

PART I
REVIEW OF ACTIVITIES

1 July 1966—30 June 1967

REPORT OF THE CALCOFI COMMITTEE
PARTIAL REVIEW OF AND PROPOSED PROGRAM FOR RESEARCH TOWARD
UTILIZATION OF THE CALIFORNIA CURRENT FISHERY RESOURCES

PROEM

In 1961 the CalCOFI Committee proposed to the MRC a number of programs that were an outgrowth of the realization that the CalCOFI research had obtained much understanding and thrown much light on a far broader spectrum of the living resources of the California Current system than the original object of study—the sardine. The programs were in addition to the basic studies and were aimed toward the development of these unused resources.

During its meeting of 8 August 1967 the Marine Research Committee requested the CalCOFI Committee to review these several proposed programs and to report on the development and present validity of the programs and to modify and augment the discussions, programs and needs in the light of present understanding.

The following restatement of the 1961 proposals comprises the CalCOFI's evaluation, report and present proposal for expanded research.

INTRODUCTION

Much of the basic work that the CalCOFI Program has performed is of fundamental significance to the understanding of the abundant species of fishes in the area. These species include the hake, anchovy, saury, squid, jack mackerel, Pacific mackerel, myctophids, deep-sea smelts, elasmobranchs, and, of course, the sardine.

The basic work has provided a substantial fund of information on the relative and absolute abundance, distribution, population stability, and other aspects of these species. For some time, this information has been quite adequate for a preliminary evaluation of the economic significance of these resources. In general, the level of knowledge is greater than that commonly available when fisheries are established elsewhere, and even greater than the understanding that now exists in many established fisheries. The private sector of California industry has not acted or been able to act on these resources, and the question naturally arises as to what restricts the utilization of the resources, i.e., are the constraints scientific, economic, social, or political?

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.

The CalCOFI Committee has thus undertaken to design a program of added research that will lead to an identification of the factors that constrain the utilization of those living resources of the California Current system which are presently underutilized.

It should be made clear that the program proposed in the following is an addition to the existing program rather than a major reorientation of the basic program of ecological studies that has yielded the present level of insight. This basic program, its continuance and its subtle reorientation is as essential to the presently proposed course as it is to the identification of the future opportunities that are presently unsuspected and unidentified.

It is the purpose of the present discussion to propose inquiry and research, drawing on the existing fund of knowledge, and ultimately permitting the conservative utilization of the great resource represented by the underdeveloped and underutilized living pelagic resources of the California Current system.

The *primary purpose* of the proposed research is to obtain an understanding of the factors associated with the development and management of fisheries on these pelagic populations of the eastern North Pacific.

The evidence points to the existence of populations of hake and anchovies in these waters that are measured in millions of tons. The populations of the other species are also of large magnitude. A presently proposed fishery on the anchovy of 200,000 tons per year is based on highly conservative estimates for a beginning experimental fishery. Without question the anchovy can be conservatively harvested at a considerably higher level (which can be determined as a fishery progresses) and several of the other species have an equal or greater potential.

Several *secondary objectives* will guide the approach to the primary objective. These include attaining understanding of the factors that might permit:

- A. Diversification of the commercial fishery.
- B. Reduction of competition between sport and commercial fisheries.

- C. Alteration of the fish population toward a composition of preferred sport and commercial species.
- D. Accommodation to foreign utilization of local resources, and
- E. Development of broadly-applicable fisheries science and technology.

A. Diversification of the Pelagic Commercial Fishery

The economic success of the pelagic commercial fishery (principally sardine) has undergone a serious collapse. Now that the causes of this collapse of the sardine fishery are better understood, it is apparent that some abundant species have relationships with oceanographic (and marine biological) conditions that are complementary to those of others. So, for example, when the sardine has a series of poor year classes, the anchovy may have a successful one and vice versa.

