean Research Laboratory, Stanford. Research underway at these laboratories as it progresses will provide the fisherman with information which he can use to improve his tactical scouting and catching operations. Already considerable progress has been made in forecasting space and time variations in the distribution and abundance of albacore along the west coast. Also, radio advisories are provided to albacore fishermen as well as sea surface temperature charts which are used in their fishing operations. There is no reason why similar information and services cannot be developed for other fisheries in the California Current as we increase our understanding about the resources, provided the funding situation is favorable.

Besides the contributions which biological and oceanographic research and services can make towards the rational and efficient harvest of the living resources of the California Current, the Bureau looks to important contributions which can be made from research in technology, marketing programs and gear research.

Whereas government, both State and Federal, as well as the academic institutions, must assume the leadership for and the conduct of the biological and oceanographic work, the fishing industry should do an appropriate share of the work in marketing and technology. It is not entirely clear to me just who should assume the major responsibility for the gear research. I think that I favor the idea of researchers developing the understanding of how the biological characteristics of various species of commercial fish may affect their reaction to fishing gear of conventional and unconventional types. Such work can suggest or even demonstrate how fishing gear can be made more efficient. Application or adoption of the findings would be up to industry.

Unfortunately, too little attention is given to problems of handling of the catch at sea, its processing ashore, and its marketing and distribution to the consumer. Industries depending on the resources of the California Current would become more competitive if they could improve present methods in these areas, develop new products, reduce labor costs and recognize the markets of convenience. The fishing industry, if it is to compete with agricultural products and foreign fishery imports must be imaginative, creative and watch for the application of new developments. It spends too little for research and most of it is in the field of quality control rather than the other areas mentioned.

Solution to the problem of giving more attention to technology and marketing in California's fishing industries is difficult because, other than in the tuna industry, the plants are generally small and independently operated. Similarly, most vessels are independently operated rather than fleet controlled. Separately, small independent operators cannot contribute effectively to technological research and market promotion. It appears that somehow means must be taken to make it possible for industry to pool its resources and efforts.

Our Bureau, of course, has a small technological laboratory at Terminal Island and we also have a small marketing program. Our resources are not, nor likely to be, equal to the entire effort required in technology and marketing. Even if they were, I doubt that we are in a position or have the capability to judge best industry's requirements in all matters. I believe that we should continue to undertake special projects in these areas, to coordinate activities where appropriate and to assist in other ways according to need.

As mentioned earlier, money is a key requirement if the California fishing fleet is continually going to adopt advanced technology in its methods of operation as such becomes available. At the present time, fishermen generally have difficulty obtaining loans to finance the cost of constructing, maintaining and equipping their vessels. Banks and other lending agencies are reluctant to loan money for these purposes. While the Bureau has financial assistance programs which are helpful, they are not adequate to handle all the fishery loan requirements. The availability of money for loans to fishermen does not seem likely to improve until a more favorable climate exists, one which encourages fishing and offers reasonable opportunity for California fishermen to compete for the market in the State and elsewhere.

Creation of a better climate requires the joint effort of the State and Federal Governments and the fishing industry and it requires public support. It is incumbent on all parties to work to this end. If we do not utilize the living resources off our shores for our benefit, other nations will. If there is doubt about that, we need only remind ourselves that the prelude to large scale fishing on the part of other nations is now occurring off our shores.

Calif. Mar. Res. Comm., CalCOFI Rept., 13: 95–96, 1969

VIEWPOINT OF THE U.S. BUREAU OF SPORT FISHERIES AND WILDLIFE

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The Bureau of Sport Fisheries and Wildlife operates under the Department of the Interior. Actually, the name "INTERIOR" is a misnomer—for the Department should more properly be called the "Department of Natural Resources," since it is the principal conservation agency of the Federal Government. The Bureau of Sport Fisheries and Wildlife and the Bureau of Commercial Fisheries are the two Bureaus of the Fish and Wildlife Service which date back to their antecedents—the Biological Survey, the Bureau of Fisheries, and the U.S. Fish Commission which began in 1871.

Operations of the Bureau of Sport Fisheries and Wildlife, specifically in marine waters, however, began in 1959 when the Secretary of the Interior was authorized and directed by the Congress "to undertake continuing research on the biology, fluctuations, status and statistics of the migratory marine species of game fish of the United States and contiguous waters."

While it was recognized as early as 15 years ago that marine game fish angling was increasing in popularity at a fast rate, its magnitude was uncertain. In 1955, the U.S. Bureau of Sport Fisheries in cooperation with the Bureau of the Census began a national survey of hunting and fishing which is carried out every five years. In that year, it was determined that over 4 million citizens participated in marine game fish angling. The survey in 1960 showed that this number had increased to over 6 million. In that year, a study was made to determine the numbers and poundage of fish taken. The best estimate obtainable was 1.4 billion pounds. This compares with a catch in the same year and in the same waters of 1.7 billion pounds of edible species by our commercial fishermen. Even taking into account the possibility of errors in calculating a population from a relatively small sample and the known proclivity of fishermen to sometimes exaggerate the size of their fish, the catch is still impressive.

The 1965 survey disclosed that over 8 million citizens were serious marine game fish anglers. This is an increase of 82 percent in 10 years. In contrast, the United States population during the same period increased only 17 percent. In carrying out this means of recreation, the sport anglers not only paid for tackle and bait, but many drove long distances, paying for gas and oil, hotel and motel accommodations, food, boats and motors, boat charters, etc., an amount totaling almost 800 million dollars. The survey showed that over 2 million of the anglers fished on the Pacific coast, spending an amount estimated at almost 300 million dollars in 1965 in pursuing this sport. The Pacific coast commercial catch of fish in the same year was valued at the fisherman's level at about 125 million dollars. By the time the commercial catch reaches the consumer level, it has probably generated to the economy of the country two or three times the value to the commercial fishermen, or about the same as for the sport fishery.

We don't have a breakdown by states, but because of its population, better weather, facilities, and species available, California undoubtedly enjoys a big share of the sport fishery effort and catch.

I have particularly stressed the value of the sport fishery because too often it has been overlooked or minimized in discussions of our marine resources. This is particularly true at the National level in spite of the fact that a National Academy of Science, Committee on Oceanography report states that one of the highest returns for research dollars invested in oceanographic studies could be obtained through research on recreational fisheries. Oviously, sport fishing has reached such proportions that it must be considered more seriously if we are to manage intelligently the resources of our marine environment, and this applies particularly to the living resources of the California Current system.

Conflicts between sport and commercial fishermen are recognized by the U.S. Fish and Wildlife Service as being detrimental to the wise utilization of our marine resources. The Service recently appointed committees from both Bureaus to discuss these problems. The only current conflict recognized in California waters was the one related to the northern anchovy. The commercial fishermen would like to harvest a greater tonnage of this species, and the sport fishermen are opposed to this, based on the not unreasonable hypothesis that this species is essential to sport (and commercial) species as a forage fish, and that the commercial fishery, once begun, would continue to expand until the resource was reduced to a bare subsistence level as has occurred with the sardine.

Among other things the Service has recommended that it should:

"1. Work toward representation of both sport and commercial fishing interests on interstate, national, and international fishery committees and commissions where appropriate.

2. Work with state fish and game agencies and interstate commissions to develop comprehensive sport and commercial fishing statistics.

3. Work with state fishery agencies to establish local advisory communities to assist state and federal agencies, sport groups, and industry to prevent or resolve conflict issues.
4. Make itself available to help mediate sport-commercial fishing conflicts when called upon by appropriate officials.
5. Take advantage of opportunities to participate in meetings where sport-commercial fishing issues are to be discussed."

Other recommendations were suggested for each Bureau and State fishery agency.

Actually, the policy of the Fish and Wildlife Service has not changed since it was first expressed by Assistant Director, Charles E. Jackson in 1940, restated by Thompson in 1953, and again by the Fish and Wildlife Service in 1967. This includes the following points, and I quote:

"a. The Service, lacking the regulatory powers of the states, is concerned with conservation based on technical information and will not take sides on social and political issues.

b. When a fish resource is not sufficiently large to permit both commercial and recreational fishing, it should be used so that the greatest number of citizens will benefit.

c. The Service is against waste, overfishing, and depletion, but also is against undocumented charges of these.

d. The Service urges that both sides actively support their respective associations, interstate fishery commissions, federal and state fact-finding, and equitable distribution of costs between groups."

Sportfishing in the marine environment will undoubtedly increase in future years. As a nation we enjoy more leisure each year. Our workweek has been reduced during the past half century from around 60 hours to about 40 hours per week. Several trades and professions now have a workweek of 35 or 36 hours. More and longer vacations have also tremendously increased leisure time for American citizens. The amount of money spent on vacations has doubled since World War II, while the amount spent for liquor, for instance, has increased by only 7 percent.

It is very fortunate that we do have more leisure time. The stress and strain of modern living, particularly in our burgeoning urban communities, makes it increasingly necessary to seek meaningful, relaxing, recreational opportunities and many are turning to marine game fishing as the answer.

A conservative forecast shows that we can expect a continual growth in the number of marine anglers to 18 million by the year 2000. More than 95 million days were spent by anglers in coastal fishing in 1965—and this amount is expected to increase to 360 million days by the year 2000. Since the population of California is increasing faster than that of most states, we can expect more than the average increase in sport fishing pressure here.

Some of the living resources have already suffered declines in abundance partially, at least, from overfishing. Many more may suffer similarly from the destruction of their environments. The estuaries, where many of our ocean species spend part of their lives, are continually being degraded by draining, filling, dredging, spoil deposition, and pollution from many sources. Pesticides and herbicides, draining from agricultural areas, have invaded the estuaries and also the ocean. Thermal pollution is another factor that will become more prevalent and its effect is unknown.

Obviously, we are going to need more facts if the California Current living resources are to be utilized more wisely. One of the greatest needs is a sport fish statistical program which will produce total catch by species and amount of fishing. Increased research, particularly on problems related to the sport fishery, will be necessary, since in the past this aspect has not received the attention it deserves. More funds will be required. The research should be coordinated between all state and federal laboratories working on these problems, so as to produce the most knowledge with funds provided. Fortunately, the relations between laboratories has been good. We at the Tiburon Marine Laboratory have received assistance many times in the past from both state and federal laboratories for which we are grateful, and have offered assistance in a small way to the other laboratories when we were able. We will do our part to see that these relations continue. Working together we probably will never solve all the problems, but perhaps we can show the way towards realizing the utmost from this natural resource.

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USE OF THE PELAGIC LIVING RESOURCES: THE LEGISLATIVE POINT OF VIEW

WINFIELD A. SHOEMAKER [1]

We are all aware of the statistics of California's dynamic growth, which by almost any measure—rate of population increase, gross economic product, variety and volume of agricultural, national resource, and industrial products, or miles of freeways and numbers of motor vehicles, for example—exceeds that of the other states, as well as most *nations* of the world. Only very recently, however, are we becoming aware of and concerned about the impact of this explosive growth upon the extraordinary variety and abundance of natural resources that contribute so much to the unique qualities of California life—a heritage which is perhaps unequaled by any political entity in the world. The result of this increasing awareness is a growing emphasis by many elements of the public and private sectors on the development of a much broader, comprehensive view of the effects of growth upon our environment, and the formulation of new public policies mandating the more rational, responsible, factually-based management of our remaining natural resources in the total public interest.

Because of its capacity for direct response to the mood and needs of the people, this new emphasis on environmental and resources planning is perhaps most dramatically manifested in the State Legislature, in which I am privileged to serve. Thus, we have seen the increasingly successful legislative effort in recent years to develop more comprehensive resources and environmental management policies in a wide array of problem areas such as transportation and freeway planning, forest practices and watershed management, the control of air and water pollution, the preservation and conservation of open space, the meeting of burgeoning outdoor recreation needs, the regulation of such environmental pollutants as billboards and junkyards, and regional resources and development planning in such unique areas as the Lake Tahoe Basin and the San Francisco Bay Area.

However, as vital as the success of these programs is to the maintenance and improvement of the quality of life in California, they are focused essentially on the use of resources and management of the environment on the continental land mass. They are not directed toward the orderly conservation and development of the last, and potentially the richest, untapped natural resource in California—the proximate Pacific Ocean and its coastline. The full significance of this resource becomes apparent when one realizes that California—as a state of the United States—is economically, scientifically, and strategically more important than most maritime nations of the world, and that by 1980 over three-fourths of its rapidly-expanding population—perhaps some 25 million people—will live in the counties and metropolitan areas along the 1,200 mile California coast.

In recognition of these facts, in 1965 I was privileged to be appointed Chairman of the Assembly Subcommittee on Marine Resources by Chairman Edwin L. Z'berg of the parent Committee on Natural Resources, Planning and Public Works. The Subcommittee was charged with the responsibility of conducting the first major legislative examination of the policies and programs governing the conservation and development of the resources of the marine and coastal environment in California. Based upon our studies, in which we reviewed in depth the roles and responsibilities of the many federal and state agencies concerned with our ocean resources, and during which we reviewed the carefully-considered views of many distinguished representatives of the academic community and the private sector, the Subcommittee concluded that there is an urgent need to replace the existing series of inadequate, uncoordinated state policies and programs in this field with a comprehensive, coordinated state policy and program ensuring the long-range, multiple-use conservation and development of the resources of the California marine and coastal environment in the total public interest.

Responding to this conclusion of the Subcommittee, in the 1967 Session of the Legislature I successfully authored the Marine Resources Conservation and Development Act of 1967. This Act, the passage of which places California in the forefront of the maritime states in marine and coastal resources policy, declares it to be the policy of the State of California ". . . to develop, encourage, and maintain a comprehensive, coordinated state plan for the orderly, long-range conservation and development of marine and coastal resources which will ensure their wise multiple-use in the total public interest . . ." To implement this policy the Act mandates the preparation of a "Comprehensive Ocean Area Plan" by the Governor, which is to be reviewed by the California Advisory Commission on Marine and Coastal Resources created by the Act. The Plan, which is intended to provide the basis for long-term continuing legislative and administrative action, is required to contribute to the achievement of such specific objectives as the increased use of the mineral and living resources of the sea, the improvement of commerce and transportation, the wise use of coastal, tide, and submerged lands, the expansion of knowledge of the marine environment, the encouragement of California leadership in

[1] At the time of the symposium, member of the California State Legislature and Chairman of the Assembly Subcommittee on Marine Resources.

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the marine sciences, the improvement of scientific capabilities in the development of marine resources, and maximum cooperation and coordination of state marine resources programs with other levels of government, other nations and the private sector. Establishment of the Commission, which will be composed of representatives of the academic, research, development, and marine law communities, both public and private—including the State Legislature—concerned with the conservation and orderly utilization of the resources of the marine and coastal environment, ensures that the broadest possible range of expertise will be brought to bear on the formulation and adoption of public policy in this vitally important and complex field on a continuing basis.

In addition to reviewing the interest and role of the State in the conservation and development of marine and coastal resources, and recommending the organization structure of state government which can most effectively carry out the provisions of the Comprehensive Ocean Area Plan, the Commission is charged with the responsibility of reviewing and recommending the appropriate legislative or administrative action relative to each specified element of the Plan, which include the effects of population growth and urbanization on the marine and coastal environment; land use in the coastal zone; the administration of tide and submerged lands; the conservation and utilization of the mineral and living resources of the marine environment; recreation; wastes management, water quality, and pollution control; water and power development, including use of nuclear energy; transportation and trade in the coastal zone and on the high seas; engineering and technology in the coastal and deep ocean environments; research and education; weather, climate, and the monitoring of oceanographic conditions; and social, economic, and legal matter relative to the conservation and utilization of ocean resources. To provide the Commission with the soundest possible basis for the evaluation of these Plan elements, the Act directs it to undertake a comprehensive investigation of all aspects of the marine sciences and the marine and coastal environment in and proximate to the State, including a review of the known and estimated future needs for natural resources from the marine and coastal environment necessary to maintain an expanding state economy, a survey of all existing and planned marine science activities in the State, and a determination of the surveys, applied research programs, and ocean engineering projects required to obtain the needed natural resources from the marine and coastal environment.

Within the context of the comprehensive state policy established by the Marine Resources Conservation and Development Act of 1967, utilization of the pelagic living resources are obviously a major consideration. Although it will be necessary to await the data required to be developed under the Act for a precise notion of the total significance of the living resources of the proximate ocean to the future of California, from all indications it is apparent that they represent a major underutilized resource. In fact, testimony received by my Subcommittee revealed the curious situation that although California is among the leading commerical fishing states in the nation, the landings of fish in the State are trending steadily downward. This paradox persists in spite of the steady upward trend in the use of fish in the State, nation, and world as a source of cheap animal protein, and increasing research evidence suggesting the large underutilized fish resources in the California Current Area. Included among the many complex reasons for this situation are the restrictive state laws which are often based upon inadequate data or have been successfully pressed by conflicting interests among the commercial users themselves.

Sharing—and often conflicting with—the utilization of pelagic living resources by the commercial user is the sport fisherman, who as a member of the rapidly growing California public is increasingly demanding this recreational opportunity.

Complicating the existing and potential conflicts between the commercial and recreational users are the effects of uncontrolled growth on the living resources of the sea, such as those produced by irreversible modifications of the shoreline and bays by dredging and filling; the use of ocean areas for the disposal of municipal, industrial, and agricultural liquid and solid wastes; and the pollution and seismic explosions generated by offshore mineral and petroleum operations. Additional complicating factors are the retention by the Legislature of the power to regulate the taking of fish, and the intrusion of foreign fishing interests—legally or illegally—into California ocean fisheries.

In view of the tangled and complex nature of the obstacles to achieving just this one objective of the Marine Resources Conservation and Development Act—" . . . the increased utilization of . . . food and other living resources of the sea . . ."—it is clear that we have our work cut out for us. The problem is at once technical and political—with the achievement of political success clearly dependent upon a solid base of scientific and technical information. However, the Act provides the mandate—and the tools—to achieve both goals, by authorizing the inventory of harvestable fish population and associated ecologies and the determination of the methods of optimums long-term utilization, and requiring the recommendations for appropriate legislative and administrative action for the balanced conservation and utilization of the living resources of the marine environment.

Because the resources of the sea are largely public property, and not susceptible in any degree to private ownership and control, the responsibility of the Legislature as the direct representative of the people is clear. I believe that passage of the Marine Resources Conservation and Development Act of 1967 is solid evidence that we have taken the first step toward defining and protecting the public interest in the living resources of the sea, and in partnership with the spectrum of interests—public and private—we stand ready to take all the additional steps necessary to solve the legal, economic, sociological, and technological problems impeding their best use.

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THE POINT OF VIEW OF GOVERNMENT: CALIFORNIA LOOKS TO ITS OCEAN RESOURCES

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I am very happy to be here this morning. I believe that what you discuss during these three days will be of great benefit to us all.

With respect to our obligations to manage our resources in the ocean, the following considerations should be kept in mind. There is no doubt that the State has the power to enact legislation for the conservation of its fisheries, excepting only those areas otherwise covered by Federal legislation, such as fisheries treaties. In addition, the Supreme Court of the United States has held that the State's laws may govern the conduct of its citizens on the high seas respecting matters of legitimate interest to the State.

Moreover, the State has the authority to regulate landings of fish in the State and can control fishing activities within the territorial sea. On the other hand, the State does *not* have authority over foreign fishermen, so long as they are fishing in international waters.

As you know, the Department functions under Constitutional law and Legislative law. We also operate under policies of the administration and the Fish and Game Commission. The Legislature has delegated to the Commission the authority to set regulations for hunting and sportfishing. Commission authority over commercial fisheries is limited but does extend to issuance of reduction permits, the shrimp fishery, and some other matters.

The Department, as I mentioned, operates under administration policy, and as you are well aware, Governor Reagan is trying to effect economies in State Government. We are cooperating with the Administration by doing everything we can to reduce the cost of operating our Department, without reducing essential services.

As to our funding, approximately 85 percent of the Department's income is from the sale of hunting and fishing licenses, tags, and stamps. The other 15 percent comes partly from fish and game fine monies, federal aid, various contracts with other state agencies, and from commercial fisheries taxes.

I mentioned that the Department works under Commission policy, and one of the areas the Commission has asked us to look at very carefully is the area of marine fisheries, and particularly the portion of our work which is oriented primarily toward the benefit of the commercial fisheries. We estimate that the cost of these programs now exceeds our income from the commercial fishing industry by more than $1 million a year, and the imbalance is continuing to increase.

We are currently holding a round of discussions with industry and with sportfishing interests trying to find a way to make our commercial fishing oriented programs more self supporting. We have not found a solution yet, but we will continue to work with all interested parties until we do solve it.

In our approach to resources management, we must consider the good of the resource as well as the good of the public at large and of all the users of a resource. This means some 20 million people must be considered when we make management decisions in the resources field.

As we look at the problems that face us and try to find solutions to them, our efforts fall into four general areas. That is, we have four main jobs to do if we are going to manage the use of our marine resources in an effective and efficient way. These jobs are (i) Coordination; (ii) Research or Fact-finding; (iii) Communication; (iv) Planning.

The first of these is much like the job that CalCOFI is doing. It is a job of coordination, bringing together the varuous interests and keeping each other informed of what each is doing, or should be doing.

The second area of responsibility is research. As the world population continues to increase by leaps and bounds, we keep hearing about the ocean as being the answer to feeding these multitudes. The expression goes something like this, "We will one day have to turn to the sea, with its limitless resources, to feed the peoples of the world."

Wouldn't it be wonderful if they really were limitless? Then we wouldn't have any probelems at all. But you and I know better. These resources need management, and management needs research.

Although our Department is primarily responsible for living resources, we also have the responsibility of seeing that the utilization of nonliving resources is done in such a way that fish and wildlife are not harmed. This extends our need for research beyond the living, and encompasses both living and nonliving resources.

The role of the scientist in research is to give the best scientific evidence available concerning the resource. The scientist should understand the processes moulding his findings, and appreciate the fact that his findings cannot always be implemented overnight. This should in no way influence his work or leave him feeling unappreciated. It is for others, with different responsibilities, to take into consideration the social, economic, and political implications of management decisions. But in all cases, management decisions must first protect the resource from overutilization.

The decision making process is partly the responsibility of the Department of Fish and Game. First, any decision must be based on the best scientific information available. The Department also must take other factors into consideration, and make its final decision and recommendation only after a full discussion with all interested groups. Then this recommendation is presented to either the Governor, the Fish and Game Commission or the Legislature.

Let me here emphasize that we do appreciate the work our scientists are doing because their work forms the foundation upon which all true management programs are built.

The third area of responsibility is the need to communicate effectively with society.

We have, at the present time, a communications problem between ourselves and the public concerning use of the anchovy resource. We have been unable to convince the public that we know enough about the anchovy to manage it effectively, and we cannot convince them that the reduction fishery will not adversely affect the resource.

The public is concerned that the anchovy resource may disappear, just as the sardine has disappeared, and we have not been able to convince the public that, under proper management, this will not happen.

Let me say here that the Department recommended a 200,000 ton reduction quota to the Commission. The Commission reduced this to 75,000 tons with the promise that if this quota is reached during this fishing season, the commercial fishing industry could come back to the Commission and additional tonnage would be allotted. I think this is progress. In addition, I would like to point out that generally sportsmen's interests endorsed the 75,000 ton quota—which is a real mark of progress in achieving mutual understanding in this emotionally charged field.

One of the things we have to face up to in the anchovy reduction problem and in other problems we will face is that there always is a time lag between the time the scientists arrives at his findings and the time the public accepts them. This is inevitable. So as we turn to the sea, and the world is doing this at an accelerated pace, we must communicate effectively with the public so that the time lag is as short as possible and so that it does not grow into a major problem.

We must utilize our marine resources in an orderly and sensible manner in order to perpetuate our renewable resources and in order to use our nonrenewable resources in such a way that they are not wasted, and are not exploited at the expense of other resources. And we must obtain public support for our management programs or they will not be accepted. Our failure to communicate in an effective and timely manner has resulted in an "Anchovy Curtain," which must be penetrated regardless of how difficult the task may be. We must not allow other such curtains to arise over use of our other marine resources.

A fourth responsibility is the need for comprehensive, long range planning. The State of California is well aware of the need for the orderly development of marine resources. In the recent session of the Legislature, a law was passed creating the California Advisory Commission on Marine and Coastal Resources. Its most important task, and I quote from the law, is "To review the known and estimated future needs for natural resources from the marine and coastal environment necessary to maintain an expanding state economy." With special reference to the coastline, the Commission is to prepare a report for submission to the Governor and the 1969 Regular Session of the Legislature, which sets forth the public interest in the coastline of California, together with recommended legislation defining and protecting such public investment.

The Resources Agency, the Department of Fish and Game, and several other agencies of state government will be very much involved in this planning effort. We are now in the process of preparing a use plan for the resources of the ocean. What we come up with will be submitted through channels to the governor, and he, in turn, will call on the Advisory Commission to review our proposals. The Commission is yet in the formative stage, and its work could be very vital to California's future.

Thank you for inviting me there today. I am looking forward to working with you and other resource users for the mutual benefit of the State and its people.

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THE CALIFORNIA FISH AND GAME CODE

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Whenever the subject of the development and encouragement of commercial fishing in California is discussed with persons concerned, such as this group, the Fish and Game Code seems to come in for considerable criticism. There appears to be a generally accepted premise that the laws relating to commercial fishing are archaic and far too inflexible and restrictive, and that the Fish and Game Code and the regulations of the Fish and Game Commission are the primary reasons why the State's commercial fishing industry has not made greater strides. I don't believe that any one familiar with California laws would deny that our code should be reviewed with an eye to removing those sections which are outdated and perhaps are inhibiting commercial fishing unnecessarily. As a matter of fact, our Department last year began a comprehensive review of all laws pertaining to commercial fishing. At the present time we plan to solicit recommendations and comments from knowledgeable persons in the industry. Undoubtedly some of you gentlemen here today will be contacted. It is my opinion that the Fish and Game Code is not as restrictive or as inflexible as you may have been led to believe. As an example, how many of you are aware of the provisions of Section 8606 of the Fish and Game Code? Briefly, this section authorizes the Fish and Game Commission to permit the use of any newly developed fishing gear or any newly developed method of using already authorized gear. We felt that the addition of this section to our code was necessary to encourage the use of new gear and techniques and under our code it is unlawful to use any fishing gear unless it is specifically provided for. Although this section was adopted by the Legislature in 1963, to date not one request for such a permit has been received.

The Department of Fish and Game has tried in other ways to encourage commercial fishing when it could be done without damage to the resource or to existing interests. For years the possession of drag nets was prohibited in all harbors south of Santa Barbara. This quite effectively stopped all dragging in the southern portion of the state and also forced all drag boats to unload elsewhere than in the southern California ports. We felt that the law was unnecessarily restrictive and this opinion was certainly shared by fishermen and dealers in San Diego and San Pedro. Consequently the Department supported legislation in 1965 to allow the possession of drag nets in these prohibited areas. The legislation passed and we fully expected to see an increase in dragging activity in southern California waters, and certainly an increase in the landing of drag fish in San Pedro and San Diego. However, dragging has not increased, and to my knowledge not one load of drag-caught fish has been unloaded south of Santa Barbara since the passing of this permissive legislation.

We also hear complaints that our laws regarding size limits on tuna and skipjack are discriminatory and that they are responsible for fish being delivered to ports outside of California where size limits do not exist. Naturally, when this occurs our industry suffers. We have long recognized this as being a bad situation and as early as 1950, the Department caused legislation to be introduced which would have repealed the undersize tuna and skipjack laws. However, the tuna-canning industry saw fit to oppose the measure and was successful in defeating the legislation. The Department is still desirous of removing these size limits. There has been considerable interest in the possible development of a reduction fishery for hake. In this connection it has been said that our laws regarding the legal mesh size on drag nets ($4\frac{1}{2}$ inches) would prevent the efficient harvesting of hake. We have repeatedly told people interested in this potential fishery that we would recommend a more suitable mesh size for hake, probably 3 inches for vessels dragging for hake, provided a reasonable limit were placed on the possession of other fish on the vessel. The Department and the Fish and Game Commission have, in the past, cooperated with the industry in attempting to develop a hake fishery by granting a permit to a major processor to take and use 100 tons of hake for reduction in order to gain the necessary data relative to yield, protein, etc. Unfortunately the permit was not used.

There are those who feel that all restrictions on the use of nets, size limits, etc., should be repealed in order to assist and improve the commercial industry. These people fail to take into consideration that, unlike some other states, California has a large and exceedingly important sport fishing industry. In most instances, this industry relies on the same fish the commercial fisherman is seeking. An increase in the amount of fish taken by the commercial fisherman at the expense of the sport catch would not necessarily be of benefit to the State of California. The take of such fish as barracuda and halibut is presently greater than the commercial take of these species and certainly these fish, in being used for food, serve their ultimate purpose. We have some areas closed to the use of most commercial fishing gear and these areas are criticized by the commercial industry. They claim that biologically speaking, conservation is not served by these so-called "closed areas". One such area is Catalina Island. For you who are not familiar with this closure, let me explain that basically all of the north or lee side of the island is closed to the use of round-haul nets which effectively stop fishing for mackerel, anchovies, and bluefin tuna within the area. While closed areas do not appear to be of too much benefit conservation wise, there are other factors that must be taken into consideration. The lee side of the island is easily reached by small boats. It is not unusual to see 16-foot skiffs fishing at Catalina. A 50-ton school of bluefin tuna in the closed area can provide fishing for the party fishing vessels, as well as private craft, for weeks. If the area were opened to net boats one or two nights of fishing would either see all the fish taken or driven out of the area.

We must keep in mind that the fish taken by the sportsmen are used and it appears that not only have these fish provided a great many hundreds of man-hours of recreation, they have been as valuable, in an economic sense, to the people of the State as if they had been taken by a purse seine net and processed.

As in any code there are sections that apparently do not serve any particular purpose or are not based on sound fact, and this can be particularly true when dealing with something as complex as fishery problems. On the whole, however, the recommendations of our biologists and research people are listened to by our law makers and are considered.

As I mentioned earlier, however, there are other considerations that must be taken into account when fishery laws are being considered. These can be economic or sociological in nature. While laws based 100% on biological data might appear to be the ultimate, the society we live in demands that other interests be considered. I believe that in California our fishery laws reflect the interest of all groups and are not in themselves detrimental to our commercial fishing industry.

Calif. Mar. Res. Comm., CalCOFI Rept., 13: 103–107, 1969

THE POINT OF VIEW OF INDUSTRY: THE PROCESSOR

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We are asked to look at "The legal, economic, sociological, and technical problems which impede the best use of the living resources of the California Current and how these problems might be resolved." I will give primary emphasis to resolving the problems delineated by considering what resources we have to apply to the resolution process.

THE INDUSTRIAL RESOURCE

The commercial industry in California is quite diversified as already alluded to by previous speakers. We range from very small individual operators, and small companies to some of the largest, if not the largest, vessel operating groups and processing-selling companies in the United States. The impact runs far beyond California. Many of you have taken part in many activities related to foreign areas and areas outside California, such as the Northwest and Alaska. To name a few activities:

A San Diego company this year began operation of the largest king crab processing ship in the Alaskan area. It is several times larger than the nearest ship of its kind. Puerto Rico is now the largest tuna processing area in the world and was entirely begun by Californians, and is supplied by tuna vessels owned by Californians, with the top fishing skills provided by Californians. This forms the base for a large grant of federal fisheries funds to carry on research and similar activity there for further advances. The first tuna cannery in Central America (Costa Rica) was started by Californians.

Ecuador, where there has been one tuna cannery (begun by a California company), has seen the start in operation of additional canneries and vessels principally initiated by California companies.

The most explosive growth in world fisheries has been in the anchovy fishery of Peru. Californians have been a large part of this and two of the leading three or four companies are from here.

These developmental activities can be expanded into the African area where fishing bases and cold storage plants were started in Sierra Leone in conjunction with Spanish fishermen, in Ivory Coast, Brazzaville Congo and Senegal with the French, and in Liberia. Japanese fishing companies worked with the Californians in providing much of the supply. Aden and the South Arabian areas were explored.

If we stick to island areas, the development of American Samoa, and Palau in the Trust Territory are also the contributions of California companies and skills.

These developments have considerable relevance when we view what might or can be done about California development problems.

THE MANPOWER RESOURCE

A word about the men. There was sufficient skill in California to open up the tuna fisheries of the Eastern Tropical Pacific, for one example, and to push the developments already noted.

One of the most encouraging things about the California fisheries has been the entry of our young people. Using tuna as an example, during the tough days of the 1950's we used to measure the age levels of fishermen. It was a constantly ascending line but has not been so in the last three or four years. (This can be noticed in Alaska, too.) We have a lot of fishermen, boat owners who have been every place but a growing number of young newcomers who intend to go every place. This has a great meaning competitively.

During the difficult years (and I suppose that in the fisheries end there are few, if any, easy ones) we often heard from foreign competitors, reminding us that Americans would ultimately withdraw from fisheries, particularly the high seas fisheries. This was not the life Americans liked to pursue and they would end up staying home. This has not occurred. It is both amazing and encouraging to discover how many young people in this country are getting into commercial fisheries directly and into the fisheries science, technological and other support areas.

This is happening in California and is a positive force to consider in the resolution of fisheries resource development problems. It can have impact on our fisheries growth.

THE SCIENTIFIC RESOURCE

No state has more concentration of marine science skills than California. At our meeting here we are privileged to have a number of people representing these skills and their organizations which include the California Academy of Sciences, Scripps Institution of Oceanography, California Department of Fish and Game, U.S. Bureau of Commercial Fisheries, the combination of these in CalCOFI, U.S. Bureau of Sport Fisheries and Wildlife, Inter-American Tropical Tuna Commission, and the several university and private organizations. Added to these is the thrust given by corporations interested in the sea.

It was mentioned this morning that California has exported a considerable amount of such skills, but it has also imported and retained a great number. This has very considerable meaning when we consider bringing scientific skill to bear on California fishery resources and problems.

THE POLICY MAKING RESOURCE

California has made a strong impact on fisheries policy development in the U.S. Such policy development over recent years was referred to this morning.

In terms of specifics, the framework of the Fish and Wildlife Reorganization Act of 1956 was developed in San Diego. It was presented to Senator Magnuson in 1955 with the principal idea of getting fisheries out of the basement at the national government level.

Many talented people were doing useful things. They were individually commended but it was apparent that Congress and the Executive Department were not reading the material. We felt chances for recognition of the importance of fisheries would be improved by adoption of legislation. We wanted an Assistant Secretary charged with fisheries responsibility. Those acquainted with this will recall that there were differences vis-a-vis sport people in the development of legislation which were composed. This joint effort brought about the present U.S. Bureau of Commercial Fisheries and U.S. Bureau of Sport Fisheries and Wildlife. The presence of these Bureaus in California has been a positive force in fisheries developments. To say that similar reforms cannot be effected in California defies good judgment. Once we define what we want to do, it can be done.

There are other broad policy issues in which Californians took leading parts but this one will serve to illustrate the point.

THE LIVING RESOURCE

According to the California and Use of the Ocean report of IMR [1], 20 species make up about 97% of the volume and value of the commercial catch. The sport fisheries are based on about the same numbers but not the same species. There are seven or eight species appearing on each list. Let us examine some of the principal commercial species.

Tuna

Tuna has represented about 50% of the landings volume and 80% of value for some time. The challenge is to maintain tuna volume and increase other species volume. This requires attention as we have no secure position with respect to tuna with competition from many areas, some of it self generated. We compete with ourselves when we operate out of Puerto Rico, which offers strong tax attractions which are difficult to combat. Fortunately, the fisheries immediately to the south and sometimes to the east with heavier percentages of yellowfin make California a more economic point from which to fish than from Puerto Rico. California does not have a fishery by gimmick as in Samoa. This is a distant tuna fishery (1,000–1,200 miles) but foreign flag vessels can enter as American Samoa is not within the customs district of the U.S. California has no such device available to it. I foresee no drastic growth in tuna but forecast no decline.

Pacific Hake

Hake has been referred to in Alverson and Larkin's paper [2] as a potential commercial resource. A small amount of work has been done off California, more is planned. Initial evidence while fragmentary is interesting. Who should be responsible? Viewed from the standpoint of property rights, or lack of them, and the legal status, this lies properly within the province of government.

Northern Anchovy

Anchovy is a matter of regulation. The potential is great. The economics present formidable present barriers which I will refer to shortly. What is needed in the anchovy matter at this time is opportunity. While present fisheries activity is limited by the depressed state of the fish meal market, the opportunity is needed for future development.

Jack Mackerel

Blunt's paper [2] on jack mackerel suggests what may be a major possibility for expansion. We have been limited by vessel size and it seems to me that exploratory fishing on the extended high seas areas can be helpful.

Dover and English Sole

Dover and English sole present possibilities for expansion but are limited by the market situation according to Orcutt's paper.[2] This does not lie in the province of government. Industry ought to be able to figure out an answer to this.

Pacific Saury

Saury was mentioned by Smith [3] as representing a potential resource of value. Saury for use as bait commands reasonably high prices. A question was whether it could be sent to Japan. Some California and Mexican companies are sending fish and shell fish to Japan. In fact, Japan is now importing a number of fishery products so it appears that saury is not out of the question, if this was the best use for it. There are certain other uses and one paper mentions its acceptability as a canned product. Here again, once the resource is proved up which can be done by exploratory fishing, the technological and marketing studies can be undertaken by industry.

Sablefish

Sablefish were mentioned in Longhurst's statement [2] on squid and red crab. His views are worth examining and a combination of industry and government should explore the potential of these resources.

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[1] California Institute of Marine Resources. 1965. California and the use of the ocean; a planning study of Marine Resources. California University, La Jolla, IMR Ref. 65-21.

[2] Published elsewhere in this report (Calif. Mar. Res. Comm. CalCOFI Rept. 13, 1969)

[3] Presented during this symposium but not published.

Pacific Bonito

Bonito could be the subject of a resurgence. The bonito fisheries of Peru have declined more through lack of effort than otherwise. There have been very vexing competitive problems for the Peruvian which devaluation has not cured. We have an opportunity to move in the bonito area.

These are some of the species given more than passing mention at this conference and illustrates some of the avenues which can be followed on resource development. There is much evidence that we have many resources to work on.

RECENT DEVELOPMENTS

If we have all these resources what are the barriers impeding development? First, it should be observed that in the lengthening period after World World War II, there has been explosive development in many quite undeveloped areas of the world at a time California's principal volume fishery of sardines was disappearing. It is natural that attention was directed elsewhere.

Looking at them broadly in California we find a good review of them in the reports of IMR and the Governor's Advisory Commission on Ocean Resources.

We need some perfecting of the State's administration of fisheries. We need some pulling together of both a scattering of control and a miscellany of laws and regulations.

We were advised today that these regulations were no great barriers and an intensive review was under way. Perhaps the genesis of the review lies in the work done on these reports. However begun it is a heartening sign that review is going forward. We hope that all of us concerned in any way with our marine fisheries get a shot at these before the final work is done.

I will refer to the realignment of administration responsibility and authority under the concluding section on recommendations.

These recent reports deal with a number of barriers to progress with considerable emphasis on government. There are economic barriers to be measured. We can talk all day about what the quota on anchovy catches should be. Present economic considerations *alone* might dictate in rough terms that you have to have a hole in your head if you want to get into that business—but these conditions change. Who realized in 1953 when the take of Peruvian anchovy was well below 100,000 tons that in a few years 8,000,000 tons would be taken in an area of 20–30,000 square miles and that it could and would be sustained.

Initially there was great concern about elimination of bird life in Peru which was the basis for a long established guano industry. Later it was thought that perhaps shore plants were more efficient means of utilizing the raw material. The birds were not eliminated and the primary problem in recent years has not been resource abundance but supply-demand relationships in finished product. This supply demand relationship forms an economic barrier to development of the anchovy fishery. What the anchovy fishery needs is an opportunity to move effectively when the economic situation clears. The present procedure used in setting quotas did not and does not give the opportunity now and is unlikely to do so in the future. The recent development which can help this is the plan to study how our California fisheries should be administered which could place such matters under the administration of technically competent people.

Elton Sette [2] talked about research and forecasting as part of the economic picture. Industry can certainly adopt more advanced forecasting techniques with respect to its raw material. I have had some continuing connections with such an effort and it was successful. It was and is an important tool and the key to it was not only talented people who can understand and interpret information—but very importantly that over a number of years a lot of West Coast people successfully battled with the Bureau of the Budget and the Congress to get some more money into fisheries activity by the federal government so that research could be started and carried onward. Like everyone else, I would like to start research on something tomorrow with the expectation that an answer be provided by next week. As you know the things we can use are almost always the accumulation of many years work.

The forms of product are principally industry undertaking but government can be, and often has been, an important contributor. The recent development here is in the pilot plant work on Fish Protein Concentrate at College Park done by the Bureau of Commercial Fisheries, and finding further expression in the new plant to be built somewhere in Senator Magnuson's state. These are good beginnings. The results will be available to us all. The utilization of California's fishery resources can be advanced by this.

Hardly a recent development but affecting progress are the differences between commercial fishermen and commercial sport fishing interests. A recent development in California has been concern over best use of fishery resources. Today I learned that about 8,000,000 people fish recreationally (marine and inland) and their views are important. I estimate that about 120,000,000 people eat fish and think it almost goes without saying that their eating is important. But, there is no contest here on sheer numbers of who does what and who contributes the most. As said this morning, there is so much more in cooperation than in opposition. We are all in the same ocean. This recalls a theory I had when I was running a shipyard. I had two problems—first was the customer who always bothers you. He is a nuisance but there is no way to get along without him. The second was competition which was a bigger nuisance but it kept you on your toes. It is natural that commercial fishermen and sport fishermen compete. We can sublimate this competitive factor by considering that it is what there is to divide that should occupy us—not what divides us. We don't want decision by decibel count or license count. We want and, indeed, urgently need decision on the basis of scientific facts and the rational interpretation we can bring to bear on them.

If you are still with me, I am on the topic of the resource California has in recent developments. These developments create their own barriers and become challenges. Just assume you wanted to build a large anchovy reduction plant in California. This would mean not only a great investment, a large undertaking but new method. We have to have an eye on the neighborhood around us and the effects on it. Our march to the sea is heavy in building waterfront residences, hotels, and marinas. We have to fit in with these. What at one time could not be done can now be done.

While not a recent development, but usually unknown, is the fishing ability of U.S. fishermen as an asset. An analysis of catch per man of American fishermen stacks up well with any competition. It has been generally assumed, to use one example, that the Japanese were the most efficient tuna fishermen and yet U.S. fishermen catch from 3 to 4 times as much per man. This may be only arithmetic as crews were generally 3 to 4 times as large and perhaps a product of a social system. However, there is no basis in individual productivity where we need take a back seat. There is a strong case for individual ability, it is a California asset, or resource. One area where we are being out-distanced is in design, or better said, construction of fishing vessels.

WHAT DO WE DO WITH THESE CLAIMED RESOURCES?

I have listed a number of resources which California can legitimately claim. In combination they are impressive. How can they be brought to bear upon development in California and upon the problems therein?

Courses of action are clearly set in the reports I have referred to. Let us look at the IMR's report *"California and the use of the ocean"* as a particular reference point. It had the benefit of contributions from many in this conference. Let us see if the recommendations in this report represent a clear course of action.

On living resources the first item reads:

"1) The State Government, through cooperation of executive and legislative branches, should establish policy concerning the conservation and utilization of the living resources of the sea under its jurisdiction and influence which will encourage their maintenance and full utilization for the benefit of all of our citizens, which will promote the development of local fisheries and of distant-water and overseas fisheries based on California, and which will be in harmony with the international law respecting fishing and conservation of living resources of the high seas."

It is important that we advance our research to that stage where we can meet the standards of the treaty on conservation of the living resources of the sea as a link with the international conventions on Marine resources and the continental shelf. When we mention, as in the preamble, what has to be done we have to remember that a lot has been done.

It is heartening to hear that the State Legislature has ordered a study and a development of a plan for California's marine resources. This study can be eased and accelerated by work already done in California. I hope it concludes that we move toward professionalization of our fisheries resources management.

As a conference group we should hear the objectives which follow the first recommendation, together with the remaining recommendations on our living resources of the ocean. These are:

"a) To maintain sufficient populations of all species of marine organisms to insure their continued existence.

b) To maintain adequate aesthetic, educational, scientific and recreational uses, both extractive and non-extractive, of the living resources of the California Current.

c) To give priority to aesthetic and recreational uses in those cases where a species which is an object of sportfishing, and is under control of the State, is not capable of supporting the reasonable requirements of the sportfish harvest and the existing or potential commercial harvest; however, reasonable use of recreational fishing should include curtailment of individual sportfishery bag limits to the quantity that is sufficient to provide satisfying sport.

d) To encourage the growth of local commercial fisheries, consistent with aesthetic, educational, scientific and recreational uses, to foster the utilization of unused resources, and to encourage the development of distant-water and overseas fishery enterprises.

e) To manage, on a basis of adequate scientific information promptly promulgated for public scrutiny, the fisheries under the State's jurisdiction and to participate in the management of other fisheries in which California fishermen are engaged, with the objective of maximizing the sustained harvest and decreasing costs of commercial production.

"2) The present fisheries research and management system and organization should be revised or replaced to make possible the implementation of the recommended policy. This will involve changes in the present statutory basis for fisheries research and management, changes in methods of financing, delegation of additional authority to the management agency, and the establishment of adequate scientific services. A comparative study of systems employed in other states and nations should be made as part of the basis for revision of the California system.

"3) To provide the factual basis for resolving conflicts over the utilization and allocation of use of living marine resources, and to provide a proper scientific basis for conservation management, it is essential that the statistical and scientific services be greatly improved. In particular, means should be developed to provide:

a) Adequate quantitative information on recreational uses of resources especially data on total catch and on catch and effort, for the sportfishery.

b) Adequate catch and effort data for the commercial fisheries, both local and distant-water, to supplement the presently satisfactory data on total catch.

c) Adequate research to furnish in timely fashion required information of the population structure, life history, ecology, and population dynamics of the exploited fish populations, and their associates.

d) Economic research concerning both recreational and commercial uses of the living resources.

e) Prompt publication of scientific data and research results. In developing the research functions, the State should improve scientific service of its own administrative agency and should utilize the capabilities of researchers in the University and other academic institutions.

"4) Existing laws, regulations, and administrative practices regarding the taking of fish and other organisms for recreation or commercial purposes should be thoroughly reviewed, and those which serve no useful purpose, especially those that handicap full use of underused resources, should be removed. Restrictions on the commodities which may be manufactured from fish, as well as restrictions on types and specifications of commercial fishing gear and ancillary equipment, should expecially be revised as promptly as possible. The present system of fishing regulations should be thoroughly revised and replaced by measures better designed to maintain the fish populations at levels permitting maximum sustainable harvest, while encouraging their efficient harvest by California fishermen. A comparative study of measures employed by other states and nations should be made as a partial guide to this revision.

"5) Proper and adequate zoning of the uses of the land along the margin of the sea, making provision for waterfront facilities needed for recreational and commercial uses of the living resources, should be undertaken immediately. Planning for the multiple use of the inshore margin of the sea, including bays, estuaries and the outer coast, should take full account of needs and opportunities for use of the living resources. Long-term planning and adequately unified control is especially required with respect to disposal of all classes of wastes.

"6) The development of distant-water and overseas fisheries should be encouraged by removal of institutional handicaps, as indicated above, and by provision of adequate harbors and other facilities for distant-water vessels.

"7) Underutilized populations of relatively non-migratory sportfish should be made accessible for recreational fishing by additional access roads and small-boat harbors.

"8) A program of habitat improvement for inshore fishes should be pursued, including construction of artificial reefs, abatement of pollution, introduction of 'pollutants' in ways to benefit the living resources, encouragement of kelp beds, and judicious predator control. Research on the relation of harvestable organisms to their habitat should be accelerated to provide guidance for these activities."

It is my view that the quality of this work, and the depth of these recommendations, provide the basis for answers to development problems. I recommend that we all reread them. I reemphasize my earlier point that administration of California's fishery resources should be put in the hands of full-time technically competent people.

As I have not been involved in California fisheries matters for many years, a re-reading is necessary for me. It is encouraging to see what work has been done, the comprehensive sweep of the recommendations in this and other reports, the resources which we can call our own, and that Mr. Roedel has been able to call this group together to consider what should be done with them.

Calif. Mar. Res. Comm., CalCOFI Rept., 13: 108–109, 1969

VIEWPOINT OF THE INDUSTRY: FISHERMEN AND ALLIED WORKERS

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I feel that because of the lack of proper interest on the part of top-level people in the State of California and the Federal Government, our fisheries have disintegrated and fishermen have abandoned the trade at an alarming rate since the end of World War II.

Tremendous amounts of money are being appropriated for the exploration of outer space, defense build-ups, experimental uses of atomic power, etc., but appropriations for oceanography and fisheries research and development are notably lacking. Programs that have been scheduled and monies that have been allocated to fisheries are all well and good as far as they go, but they neither *go far enough, nor soon enough.* There is little value in developing a great wealth of knowledge and know-how in fisheries as to the conditions and abundance of the resources and stocks; the spawning and migratory habits; the best methods of catching, preserving, freezing and processing these fish; blueprinting better, faster, newer and more efficient vessels and gear, if no one remains to benefit from it all.

Today, now, immediately is the time for action, *not tomorrow.* A crash program to assist the fishermen is needed if we intend to maintain California's fisheries and industry. A fire must be started among the top people at both State and Federal levels to awaken them to the fact that up until now fishermen have only touched the outer fringes of the tremendous resources that abound off of our shores. They must be made to realize that unless we range out, explore, find and develop these resources, they will eventually be wiped out by foreign fishing fleets without regard to conservation. The economic loss from such action would be felt by our fishermen, community and State, for decades to come.

It would be shameful indeed if we as fishermen and Californians stand idly by and watch the remnants of what was once a very great California industry die, as our State and Federal government seems prone to do. I believe that at one time fisheries ranked third or fourth in value in our great State and there is no reason why this industry cannot once again regain that important position, thereby benefiting the citizens and State.

I submit ten cardinal points for your consideration as to some steps that should be taken to keep this industry alive while we are awaiting the development of long-range plans and programs.

It would be greatly appreciated if strong thought and study be given to them.

1) Continuation and expansion of work being done by the Marine Research Committee and CalCOFI scientists
2) Ways and means to raise additionally needed monies to expand programs of scientific research, experimentation and development
3) Scientifically-managed fisheries to:
   a) Afford maximum protection and conservation of all the resources in coastal waters.
   b) Equal utilization of the resources to all Californians, whether for recreational, sportfishing or commercial fishing purposes.
   c) Protection of these resources from inroads by foreign fishing fleets to prevent abuses of our conservation programs and depletion of the stocks.
4) Continued and expanded scientific research on the following species:
   a) Anchovies
   b) Jack and Pacific mackerel
   c) Pacific hake
   d) Pacific saury
   e) Squid
   f) All other species which might be suitable for canning, reduction or fish protein concentrate purposes.
5) Exploration research to establish the following:
   a) Geographical areas of the stocks and locations as per species.
   b) Abundance and size of the stocks.
   c) Spawning areas and months.
   d) Pattern of migration as per months or season, inshore, offshore, north, south, etc.
   e) Depths of the stocks.
   f) Feed and environmental habits.
   g) Effects of shoreside pollution on the stocks, feed, plankton, etc.
6) Research and development of new and appropriate fishing gear and techniques
   a) Bottom trawl.
   b) Mid-water trawl.
   c) Seine or round haul nets.
   d) Electrofishing.
   e) Winches and retrieving gear.
   f) Depth sounders, fish finders, scanners, etc.
   g) Installation of water temperature and weather equipment.
7) Removal of present State restrictions which presently prevent the following:
   a) Utilization of certain types of fishing nets and gear.

b) Taking or landing of certain species.
c) Fishing in closed areas, for military or sport reasons, which could be fished at nights or at certain times or months.

8) Establish schools in sea ports to train new, young fishermen in the following:
   a) Engineering and diesel engines.
   b) Refrigeration systems and methods.
      1) Brine
      2) Spray
      3) Sharp freeze
   c) Navigational equipment and aids.
      1) Geographical
      2) Celestial
   d) General over-all rigging.
      1) Wire splicing
      2) Rope splicing
      3) Winch handling
      4) Cables, blocks and retrieving gear
      5) Proper method of hanging and/or constructing various types of nets, and repairs thereto
      6) General over-all knowledge of ship nomenclature and ship handling
      7) Safety, aboard ship and at sea
      8) Ability to read and understand weather charts, temperature charts, currents, thermocline and their effects on the fish. Signs of pending storms, etc.

9) Creation of a separate marine commission for ocean resources
   a) Present Fish & Game Commission too overburdened to carry out proper and just responsibilities of ocean resources.

10) Financial assistance from state and federal government to boatowners, fishermen and processors to/or for:
   a) Designing, developing and constructing newer, faster and more efficient vessels with better holding and freezing facilities, fish finding equipment, etc.
   b) Construction of new types of fishing nets, gear and equipment based on new highly sophisticated methods, backed by research and proven experimentation.
   c) Monetary subsidy to pay for fish being utilized in new infant fisheries caught by boatowner and fishermen beyond what price processors can pay during early development of proper processing methods, such as in hake fisheries.
   d) Assist canners and processors in proper and new methods, including pollution controls, as an incentive to keep them from going out of business or relocating outside of California.

Calif. Mar. Res. Comm., CalCOFI Rept., 13: 110, 1969

THE POINT OF VIEW OF INDUSTRY: FISHING BOAT OWNERS

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We observe other nations expanding their fisheries to the fullest extent and we ask, "Why are United States fishermen falling behind and what can be done to save the fisheries?" United States fishermen need help in many ways. Financially they have reached the point where they can no longer afford to gamble. Help is needed from Federal and State levels. Aid from these governmental agencies should be given in the following forms:

1) Financial encouragement should be given without an excessive amount of red tape.
2) Exploratory vessels, State or Federally subsidized.
3) Research information on:
   (a) Latest types of fishing gear and electronic equipment.
   (b) Availability of resources which can be properly harvested.
   (c) Exploration of new fishing grounds.
4) Schools for both experienced and novice fishermen to learn new techniques in fishing gear and how to operate the latest electronic equipment.
5) The entire California Fish and Game Code should be reviewed and, where needed, revised to allow California fishermen to compete with nations who are starting to fish off our coastline. Foreign fleets fishing without gear, season, or method restrictions can and will exploit and damage available stocks.

Fish resources available to California fishermen, such as northern anchovies, Pacific hake, and jack and Pacific mackerel are of great abundance and are very valuable. These resources should be harvested to the fullest extent without damaging the stock. California fishermen cannot do this because of State restrictions on areas and fishing gear. In 1967 the State Fish and Game Commission authorized a take of 75,000 tons of anchovies from an estimated 2–4 million ton local population. What they did not say was that they were going to tie both our hands to prevent us from harvesting them.

The Russians have more information on our different species than we have or than we can obtain from our fisheries agencies. There is no limit on what the Russians can catch 12 miles out. They have no season and no restrictions on fish size. By comparison, we will be arrested if we fish anchovies within 3 miles of our coast, and can only take 45,000 tons outside of 12 miles. If we attempt to use pelagic mid-water trawls of smaller mesh size than our Code allows, we are again subject to arrest. We are subject to arrest for everything we do.

We know that most of the leading fishing nations in the world are building new ships and boats. Their equipment is mostly for trawling. San Pedro fishermen are watching these developments very closely. Many of us would like to change from purse-seining to trawling but legal restrictions prevent us from doing so.

We hope that State and Federal officials will soon wake up to what is happening to the United States and California fishermen. If something isn't done soon there will be no commercial fishermen to worry about. The only thing to worry about will be the restrictions of the Russians.

Calif. Mar. Res. Comm., CalCOFI Rept., 13: 111–112, 1969

THE POINT OF VIEW OF RECREATIONAL INTERESTS: THE ORGANIZED SPORTSMEN

ROBERT VILE, President
Ocean Fish Protective Association, Inc.
Los Angeles, California

California has one of the longest coastlines of any state . . . 1,200 miles of coastal waters. Since World War II the number of citizens who find recreational pleasure fishing in our coastal waters has grown in direct proportion to the increasing population.

Now this type of recreation depends upon a resource that must reproduce. It is not a recreation that man creates for himself.

Abusing this resource destroys the recreation. In the last 20 years, sensitive, aware sportfishermen have come to understand this basic fact.

As the sportmen's interest and concern grew, it became clear that active steps had to be taken to keep this resource growing and healthy.

To safeguard the fisheries, programs in: research; resource management; education in responsible utilization on the part of those who fish for profit, or for recreation; law enforcement; and long-range ocean resource planning, and the means to fund them; must be undertaken without delay.

At this point let me thank you for the privilege of presenting the organized sportsmen's views and interests.

I also like to think that I am presenting the thinking of the unattached sportsmen who have not yet found their way into an organized club or one of the many conservation groups in this state.

The importance of the sport of fishing in our economy . . . and in our way of life . . . is a matter of record. National surveys prove that as do the annual reports of our own Department of Fish and Game.

Now, for the programs that we believe are needed to safeguard this important use of the fishing resources:

RESEARCH

The ocean angler is a strong supporter of research. He feels that without adequate research, it would be impossible to implement the wise use of the resources that make possible his recreation.

We are deeply indebted to those hard working, conscientious scientists who have made possible projects such as the Salton Sea . . . the restoration of the kelp and sand bass fisheries, the management programs that have been put into effect to date, and all the other fine projects that have contributed to our knowledge of ocean fisheries.

However . . .

Monies in the form of license fees are collected from the California recreational ocean angler to support our Department of Fish and Game. The figures on that portion of the license money spent on state marine research definitely show that the sportsman remains an orphan . . . little if any research is aimed at how to better sportfishing.

On the Federal level the sports fisherman has received token attention while most of the efforts have gone toward locating fish, improving harvesting methods, and developing ever more efficient gear and marketing methods for the commercial fishermen.

Oftentimes we hear the statement that research for commerical fishing is also of benefit to the sportsman. But is it? Can you tell me, for example, what benefit the sportsman has received from all the sardine and Pacific mackerel research?

When there has been research that could have benefitted the sport, it has often been put on the shelf where it is collecting dust. Certainly such research should be reviewed and promising recommendations put into effect.

Knowledge of the relationship between the different species of fish is sadly lacking. For instance, the relationship between the forage species and those species that prey upon them, has not been clearly established.

Even data on the number of ocean sports fishermen is inadequate. Party boats, for example, are no longer the big haulers of passengers . . . yet these figures are still used by the Department of Fish and Game as the main index to count sportsfishermen. They completely ignore the small-boat fishing armada.

Sportsmen are reluctant to provide additional funds for research unless there is some assurance that more attention will be given to their interests.

RESOURCE MANAGEMENT

Management and research are a team that must work together to achieve the wise use of our resources. Unfortunately, we feel that California's system of management . . . with the legislature controlling the major amount of commercial activity and the Fish and Game Commission regulating the activities of the sportsmen . . . leaves a house divided. What is needed in California is complete control over the fisheries by the State Fish and Game Commission.

There seems to be a growing tendency in this state to create intermediate agencies and various advisory committees. These only add to the confusion in attempting to resolve California's ocean fisheries problems. After all, how many experts can you have advising you? Won't all these advisors have to turn to the researchers and the enforcers to find out what the gut issue is, and what works and what doesn't when it comes to handling the issue?

There are many species of fish on which the regulatory powers still remain in the hands of the state legislature. We feel it would be in the best interests of the resource to transfer these powers to the Fish and Game Commission where a more flexible management program could be exercised.

EDUCATION IN RESPONSIBILITY FOR RESOURCE USERS

We must keep in mind that many of our California fisheries are now being harvested to their maximum capacity. Imports are necessary to meet the demands of the general public. For example . . . we have to depend on our northern neighbors . . . Oregon, Washington, and Alaska . . . for crab meat, salmon, and halibut. We bring in lobster, abalone, and shrimp. Other fish are brought in from such far away waters as Norway, Japan, and Southwest Africa.

And while we are on the subject of foreign imports, let it be noted that the complaint by the commercial fishing interests against "foreign competition" is a hollow one. Some of them create "foreign competition". Many American commercial fishing interests have financial interests in these "foreign firms."

We feel there is unwarranted emphasis on the need for fishery products as a source of protein for the people of the under-developed nations. There is much substantiating research to show that proper protein can be provided quickly and cheaply in massive quantity by fast-growing land crops such as soybeans, chick peas, etc.

LAW ENFORCEMENT

We need research to provide information on how to manage properly. Then we need enforcement of the regulations that management deems necessary. Presently the personnel and equipment provided by the State are wholly inadequate to enforce the management regulations.

LONG RANGE OCEAN RESOURCE PLANNING AND FUNDING

Planning

The ever-expanding development of offshore oil will strongly affect inshore fishing along the coast. While there is no effect from the actual removal of the oil from beneath the ocean floor, the processing which it must undergo definitely perils inshore fishing. The return of the concentrated brine along with heated and deoxygenized waters into the ocean, creates a completely different ocean climate and adds to the pollution hazard. This could destroy the habitat provided by the kelp beds and destroy the sand crabs, mussels, abalones and lobster which provide food for such species as perch, croaker, opaleye, sand and kelp bass.

Power-generating plants being built along the shoreline will bring thermal pollution when they dump heated water into the bays and estuaries. What will happen to the fishery resources is an unknown element which we feel must be studied . . . and soon!

Desalinization plants may raise temperature and salt concentrations beyond the point of tolerance of many fish.

Harbor developments and beach expansion with the necessary dredging will destroy habitat. Estuaries are being filled and/or dredged to make way for residential development thereby destroying fish nurseries and food supplies.

Another area which looms large on the horizon is our relationship with Mexico. Strong cooperation between our government and that of Mexico must be worked out. since so many of our sport fish migrate between California and Mexican waters. As both commercial and sport fishing expand in Mexico, this will become another steadily rising source of pressure on the *same* resource.

Funding

Present State law reserves all the monies paid for license fees and taxes by sportsmen and commercial fishing interests, for the operation of our Department of Fish and Game, which carries out the policies determined by our Fish and Game Commission. The structure of this law precludes supplements from the State's General Fund. We see nothing to be gained by altering this. But present funds are not now adequate.

The time has come when there are just too many problems dealing with recreational fishing. It is our belief that the only way these problems can receive immediate and adequate attention, is that some assistance be given our Department of Fish and Game by the Federal government through the U.S. Bureau of Sport Fisheries and Wildlife.

Calif. Mar. Res. Comm., CalCOFI Rept., 13: 113–116, 1969

THE POINT OF VIEW OF THE PARTYBOAT AND LIVE BAIT INDUSTRIES

R. A. IZOR, President
Associated Sport Fishermen of California, Inc.
Santa Ana, California

I am not a trained scientist; however, I hope that I qualify as a "practical scientist". I have lived in southern California for 44 years, have been fishing since four days before I was born, according to my mother, and I have been in the sportfishing business for 20 years professionally.

I hope I bring a laugh to you when I say "There is no sport in sportfishing and there never has been." I consider myself a recreational killer hired by sub-killers to take them out to do recreational killing.

We heard from Mr. Cary just before lunch (see Cary this symposium). When you get down to the field of predators, I am glad I don't live in the same jungle with this man because I'd have lasted until about the first morning. He would have had me for breakfast. This sort of crafty, bright businessman is one of the reasons I am trying to fulfill some sort of limited function by discussing problems which the scientific community must come to grips with in the battle for the minds of the great population which raises a hue and cry when you threaten to reduce anchovies or do any other dastardly deed like that.

The very fact that the scientific community allies itself with a commercial fishing industry, where there is a profit motive, already makes you suspect no matter how blessed be your findings or your research. If what I say bites you the wrong way just reject it and think nothing more of these remarks. They are just the opinion of one man who has been on the waterfront for a long, long time.

The best example that I can bring to the minds of those of you who were interested in or had any close relationship with the Great Experiment,[1] as I like to call the effort by the California Department of Fish and Game to create a 200,000 ton anchovy fishery in southern California, I can best talk about because I was one of the leaders of the opposition. I can tell you what we did and how we did it in trying to discredit a really fine scientific mind in the person of Phil Roedel. The undercurrent of fear that prevailed among the professionals in the recreational fishery was founded on the past performances of the commercial industry. The local industry simply does not understand the word conservation, and they never have. I don't know anything about Mr. Cary's elaborate world-wide functions, but the local fishermen in the San Pedro, California area will poach and destroy and catch every last scale if he can get away with it. He doesn't care about tomorrow and he never has. Unless I can make these things clear to you I am afraid I won't do anywhere near the job I want to here today.

We have grown up with this fear so it is not surprising that when the 200,000 ton anchovy fishery experiment was proposed we began to hear rumors that the big fishing companies had plans on the drawing board for one-million ton reduction plants and the fishing nets were on the way. Rumor? Yes, but nevertheless it threw fear of a repeat of the sardine and Pacific mackerel debacle into us. So we waged a major emotionally charged, factless campaign against a dedicated guy whose presentation[2] before the California Fish and Game Commission, the day the Commission authorized the present reduction fishery, was truly enthralling. If I had been on the Commission, I would have bought it lock, stock and barrel in spite of the fact that I was there as part of the loyal opposition. It was thorough investigative procedure, the best the scientific community could produce. Yet, unfortunately, because you neglected one little facet, an iron clad lock that the fisheries should progress slowly, we had to battle you down to the wire. We had to prepare elaborate Letter to the Governor and Letter to the Commissioners campaigns. I had to hire a public relations firm to get our name, Associated Sport Fishermen of California, in every paper in California; and we saw to it that the local metropolitan newspapers in Los Angeles carried editorials supporting our position. Actually, it was a shame because the 200,000 ton request was just a dent in what I know to be the anchovy population. Knowledge not based on egg and larval surveys but my day to day running of the sportfishing boat between the local channel islands. There are lots of anchovies.

Another source of conflict is the $1 per ton tax on pelagic fishes that helps support the scientific community. I want you to reject what I am about to say if it doesn't apply, but if it does then damn it act accordingly. The fact is that accepting that $1 per ton, for study on the pelagic fishes, has to jade your opinions when you approach a borderline decision as to whether we should, or should not, go ahead with a fishery. If I was an underpaid biologist, a scientist dedicated to a facet of a fishery study that would be enhanced greatly by just a couple of hundred thousand dollars, 200,000 tons would suddenly look like nothing. I don't know whether anything like this can be altered, or even needs to be. I just hope it would

[1] Requirements for understanding the impact of a new fishery in the California Current System. Ahlstrom, E. H., J. L. Baxter, J. D. Isaacs, and P. M. Roedel. 1967. Report of the CalCOFI Committee. *Calif. Mar. Res. Com., Calif. Coop. Oceanic Fish. Invest., Rept.*, 11:5–9.

[2] Report on the anchovy fishery. Roedel, P. M. 1967. *Calif. Dept. Fish and Game, MRO Ref.* (67–21):1–27, 17 Figs.

never affect your thinking if the situation should occur.

Another facet that is most important is that every time conditions arise which call for a regulated fishery, recreational or commercial, be aware of your responsibilities and know that your findings mean enforcement. Enforcement of laws that come about by the findings of your scientific endeavor. Often enforcement leaves much to be desired. At present the citizen recreational angler, fishing in an ocean that only borders our State and is not necessarily a possession of same, is often subject to arrest and humiliation for violation of laws that have absolutely nothing to do with conservation and pertain to a resource which frequently is not even an exclusive "property" of the State of California.

The recreational angler is subject to a ream of sportfishing regulations. Partly because of his own insecurity which causes him to obtain legislation that will insure him a successful day's killing, and partly because of the scientific community which felt a need for conservation laws. Regulations have almost reached the point where the angler should fish with a code book in one hand and his rod and reel in the other. It is so difficult to remember the 30 odd species of fish that sometimes have more than one size limit, and have individual or collective numbers limits that only the rare person knows any of the laws. This is the case and will continue to be the case as long as men try to legislate conservation. So, when you are in a position where your scientific endeavors lead to laws or changes in the code, please give some thought to the fact that along with laws come enforcement and that often the result is confusion.

I would like to dwell on the fact that it is extremely important that communication continue at this or a more appropriate level. It is important that you people get out in the community that you live in and work in, and unwind and unmuddle some of the conservationists groups that you must sooner or later impress with your findings. It is too easy for special interest groups to mount a successful emotionally charged campaign, such as we did to knock the props out from under the anchovy experiment. This tactic goes on in all levels of political activity, it can be accomplished by almost any group of aroused citizens, and it is a shame. So along with all your other work, you have to get to people like me and you've got to say, "Look, Russ, this is the way the facts point. Please, with your practical experience, does it apply? Can it work? Will you help us?" Then perhaps we can evolve a pelagic fish study that will give us an anchovy fishery of some meaningful content.

I think facts that Mr. Talbot [see paper this symposium] gave you regarding the number of people who went recreational fishing in 1965 was based on a thin study. I think there were more people. Tackle sales continue to go up, up, up, so either the same people are buying more tackle all the time, or even greater numbers of people are trying to utilize the same fisheries that the commercial fishermen are using.

One of the tragedies of our communication and our public relations work is that we have never been able to sell recreational fishing. We have been compelled to sell this blood lust, this killing and our business is a failure because of it. We have never been able to talk to the angler of the beauty of nature and the beauty of the sea and the wind and the good equipment and the effort we make on their behalf. There is a certain instinctive behavior about being a predator and bringing home as a great white hunter, a mastodon draped across your back. I think my business is a failure because of our inability to communicate, but I don't think there is anything we can do about instinctive things. Man just has this blood lust. I took a 4½ day trip with a friend of mine from San Diego down to San Pablo Bay, Baja California, Mexico. The weather was beautiful, the fishing was excellent, but we 18 anglers only caught 45 yellowtail. Everywhere we stopped there was unlimited whitefish, sand bass, and rockfish; fish of this sort. A line couldn't get into the water without pulling one out but on the way home there was grumbling among the 18 "sportfishermen" because the ice hold was not full of yellowtail. When we got back to San Diego and the ice hold was unloaded of its 45 yellowtail and fillets of rockfish and whitefish, and what have you, about 30 of the 45 yellowtail were left lying on the dock. I don't know whether that came through to you or not but what they wanted was a 400-500 fish count so that they could have left 420 or 30 or 40 still lying on the dock rather than to have left 30. So, somewhere, we are failing to provide the right public relations in that respect.

One last word. One of my pet projects, and a fight that I just lost in a battle with the Department of Fish and Game, was to utilize the sportfish catch. I know that over half the barracuda that are caught today are caught by sport fishermen and that over half of their catch goes into garbage cans or is thrown out of cars to the side of the road. This is "criminal", doubly so in a world that is hungry. I would say that maybe 30–40 percent of the sport caught rockbass, probably the most desirable fish there is, is wasted. Somehow there has to be a different approach to fish and game laws than the present one that creates a condition where a fishery of this sort is turned to waste.

I know this is an indictment on my industry, but it is not that we are not aware of it. We are hamstrung by a lot of archaic ideas in the Department which sort of indicate to me that the Department itself feels a bastion of defense against the hook and line fishermen and that the hook and line fishermen could conceivably destroy a fishery if he were not so drastically curtailed with rules and regulations concerning, for instance, his ability to prepare fish for the pan while on a sportfishing boat.

As you may or may not know, the code requires all fish leaving a sportfishing boat to be in an identifiable condition. I recently tried to get the California Fish and Game Commission and the California Department of Fish and Game to authorize a filleting proposal. A perfectly reasonable approach to this problem, but because it entailed a change in enforcement procedures the enforcement section shot it down. It was a bitter disappointment to me and my industry. I don't like being party to a system that knowingly contributes to a waste of our limited resources, yet I am stuck with it until such time as I can get a chance to be heard by councils that will do something about it.

DISCUSSION

KLEIN: Didn't we hear just this morning that nothing is wasted?

IZOR: You just heard from me, a practical, experienced, 20-year veteran that one-half the sportfish catch is wasted. One of the reasons I talked about recreational killing (I am going to leave this sportfish thing out of it) is that all fish caught belong in a commercial market so that through the processes of distribution they can become a part of the fish market. The prohibition on selling sportfish is something that organized "sportsmen" brought about. Sportfish belong sold somewhere at dockside to a commercial market where they can be utilized. This is long range thinking because great obstacles are to be overcome. The minds of muddleheaded sportsmen get emotionally charged if there is any threat to an existing status quo.

ROEDEL: Are you saying that you would favor a common fishing license?

IZOR: I would like to see a common commercial fishing license for what is now a $3 license and pump that money into the scientific community.

ROEDEL: Then everyone, sport and commercial alike, would have the same license, rules and regulations.

IZOR: For example, this is what happens now. Relying on landmarks and experience I can find a certain rock on the bottom, or I know where a stringer of kelp is, or an old wreck. A man with a 16-foot skiff buys a commercial license and follows me to the fishing grounds. He doesn't know where the rock or kelp or old wreck is, but he has the physical capacity and the mechanical technique to stand there and jig barracuda or bonito or some other fish. Passengers that pay me for my services are restricted to 10 fish, which is too many anyway, but they are limited to 10 fish. The fellow with the commercial license is no more a commercial fisherman than the passengers on my boat, yet he can sit there with his jig and "sink his boat with barracuda" and take them in and sell them. The man who pays $20 for my services cannot sell his catch and at the end of the day he doesn't want the fish he has caught. So they go to waste, believe me. I have groups of doctors and professional people who have ridden my boat for 15 or 18 years and I have seen them leave 40 white seabass on my boat. It's against the law for me to sell them and I am in violation for having 40 white seabass on my boat if we only have two sportfishing licenses in my crew. So I am really stuck. The only "out" is to find some charitable organization that will take them. It's a bad situation and I think it all stems from man's desire to legislate himself a guaranteed sack of fish every time he goes fishing. It can't be done. He would rather not improve his technique as a fisherman. He wants to create laws that will guarantee this "just putting it in the bath tub and yanking the fish out."

ISAACS: Let's return our thinking to the subject of the scientific data as related to an experimental anchovy fishery. I think the point you are making is that the main apprehension of the sportfisherman was not the scientific data by itself, but rather apprehension of the inability to the total legislative regulatory process to really act on the ultimate against the commercial. Is that the opinion?

IZOR: Yes, I felt that way about the anchovy fishery. A 200,000 ton catch is not going to affect the anchovy fishery locally, but it is 30 times what has been caught for bait during the last 15 years and to the layman it seems like a lot. We have a large industry which is dependent on a daily supply of live anchovies. We are afraid of any additional fishery that will exert heavy fishing pressure without guarantees that any increase in landings would be gradual, say 25,000 to 50,000 tons per year or something like that. It seemed reasonable, to me, that this was a logical approach because if the anchovy fishery is there now, conceivably it will be there 20 years from now, so when we do need additional fish meal, or to take advantage of some new process that maybe hasn't been devised, or is lying in one of your minds right now, the resource will be there and we will know how much fishing pressure it can stand from actual practice rather than larval counts.

ISAACS: Scientific evidence that you get from some catch. Director Shannon said we had not sold the scientific data to the public. Another aspect that entered very strongly is that the public did not feel that the total legislative and regulatory process was able to, at the moment, in its present organization, withstand the eventual political pressures and thus end in over exploitation. I think this is a very important point and that we should understand there is some unanimity of opinion along this line of thinking.

GILLENWATERS: It is very important because this confrontation will never be resolved, it has to be modified. For the first time, as you know, we have some representation of your sportfishery currently on the Governor's Advisory Commission on Ocean Resources. You talk about improving communication. How can you improve it? What are your suggestions? We've got a Commission meeting coming up and the administration is dedicated to trying to modify this confrontation, not for the political benefit I assure you, for the benefit of the resources. How can we approach this communication?

IZOR: Well, idealistically, with elaborate public information programs, however, I can't help but say that people to people communication is the very best. If any of you could serve as guest speakers for 15-20 minutes it would be extremely worth while.

SCHMITT: You speak of fishermen not being conservation conscious. Do you mean just the commercial or sport?

IZOR: I think it applies to everyone, but unfortunately, the recreational angler fishes with a small hook on monofilament line and the net fishermen fishes with a "mile-long" purse seine. The chances for great profit, for instance around my favorite island, is always there and no matter how hard the Department patrols—it can only patrol so much. Funds are limited and habit patterns develop. So when you know there is only one patrol boat on maybe a 100 mile stretch of coast, and that it is at anchor and the crew is ashore, the poacher only has to go a mile or two to a bonanza that can be quickly caught, quickly racked up, and quickly moved into a safe area. That is the only definite aim in singling out the commercial fisherman. He's no worse than anyone else.

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THE EXPLOITATION OF THE LIVING RESOURCES OF THE CALIFORNIA CURRENT: A FOOD TECHNOLOGIST'S POINT OF VIEW

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Technological Laboratory
Bureau of Commercial Fisheries
Terminal Island, California

Food technology is the application of scientific knowledge and scientific methods to the production of foods in forms that are safe, economical, diverse, and acceptable to the consumer. Food technology involves factors relating to the production of the raw material, harvesting, transportation, preservation, packaging, storage, distribution, preparation, and consumption. It involves basic research, applied research, product development, quality control, production, and use.

Fishery technology is the name given to the application of food technology to the various stages in the utilization of fish. A generalized version of such a system of use showing many of the stages through which fish must pass in order to become food offered at the table is:

Resource
↓
Harvesting the resource
↓
Transporting at sea
↓
Processing
↓
Storing
↓
Distributing to the consumer
↓
Preparing for the table

The chain of events leading to the consumer's table starts with the resource itself, which is subject to many natural variations. The seasonal condition of the fish may be a significant factor in a process. For instance, the seasonal rise in concentration of oil in a stock of fish may be important, even critical, to a profitable reduction operation. It may also be a significant factor in the quality of the fish after they are canned. Many other areas of technical involvement exist throughout the chain of events leading to the consumers table as can be illustrated by the following simple chart:

Resource	Size and condition
Harvesting	Harvesting effects on quality
Sea Transportation	Preparation Chilling Freezing Holding Thawing Handling
Processing	Cutting Drying Smoking Cooking Canning Other processing Packaging
Storage	Aging and environmental effects
Distribution	Environmental effects
Consumption	Preparation Nutrition Consumer reactions and preferences

[1] Now Project Director, Fish Protein Concentrate, Division of Industrial Research, Bureau of Commercial Fisheries, Washington, D.C.

At the consumer end, the food technologist is concerned with how the differing characteristics and properties of various fisheries products, modified by their treatment in the system, affects their acceptance —and hence, the value and volume of their sale.

It is an obvious fact, but one often neglected by specialists in restricted disciplines, that all parts of this system must be functioning at a profitable level for the whole to continue as a viable economic entity. Many of us think of and deal with one part of the system without relating the part to the whole, but if any part does not function correctly, if any part is too expensive, or if any part damages the product, eventually the end product will fail to satisfy the consumer; then the whole system will fail in the competition for the food dollar. This relation of the part to the whole is one that has to be learned by every fishery technologist in industry before he can contribute usefully to his field.

Having now set fish technology in its frame of reference, let us look briefly at how it relates to the technological problems involved in the use of fish in California. In general, these problems are similar to those elsewhere in the United States. Perhaps the principal block to the increased consumption of fish in California and in other parts of this country is the variable and sometimes low quality of fishery products offered for sale. This problem of quality is due, not so much to a lack of knowledge of the technological requirements, but to a lack of application of the knowledge. Much of this lack is due to the inability of a traditional industry to keep pace with the developing requirements of the modern consumer, who demands ever higher standards and who often gets them in other products. There is no indication that this barrier of quality improvement will be shortly broken unless mandatory inspection of fishery products is instituted. Other means must be sought to increase the flow of fisheries products.

Much technological study now is being devoted to different methods of preservation that may, by extending shelf life, enable fish to be offered for sale in a fresher condition. Antioxidants and other additives, controlled atmospheres, and novel packaging and handling methods are a few of these.

Researchers also have been working along two additional lines that may help us use certain stocks of fish more extensively.

The first of these is radiation pasteurization, the low-dose treatment of fish by ionizing radiation, which markedly reduces the population of bacteria on fish and thereby prolongs its storage life at chill temperatures. Much work has been done on this technique, especially in the United States. The researchers have repeatedly demonstrated, using both small- and large-scale experiments, that exposure to a low level of radiation of about 0.1 to 0.2 megarad is sufficient to more than double the life of fresh fish stored on ice without imparting any appreciable amount of radiation, or other flavor to the fish. This technique has a great potential for increasing the availability of high-quality fresh fish in the market, particularly when it is applied at sea to fish immediately after they are captured.

At present, the Food and Drug Administration, treating radiation as an additive under the Additives Amendment to the Food, Drug, and Cosmetic Act, has not sanctioned this particular technique for use with fishery products. Their concern is that, under the anaerobic conditions occurring during some conditions of storage and with the possibility of storage temperatures rising above 40° F in commercial distribution, Botulinus organisms that are not inactivated by this level of irradiation might grow and thereby form toxin in the product. Other organisms that would act as spoilage indicators by the production of strong off odors and flavors may be inactivated by the radiation and so may not give the familiar warning of potentially dangerous deterioration. In addition, the different behavior between species of spoilage organisms is a complicating factor. Authorization by the Food and Drug Administration for the use of radiation pasteurization on fish will therefore have to await further experimental evidence now being accumulated.

A second greatly significant potential for California fisheries lies in the production of fish protein concentrate (FPC) from underused species, such as anchovy, hake, and saury—fishes not generally regarded in this country as being attractive for human consumption. Fish protein concentrate, which usually is produced by a variety of solvent-extraction techniques, is generally presented as a colorless, odorless, stable powder containing 75 to 85 percent protein with a very high protein efficiency ratio. Other forms, which appear as highly flavored hydrolyzed protein products, are of a similar nature to oriental fish sauces such as *Nuoc mam* and *Nam pla* but have so far been relatively little investigated.

FPC has been widely proposed as a supplement in the protein-deficient diets found in many under-developed countries. Without doubt, if the increases in population that are predicted for the 1970's and 80's occur, all forms of available protein will be in great demand, including FPC.

Fish protein concentrate faces three associated barriers, however, in its general application.

The first is that some of the manufacturing techniques are not yet in an advanced stage of development. The construction in the Pacific Northwest of the demonstration plant authorized by Congress will give a much-needed boost to the engineering development of the extraction method using isopropyl alcohol.

The second problem is that initial product costs, which have been estimated to run from 25 to 45 cents per pound of fish protein concentrate, raise serious problems in the use of the product by the economically depressed groups who so greatly need such protein. It is to be hoped that manufacturing expertise and continued development will bring the price down much closer to the 7 cents per pound asked for fishmeal, a price that would then make its commercial incorporation into cereal products more feasible in the developing countries.

The third barrier is that relatively little work has been done on the complex of marketing problems involved in the distribution of fish protein concentrate to the widely varying social and ethnic groups who need it. More studies are required on the food and food-distribution habits in the developing countries and of the incorporation of fish protein concentrate into different local foods. Probably no general solution to this problem exists, since foods and patterns of food distribution and consumption vary considerably from country to country and, indeed, even within a single country. So this problem is hard to solve. In fact, some people believe that the difficulties are inseparable. Having had the opportunity to participate in a limited survey of the possibilities in several of the developing countries, I myself have passed, however, from a viewpoint of considerable skepticism to one of cautious optimism.

Many of the areas of greatest need, such perhaps as Brazil, will probably be unable to supply more than a part of their own requirements, so an international trade in fish protein concentrate may develop in much the same manner that the present international trade in fishmeal has developed. It may even replace the trade in fishmeal. In either event, California fishes not presently used for food, may be used for this purpose. Such use would be subject, of course, to the removal of any legal barriers, since the manufacture of fish protein concentrate may possibly be classified legally as a reduction operation. The international trade in FPC may in practice also depend on the development of international standards for fish protein concentrate that would make FPC less expensive to produce than do the requirements of the Food and Drug Administration.

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DEVELOPMENT OF A FISHERY RESOURCE

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How is a fishery resource discovered, evaluated and developed? Perhaps it is most easily discussed by reviewing a checklist. We could be talking about the anchovy fishery in California or the sea cucumber fishery in Palau; both have potential, perhaps of a different order of magnitude, but nevertheless the evaluation process is the same.

1) *Magnitude of the Resource*
   A study of the resource size involves a compilation and review of existing information of a scientific nature and of any exploratory fishing or preliminary commercial fishing on the species. A comparison with fisheries on the same or related species in other areas may also be useful. Of course, if the resource study is not favorable, we don't need to proceed further.
2) *Political Climate*
   The concept of checking out the political climate is easily understood if the fishery is from a foreign base. However, political problems may be just as important in the development of a United States fishery. We must, in both cases, examine the impact of the development on the natives and the economy of the area.
3) *Economic Climate*
   It is necessary to examine the type of vessels needed, the expected catch rates, operating costs of vessel and crew wages. The crew must receive a return commensurate with the type of work and shore wages. At the same time, the vessel must operate profitably. Where will the raw material be processed? Costs of handling, freezing, storage, and shipping must be calculated if the material is not to be processed at the site of the fishery. What are the potential dangers of government take-over of your operation? What are the potential losses through currency devaluation or a runaway inflation? Local legislation may restrict your operations. Tax increases may increase costs.

In conjunction with this preliminary study, it is necessary to have a marketing plan. With an established product, tuna, shrimp, etc., this presents no serious problem as there is a world demand for the commodity in its raw form.

We then take all this and other information and balance the risks involved against the return on investment. The major development is done by companies who must constantly ask this question: Is the return worth the risk and effort involved? There has been a considerable change in the complexion of the fishing industry in recent years. Companies are larger. There is pressure for expansion of sales of present products and the development of new profit areas. New sources for raw material are constantly being sought. If there are latent resources in fisheries, they will be noticed, studied and if promising, developed.

Government and University research people generally measure the potential of fishery resources by magnitude of the population and minimize the political and economic problems associated with its development.

For example, let us consider the development of a fish meal and oil industry from the California northern anchovy or Pacific hake populations. The products flow freely in world trade and the geographic advantage is worth \$25–30 per ton at most for meal and less for oil. The development of the area then depends, to a large extent, on the world trends in prices of meal and oil.

Fish meal is used largely as the animal protein portion of the ration used to feed chickens and turkeys. Chow formulation is now done by least cost methods on computers. All factors of cost and value are entered in the program and the nutritional package is compounded at least cost. Under this system the usage of fish meal is closely tied to its price and plant protein prices.

In Peru, where plant protein is scarce and fish meal abundant, the ration may contain as much as ten–twelve percent fish meal. In the United States, the ready availability of soybean meal and the higher costs of fish meal (transportation of imports) restrict the fish meal usage to less than half the level used in Peru.

The major producers of fish meal in the world are:

	metric tons
Peru	1,725,000
Norway	480,000
South Africa	350,000
United States	200 000
Iceland	130,000
Chile	130,000

The major users are:

	metric tons
United States	850,000
West Germany	530,000
Great Britain	460,000
Holland	195.000
France	125,000

Neither Japan or the Soviet Union have been included in these lists as their production is used internally and their operations do not affect the supply-demand situation in fish meal and the basic costs of production.

An 11-year series of fish meal prices in the United States market shows a major low in 1960 and another in 1967. The major highs were in 1958 and 1965. Prices are currently in a two year downtrend and may go lower. Production in Peru is at record levels for the second straight year. Cost of production there is lower than anywhere in the world. We figure the breakeven point in Peru is in the 40–45 ton per fishing day level. That's tough competition for any developing fishery, either here in California with our restrictions or elsewhere in the world.

The long term picture is not so dismal for development of an industry in California. Peru has had two exceptionally good year classes back to back. Their production will most certainly decline. The Norwegian herring fishery is phasing out a very successful year class with no immediate replacement in sight. The mackerel fishery there is thought to be at maximum, as is the capelin. The world production of fish meal during 1968 will not increase over 1967 and may well be down fractionally. Usage is high so we can expect price improvements in the meal market during 1968.

Development of the anchovy resource in California is presently hampered by political and economic problems. Although the resource is large, I do not believe that the industry is passing up a great opportunity under the present climate.

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THE LEGAL FRAMEWORK FOR THE DEVELOPMENT OF OCEAN RESOURCES

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"What rights do men have to fish?"

It is my function as an international lawyer to take a national and a world view of such things. A part of the view that I have can be identified by an illustration. A recent Assistant Secretary of State of the United States, in addressing an American audience at a dinner meeting, said to them, "Now you will be going back to your homes and tomorrow morning you will be having a good breakfast, but think of 50% of the rest of the world which will not have had as sumptuous a dinner as we have just had, and furthermore they won't be eating again for one and ½ days, and when they do eat, they will have a bowl of cooked rice and perhaps a piece of fish 1-inch square." So the essential theme of my remarks relates to the problems of a scientific and technological revolution which has produced a capacity to harvest the fisheries resources of the sea and other marine resources at a time when there is also a population explosion so large that we are told that by the year 2050 of 2068, depending on whose figures you take, the population will have enlarged from its current 3.3 billion to a population of around 7 billion and this is the minimum prediction! The forecasters tell us that this population explosion in large part, 75% of it, is going to take place in the emerging and underdeveloped nations of our world. It is these nations which are obviously short in resources, including food resources. So, the point that I am suggesting is that we are on a kind of collision course—and the collision course is between famine on the one hand and a burgeoning population on the other. The question is how to resolve this kind of situation.

I have become identified with a theoretical approach to this, which I refer to as the social complex theory. This theory may be categorized under 3 headings. As category 1 are the forces of the social complex. I have mentioned already the scientific and technological revolution and also the population explosion of people. To the international lawyer there is also a population explosion of nations, the rising tide of human expectations, political-socioeconomic problems, and above all and of most importance is a sort of catalytic agent which falls within this category, namely, the tempo of our times and the quantum jumps which are taking place in all of these areas. So this is one of the elements of the theory.

Secondly, there is the factor of world institutions. One of the speakers this afternoon has already referred to the FAO (Food and Agriculture Organization of the United Nations), and I am sure that by identifying that you immediately think of a number of other specialized agencies of the United Nations including the World Health Organization, International Labor Organization, Meteorological Organization, the International Telecommunication Union, and so on. They all have a direct concern for the needs of those in the fisheries and maritime business.

Thirdly, there is the whole matter of values. This encompasses the broad subject of human rights including the problem of the allocation of scarce resources, the problem of conserving existing resources, finding additional resources and making them available to those who require them. In this theoretical approach, one arrives at the feeling—at least I do—that there is a universal and cross frontier aspect for these elements as they apply to our situation.

Now, let us return to some of the more practical aspects of my assignment.

In 1966, the United States claimed a 9-mile exclusive fishery zone in addition to an existing 3-mile territorial sea (total of 12 miles). Pursuant to Federal Legislation and also the Geneva Convention on the Continental Shelf to which the United States is a party, the U.S. exercises sovereignty over the Continental Shelf and the subsoil and the resources which are located on and below that area. The Continental Shelf is defined as the seabed adjacent to the coast outside the territorial sea to a depth of 109 fathoms (200 m), or beyond that limit to the extent of the exploitability of natural resources. But the water situated above the Continental Shelf commencing at a point 12 miles seaward from our shores constitutes a high seas fisheries area open for the exploitation of all concerned. Although what has just been said depicts accurately the present view of the United States, I wish to raise some questions about the suitability of such a regime.

Let us consider for a moment the contiguous zone concept that found its way into the 1958 Geneva Convention on territorial waters and contiguous zones. The Convention made provision for a 12-mile zone, and has to do with exclusive rights of the Littoral State to exercise protective measures in the area in so far as health, sanitation, tax, quarantine, rum running, and customs violations were involved. So we have a claim on the part of the Littoral State for some rather exclusive controls in that area. Then take the problem of the commercial air flights which come into the United States. The U.S. and a number of other states have identified what is known as an Air Defense Identification Zone. The ADIZ, prescribed by our Government, requires that foreign commercial aircraft destined for the U.S. must identify themselves at 1 hour flying time from our shores. So we have now an extension of U.S. claims to exercise a certain amount of jurisdiction in these areas. Then during World War II, before the U.S. became a participant, we asserted the right to control the high seas about 1,200 miles off the coast of Panama with the provision that we wanted the warring nations to stay out of those areas at that time. Then, an illustration relating to the high seas and to the air above those seas, was the 1962 maritime quarantine of Cuba, or more particularly, the quarantine of the shipment of offensive missiles on the part of the Soviets into Cuba. At that time, we identified a perimeter of some 500 miles around Cuba. As to this high seas area we said we would not permit particular vessels carrying these particular types of goods to enter.

What I am suggesting is that we may be obliged to review our thinking as to the nature of the claims relating to the oceans which nation states are going to be making in future years. In particular, we must reconsider the nature of both national and community claims as to exclusive or possibly cooperative rights in the oceans going well beyond the specific areas which I have just identified.

Having taken a look at the situation as it may evolve in the future, let us look back to the beginning of the 17th century. At that time, several very noted writers began to explore the problems of control, sovereignty and jurisdiction over the seas. The Dutch writer Grotius, writing in 1609, wrote a book entitled *Mare Liberum,* the freedom of the seas. A British writer, John Selden, issued a tract, 9 years later, which was in fact a legal brief. In replying to the Grotian position, he urged that there should be a closed sea, *mare clausum.* This exchange has been referred to by the commentators as a "battle of the books." In reality, this was a battle of national interests. Many have believed that this battle of interests was resolved in the Geneva High Seas Convention in 1958, which identified the high seas as free seas for the several purposes of navigation, fishing, laying of pipe lines and cables, and freedom of flight over such high seas. As to these matters, the Convention went so far as to say that the treaty merely codified the preexisting customary international law. Despite this, I am willing to venture the belief that we once again are challenged to revise our thinking respecting the freedom of fishing on the seas, going beyond the territorial waters and going beyond the exclusive fishing rights which are now claimed. This has been influenced by the claims which were made by the U.S. in 1945, the Truman Declaration, with respect to the natural resources of the sea bed and the subsoil of the Continental Shelf. You will remember at that time that the claim was made based upon apparent military and security needs relating essentially to oil and natural resources of that kind. This was followed in 1953 by the U.S. outer Continental Shelf Lands Act. This national legislation helped to give rise to the 1958 treaty on the Continental Shelf.

There are those who believe that geology may have some role in determining what the Continental Shelf may be. I would like to keep an open mind on that particular contention for I am not entirely sure that the geological formations of the land area of the sea bed and the subsoil below the sea bed, has any meaning with respect to the ultimate definition of Continental Shelf. But at least, we know at this point that the Continental Shelf is this sea bed which goes out to a depth of 200 meters—109 fathoms. There is an important open ended clause in the Convention which says the shelf extends beyond that point to a point where it is feasible to exploit and use the resources to be found. Again, this ties back to my social complex theory and particularly the scientific and technological revolution which we have seen which makes such exploitation feasible. It is becoming increasingly more feasible to go further out than the 200-meter line, including the areas of the continental slope just outside the 200-meter line, go really into the high seas, below the high seas, in order to exploit existing resources. And so my question is whether or not the people possessing the capability of exploring and exploiting these resources are going to sit back and not do anything in terms of such exploitation.

In this regard, I must mention to you some very interesting things that I had a hand in back in Geneva in July of this year at the World Peace Through Law Conference. At that Conference a proposition was put forth and adopted unanimously, to the effect that the United Nations ought to assume sovereign control over the sea bed underlying the high seas. This has now been presented to the U.N. in the form of a very long talk by the U.N. Delegation from Malta, Mr. Prado. He is now stirring a lot of imaginative approval as well as a lot of opposition with respect to the possibility that the U.N. should exercise the right to license the use of these resources and also to dispose of any income which is received from licensing and other procedures. With this in mind the question is presented whether to go one step further. Bearing in mind the claims for the ADIZ, for 12 mile exclusive fishing rights, for the 1,200 mile security zone during World War II, and for the 500 mile perimeter surrounding Cuba in 1962, as well as Continental Shelf claims, is it not feasible to think that someone one of these days is going to propose that the high seas be placed under the command of an international organization, and that that international organization would have the disposition of these resources, license, control, authorize, and so on, the taking and harvesting of marine resources. Also involved is the prescribing of what actions should be taken in conserving the resources and in the long haul, probably endeavoring to produce—as has been done recently with rice in Japan, a new hardy strain that produces 3 to 4 times as much as in the past—possibly a new strain of fish or marine life which would support in a better fashion the individuals who are living in the developing nations and whose populations are growing so rapidly.

Now, while we are thinking about the matter of conservation, I would like to call to your attention Article 3 of the 1958 Geneva Convention on Fishing and Conservation of the Living Resources of the High Seas. This provides, and I quote, "A state whose nationals are engaged in fishing any stock or stocks of fish or other living marine resources in any area of the high seas where the nationals of other states are not thus engaged," and of course, this would mean within the 12 mile exclusive fishery zone of the U.S., "shall adopt, for its own nationals, measures in that area when necessary for the purpose of the conservation of the living resources affected." So it seems to me that by reading this and understanding it, it is simply the function of the U.S. to take special conservation measures in the areas lying beyond the 12 mile exclusive fishing limit. Let me call to your attention Section 4 of the 1966 Statute. We as Californians are particularly interested in this. It says, "Nothing in this act shall be construed as extending the jurisdiction of the states to the natural resources beneath and in the waters within the fisheries zone established in this act, or as diminishing their jurisdiction to such resources beneath and in the waters of the territorial seas of the U.S." And then according to the legislative history on this particular section, it was said in the committee report that such language intended to make it clear that the jurisdiction of the coastal states to regulate fisheries within the territorial sea of the U.S. or to the natural resources beneath and in the waters of the territorial sea would not be extended nor diminished by this legislation. So, the 1966 legislation does not modify in any way, shape or form the rights which the State of California previously had and now has in the 3-mile area.

But coming back to the problem of conservation in the 4–12 mile zone, it is my argument that since under the 1966 statute a littoral state, namely California, in this instance, has no direct control over such areas for conservation purposes, it now appears that such states have the right and the duty to insist that the national government take all necessary action in this regard. I think we should start moving on that, so the conservation of fisheries and marine resources in these areas will be suitable to our economic needs and also in order to forestall the possibility, it's a remote possibility, but nonetheless within the range of legal contemplation, for some other country to come along off our 12-mile area and start conserving fish there and claiming that they by reason of this conservation activity, have a right to harvest the resources which are available there. This is easier to say than it is to develop in detail and I would want to add as a condition to what I have just said, that the Convention on the Conservation of the Natural Resources of the Sea is rather complicated and involves the possibility of a considerable amount of international diplomacy and negotiation before anything as extreme as someone else endeavoring to conserve the fish off our immediate 12-mile area could possibly take place.

A number of interesting treaties and statutes have developed since the 1945 Truman Proclamation. From the international point of view one contest has been whether the king crab is a resource of the Continental Shelf or whether it is a fisheries resource, and as such could be harvested by anyone who happened to have the ability to effect the capture, whereas if it's a resource of the Continental Shelf, then it pertains to that nation which owns the Continental Shelf, namely the United States, off the coast of Alaska. Several treaties have been entered into. The Soviet Union has conceded to us that king crab is a resource of the Continental Shelf. We in turn have conceded to them the right to fish there for a while initially taking not more than 185,000 cases of king crab during one year. This has just been revised downward to around 120,000 cases for the year we are now in, 1967, with the proviso that it will be revised periodically after that. So there has been a little give and take on that.

The Japanese, on the other hand, have not been willing to make the concession that the king crab is a natural resource of the Continental Shelf. They regard it as a free swimming fishery, although it doesn't have a swimming fin. We have been negotiating with them and as a result of these negotiations, they have also agreed to take only a limited harvest over a period of time, but they insist that they have traditional rights to capture the king crab in the waters in the Bering Sea. They are preserving what the lawyers for fishermen would call historic rights, and it remains to be seen what the ultimate outcome will be. This will be negotiated. However, it is also clear that the U.S. has put a little teeth into its beliefs in this respect. Detailed sanctions are set forth in the 1964 Bartlett Act. This statute does provide rather categorically in the language of the 1958 Convention that the king crab is a resource of the Continental Shelf and therefore appertaining to our control.

Now, in coming back to the thought that there may be a trend in the future toward the international organization of the high seas for fisheries purposes, one can readily imagine that this would call for the use of an international body. It need not be the U.N. It could be the FAO. It could be any effective organization. If such a regulatory instrumentating were to be utilized, it is my hope that it would regard itself as a trustee for the totality of the nations in the world and that they would be able to organize it so that it would possess a stable corporate structure. It would be the function of this organization—at least in part—to procure economic security to those engaged in fishing. It is feasible, under plans which you could readily imagine yourselves, for the fisherman who is fishing out of San Diego or Long Beach or San Pedro, to be just as protected and secure in his employment and the boat owners and operators would be just as secure in their investments and so on, as they are at the present time, which I gather is not quite as precise and exact as they would like to have in the most perfect of all perfect worlds.

Let me just conclude then very quickly. It seems to me that the "battle of the books", or the battle of opposing interests for competing preferred uses of the ocean's resources will continue. The principal contest is over exclusive national rights or inclusive community rights. This involves not only the right of the resource states to capture but the basic needs of the nonresource states. This contest may require the revision of existing international conventions. I wouldn't be at all surprised to see another U.N. sponsored General Conference on the Law of the Sea which would modify both the Continental Shelf and the High Seas Conventions, as well as the other two. Such formal revisions, or informal ones, will be widely influenced by the factors which I have identified under the social complex theory headings. Such factors and forces indicate that there will be substantial demands for the more efficient use of the resources of the oceans. The best way to do this is through international agreements involving the assumption by states of common and mutual responsibilities rather than through the processes of unilateral claims involving special privileges.

DISCUSSION

ISAACS: You have quoted evidence from military operations and possibilities for great extensions of some sorts of rights, and I was wondering regardless of whether this goes in the direction of U.N. or some world court, is it not possible, considering the temper of the times as we might look at them in the future, that the development for utilization of fisheries in the high seas might be one of the strongest forms of *ethics*? rather than military restrictions for some eventual adjudication of rights of the high seas?

CHRISTOL: I would agree to that. I would think there are many important modifications which would support this outcome and it might even be that we could capture the imagination of the people of the world and say, "Look, here are some elements we can struggle against and some resources we can fight for or we can develop. Let's fight along these lines instead of fighting each other, and make these resources available and substitute this sort of contest for the contest of war and the like."

ISAACS: This might be considered as one supereconomic feature in the developments of high seas fisheries by the nations.

CHRISTOL: Yes, I think this is exactly true. I could foresee a great spinoff, a large number of peripheral benefits which would be derived from this and if the population goes up as I have suggested, we might just as well put these additional bodies to work doing this sort of thing rather than something else. Probably better.

POWELL: Dr. Christol, in relation to international law of the high seas, what weight is given to traditional or historical fishing rights?

CHRISTOL: It has a very substantial significance.

POWELL: Is it a tacit one, or is it a really legal one?

CHRISTOL: It is a legal right. Law involves both written statements and ideas which are spelled out from those written statements—statements by way of implications. It also has to do with practices which have emerged and developed over the years, and I must say that this question strikes a responsive chord, because as a lawyer, I know that it is very nice to go to a statute book and pick out what I am looking for. Even then, one has to be alert as to whether this is still good law. Maybe the courts have changed it, but at the international level, it is not quite so easy to go to the statute books because there hasn't been a sophisticated type of world organization that has spelled out and spun out this type of legislation. So we have to look at practices, long ranging practices, or short ranging practices, as the case may be. If we see that there have been claims that certain practices are permitted, an acknowledgment on the part of other countries that these practices are permitted, that there are mutual tolerances accepting these practices, then the international lawyer says, "we have got enough to go on, this is the law." Then, we hope that after this has been acknowledged in a customary form just to make it a little more tangible, a little firmer, that we'll have a convention or a conference. At that point, we'll put it down in black and white and call it a treaty. We'll call it an international agreement. We'll call it an executive agreement, something of that sort. Then we've got something we can walk into court with and say, "Look, your honor, we have something in writing." But the international lawyer knows that the fact that it's in writing doesn't make a particle of difference. If it is a customary rule, it is just as sound as if it was put down in writing.

POWELL: What period of time constitutes historic fishing rights?

CHRISTOL: This, again, is not easy to respond to, but let me say that a practice that has been honored over a period of time may be regarded as long enough. A good illustration of this is the claim that the Norwegians had with respect to the fisheries off the coast of Norway. They took the British to court, you remember, in the Anglo-Norwegian fisheries case, and they were able to show that these claims that they had been asserting from time to time from about 1825–1830 on were good enough to stand up when the case came up in the 1940's. Now it needn't be that long. One writer says that the formulation of the customary law is like the glacier, moves very slowly. To this I respond, utter nonsense. It may be that in certain areas it is slow, but in other areas, it can be very fast. In terms of the development of a law of outer space, the first Sputnik went up, as you remember, in October 1957. It is my contention that by 1963 at the latest, there was a customary rule of international law calling for the peaceful uses of outer space and this might be an analogy to what I was saying earlier, in the sense that both the oceans and outer space have to be used peacefully for the benefit of all mankind. My argument to you this afternoon was to the effect that the high seas ought to be used for the benefit of all mankind. In the case of outer space, the 1967 treaty put into writing the practices which had emerged between 1957 and 1963. A short period of time will support rights where there are security involvements.

ISAACS: If I remember prescriptive rights on land are achieved by utilizing it freely over time immemorial, which is defined as 7 years.

CHRISTOL: This varies. It can be longer.

QUESTION: How specific is traditional use, for instance, if you had been using or were fishing albacore on Erben Bank, which is 100 miles off, how would that apply to the use of hake?

CHRISTOL: I think that my response there would be very nationalistically oriented, assuming that we want to take hake. The fact that you are fishing in the area is the important thing, not the kind of fish taken. This may be something we ought to research, but this would be my off-the-cuff response. Note, however, the fact of historic *fishing* would not support the taking of something else, such as a Continental Shelf Resource.

SCHMITT: How do you view present Congressional prospects for international pressure groups?

CHRISTOL: Oh, I think that the pressure groups, if I read them, that have come out of the Maltese proposal are going to be so critical of the thought that an international institution should have the resources of the sea bed that if this particular idea which I mentioned to you this afternoon were to be presented to the Congress, the first reaction would be negative. They would say, well what are we giving up and what are we getting in return? And then, of course, those fishing interests who feel they have more to gain by continuing the freedom of the seas, freedom of the fisheries on the high seas, will start to argue. But in listening to the remarks of an eastern speaker relating to the Soviet Union's application of science and technology to fishing, and you gentlemen know a great deal more about this than I do, if you can herd fish, if you can put them into given areas, I see no reason why there couldn't be a conservation responsibility allocated to a group of states on the high seas and since they put their resources in support of this, they should be entitled to treat this just like my grandfather's 160 acres of wheat out in South Dakota. Why not let fishermen who have conserved the resources have the benefits of this?

SCHMITT: Do you foresee a correctional evolution?

CHRISTOL: I think this is bound to come. I can't believe that man, with his scientific and technical capabilities is going to permit an area not being used when it does have potential.

Calif. Mar. Res. Comm., CalCOFI Rept., 13: 127–128, 1969

HOW CAN THE SCIENTIFIC COMMUNITY BEST CONTRIBUTE TO THE RESOLUTION OF THESE VARIED PROBLEMS?

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I have noticed that almost every previous speaker has made some comment on the topic on which I have been asked to talk; this is gratifying to me as a scientist, for it means that it is rather widely recognized by the representatives of the very diverse viewpoints who are here today, that the scientific community does indeed have a role to play in the solution of the problems facing California fisheries.

What I'm not so sure about is whether the previous speakers have really stopped to think about the composition of the group of people they refer to as the scientific community. We should not forget that their employers are very diverse, and employ them to look at the same problems from quite different points of view. Employees, including scientists, may be expected to keep the main interests of their employers in mind when making value judgements. To take a concrete example, it would be rather surprising to many of us if a scientist of the Bureau of Commercial Fisheries came out with a recommendation against the establishment of an anchovy reduction fishery on the grounds that it might be detrimental to the interests of sport fishermen. It would, of course, be laudable and proper, that he should do so if his data indicated to him that this was the true situation. The opposite could, of course, be true with a scientist employed by the Bureau of Sport Fisheries and Wildlife, who might well make the opposite recommendation about the same fishery.

Looked at this way, it is evident that the scientific community in the broad sense is unlikely to speak with one voice in matters controversial, and the history of the past few years has shown that this has been so. We should guard against this tendency in the only way possible, by maintaining our integrity and our objectivity. This we must do if the planners, who will not be of the scientific community and who must take our statements at face value, are to make effective use of our findings and judgements. If we join the ranks of those who plead the causes of special interest groups, and do not try to evaluate the whole needs of the state, then we lose the right to call ourselves a scientific community.

We must also recognize that this is an era of considerable confusion, generated by an unprecedented degree of economic and institutional change in the State of California; the scientific community is confused, wondering where it stands in relation to the intense phase of planning currently going on; the fishermen are confused, wondering how best to react to the economic changes of the past few years. Add to this the complexity created by the many, and sometimes vociferous, special interest groups and you have sufficient explanation of the present situation and of our present groping for priorities.

We should also recognize that our problems here, in the wide view of world fisheries, offer a very special and interesting situation. I suspect that if an FAO fisheries biologist or one from a developing country, say Ghana, were to have sat in on this symposium he would have little sympathy for our problems, and if a Soviet biologist had been here he would have found it hard to understand what our problems were. Happy people whose priorities are not debatable, who know that what they are doing is the right thing, have no problems of the multiple use of resources.

When I think about the situation in the California fisheries it seems to me, at first, that we may have here a glimpse of the future of world fisheries, and my thought is that other people, in other places, may be watching us to see how we resolve our problems. Perhaps in the foreseeable future, the people of western Europe, achieving leisure at the California level, may turn more and more to the sea for recreation, and the time may come in the Soviet Union when the interests of sport fishermen become a valid consideration in planning, which it is not considered to be today.

If others later face the kind of problems we face now, then what we do here becomes a model for the later-comers, and may be very important indeed in the future development of world fisheries. If, with all the varied and sophisticated talent in ocean sciences presently in California, we cannot solve our problems, then later-comers may indeed despair of solving theirs.

But, as was implicit in what the last speaker said, this vision of California fisheries may be totally false. What may very well happen is that the collision course between world population and food production will render the present situation merely ephemeral. The largest single-species catch in the world, the Peruvian anchovy, does not go to feed the hungry peoples of the world. as we all know, but to feed hungry chickens in Holland and California; if this economically sensible but morally indefensible situation ever changed, as it well might when hunger becomes acute enough to stir the conscience of the world. then I suspect that we may need to turn to our own anchovy resource to feed our chickens. More immediately, any upset in the present price structure of the world fish meal trade could almost overnight put us in the position of being able to make a handsome rather than a meager profit from California anchovy reduction plants—and who can doubt then that institutional problems would dissolve equally rapidly and we would have new "Cannery Rows" as fast as they could be built.

In this complex situation, it is imperative that the main body of the scientific community—fishery biologists, oceanographers, economists, sociologists, and so on—maintain a sufficient distance from the controversies of the day to retain complete objectivity in their research. On the other hand, some of us must certainly become involved in planning and in discussions about the application of our data to the present problems, and we must be as deeply involved in both camps—scientific and planning—as we are able.

Without this degree of involvement on the part of some of the scientists, in the broad sense, with the problems of the day, and with the deliberations of the planners, and with the politics of the State of California, our scientific effort may be wasted and the community at large badly served. I cannot sum up this situation better than by quoting from the writings of a gentleman from the other side of the fence, whose succinct style comes perhaps from his long experience in reaching a very large audience: "If we have a correct theory but merely expound it, pigeonhole it, and do not put it into practice, then that theory, however good, is of no significance."—Mao Tse-tung, Quotations: No. 307.

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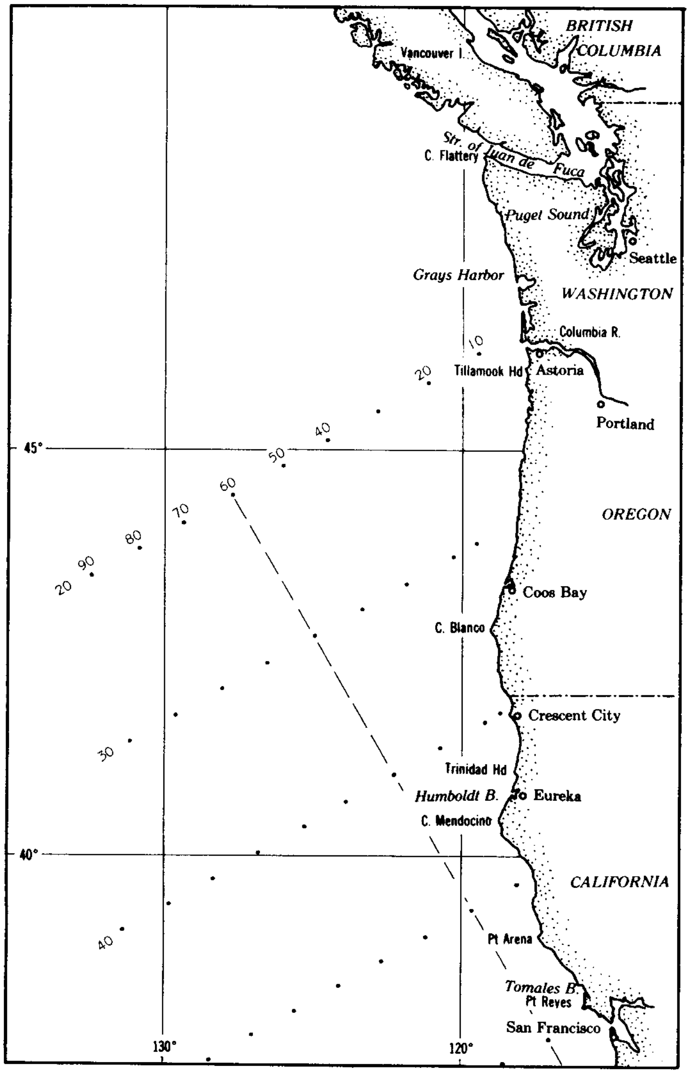

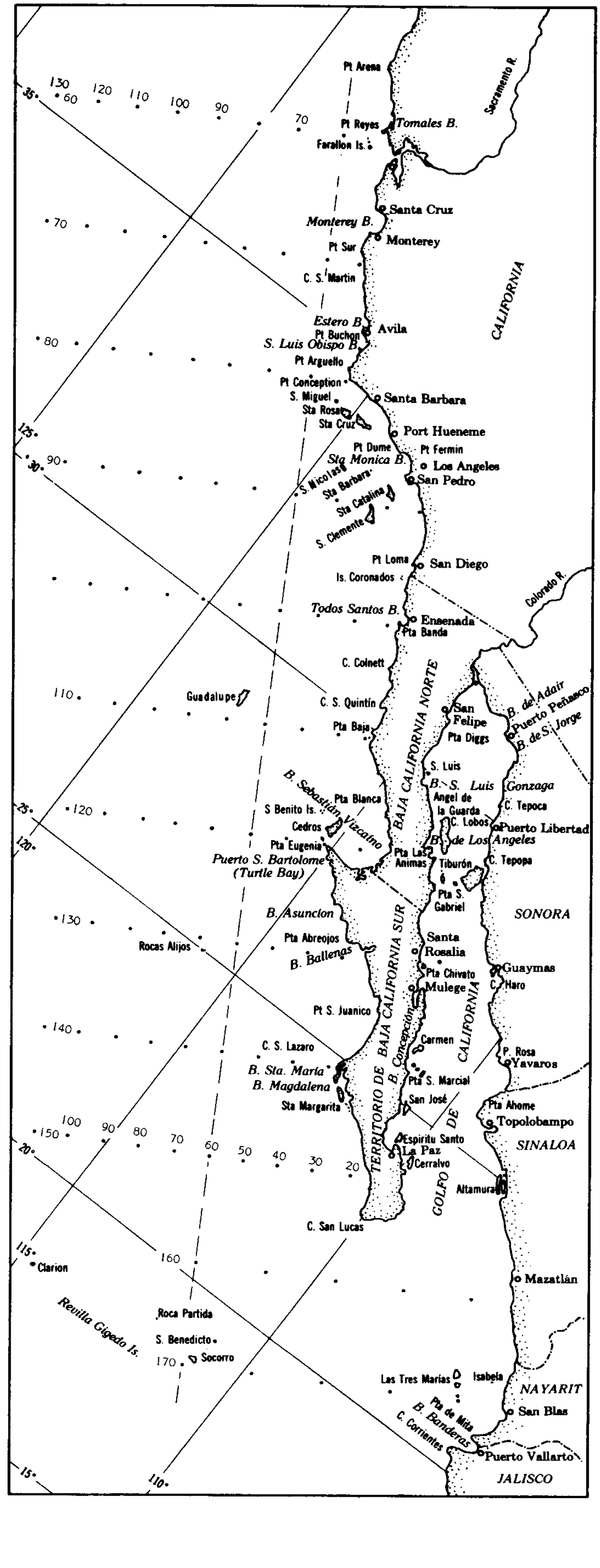

These maps are designed to show essential details of the area most intensively studied by the California Cooperative Oceanic Fisheries Investigations. This is approximately the same area as is shown in red on the front cover. Geographical place names are those most commonly used in the various publications emerging from the research. The cardinal station lines extending southwestward from the coast are shown. They are 120 miles apart. Additional lines are utilized as needed and can be as closely spaced as 12 miles apart and still have individual numbers. The stations along the lines are numbered with respect to the station 60 line, the numbers increasing to the west and decreasing to the east. Most of them are 40 miles apart, and are numbered in groups of 10. This permits adding stations as close as 4 miles apart as needed. An example of the usual identification is 120.65. This station is on line 120, 20 nautical miles southwest of station 60.

The projection of the front cover is Lambert's Azimuthal Equal Area Projection. The detail maps are a Mercator projection. Art work by George Mattson, U. S. Bureau of Commercial Fisheries.

CONTENTS

Page

I. Review of Activities 1 July 1967–30 June 1968
- Report of the CalCOFI Committee 5
- Agency Reports 6
- Review of the Pelagic Wet-Fisheries for the 1967–68 Season 11
- Publications 12

II. Symposium on the living resources of the California Current System; their fluctuating magnitude, distribution, and susceptibility to use for the benefit of the State of California. *J. D. Messersmith,* Editor 17

Keynote: A consideration of the living marine resources off California and the factors affecting their use. *Philip M. Roedel* 19

Session 1. What are the resources and what is the state of our knowledge? *John L. Baxter,* Convener

- Status of knowledge of the Pacific hake resource. *Dayton L. Alverson* and *Herbert A. Larkins* 24
- The anchovy resources of the California Current Region off California and Baja California. *J. D. Messersmith, John L. Baxter,* and *Philip M. Roedel* 32
- Mesopelagic and bathypelagic fishes in the California Current Region. *Elbert H. Ahlstrom* 39
- The jack mackerel (*Trachurus symmetricus*) resource of the eastern North Pacific. *C. E. Blunt, Jr.* 45
- Bottomfish resources of the California Current System. *H. G. Orcutt* 53
- Pelagic invertebrate resources of the California Current. *Alan R. Longhurst* 60
- History of fish populations inferred from fish scales in anaerobic sediments off California. *Andrew Soutar* and *John D. Isaacs* 63
- Fossil records of certain schooling fishes of the California Current System. *John E. Fitch* 71
- A perspective of a multi-species fishery. *Oscar E. Sette* 81

Session 2. What are the legal, economic, sociological and technological problems impeding their best use? How can these be resolved? *J. D. Isaacs* and *P. M. Roedel,* Conveners

- The State's involvement in maritime and ocean resources development. *Col. T. R. Gillenwaters* 88
- Views concerning use of the living resources of the California Current. *Gerald V. Howard* 91
- Viewpoint of the U.S. Bureau of Sport Fisheries and Wildlife. *G. B. Talbot* 95
- Use of the pelagic living resources: the legislative point of view. *Winfield A. Shoemaker* 97
- The point of view of government: California looks to its ocean resources. *Walter T. Shannon* 99
- The California fish and game code. *E. C. Fullerton* 101
- The point of view of industry: The processor. *Harold F. Cary* 103
- Viewpoint of the industry: fishermen and allied workers. *John J. Royal* 108
- The point of view of industry: Fishing boat owners. *Frank Iacono* 110
- The point of view of recreational interests: The organized sportsmen. *Robert Vile* 111
- The point of view of the partyboat and live bait industries. *R. A. Izor* 113
- The exploitation of the living resources of the California Current: A food technologist's point of view. *Roland Finch* 117
- Development of a fishery resource. *Gordon C. Broadhead* 120
- The legal framework for the development of ocean resources. *Carl Christol* 122
- How can the scientific community best contribute to the resolution of these varied problems? *Alan R. Longhurst* 127