This probability is supported by very similar experience elsewhere. The Japanese *iwashi* fishery takes a number of fish that are ecologically in close relationship, as are the sardine and anchovy. Fluctuations in the *iwashi* fishery are much less than is general for fisheries on a single species. In addition, the availability of the mature fish may also be complementary in two species, so that one or the other is more readily available in any season.

In addition, the population of certain species, such as the jack mackerel and saury, have a far wider distribution than the sardine, anchovy, etc., and it is probable that a coastal fishery for these would draw from an enormous fish population spread over the entire eastern North Pacific. A large fishery for these species therefore might place much smaller demands upon the productivity of the area.

Other implications of a fishery developed around these species will be discussed below, but, for the purposes of the objective of diversifying the pelagic commercial fishery, the committee feels it should develop understanding for a fishery that can have success under a greater variety of oceanographic conditions than the previous pelagic fishery and draw its product from a greater part of the Pacific.

B. Reduction of Competition Between Commercial and Sport Fisheries

The State of California can afford to neglect neither the development of her great commercial fishery resources that exist off her coast, nor the full development of the wholesome, rewarding, and commercially valuable sport fishery.

It shall be among the purposes of this proposed inquiry to elucidate the relationships between these two utilizations of the pelagic marine resources, understand their areas of conflict and competition, and recommend development in directions to reduce these conflicts and competitions.

The sport and commercial pelagic fisheries of California enjoy a major advantage as compared to the

analogous fisheries of other states in that their direct competition for species of fish are relatively minor. For example, except for the mackerels to some degree, the sportsfisherman seeks none of the species under discussion. Conflicts are thus principally indirect, quite unlike the case of the northern salmon, where both activities directly compete.

C. Alteration of the Fish Population

An important element of the inter-relationship of the sport and commercial fisheries stems from the highly selective demands of both of these fisheries.

Among the abundant species of fish in the waters of California, these fisheries now seek only a very limited number. These preferred species include mostly fish with relatively coastal distributions.

It is the opinion of many that if these fisheries continue to develop around this limited number of species, the general fish population will become increasingly replaced by a population of the less desirable species, whose numbers are not now reduced by either fishery. This opinion holds that the yellowtail, halibut, barracuda, seabass, anchovy and sardine may become replaced by the shark, ray, hake, saury, squid, and other presently unsought species.

This opinion presupposes that fishing can alter a population and, assuming this to be so, there is only one tool available that might reduce the number of these presently undesirable species—the commercial fishery.

Some of these unsought species have complex relationships with the preferred fishes: competitors as young, juvenile, and adults; predators on the young at several stages; and as food for the adults.

It shall be one of the purposes of this research to elucidate these relationships and to recommend development of fisheries that, if the population is affected by the fishery in any way, give the best promise that the alteration is toward an overall increase of the preferred species. The present anchovy fishery, of course, has been in part initiated with such an experiment in mind.

D. Accommodation to Foreign Utilization of Local Resources

The pelagic fishes of the California Current system inhabit international waters. The only constraint to foreign harvesting of these fish—aside from economics and in the absence of treaties—will be for foreign fishermen to cooperate in any scientific management plan on the species. Such a management plan need not involve only the utilization of the fish for commercial purposes, but should consider sport requirements as well.

Foreign fishermen already have begun using some of these fishes (hake and rockfishes) and have surveyed the potentials of others, including mackerel, anchovy, saury, bonito and sardines.

The only hope of retaining some degree of California control over these resources is to establish a scientifically managed fishery.

E. Development of Broadly-Applicable Fisheries Science and Technology

It is evident that a high level product of local fisheries has been the evolution and extended application of the fishery and processing technology developed in local waters. Among the examples of such products, the tuna industry is outstanding, where both the availability and utilization of tunas was explored, pioneered and developed in local California waters, and later extended ocean wide with important economic results to California fishermen, processors, and investors, and to the State as a whole. The sardine fishery likewise provided entries into processing opportunities elsewhere in the world.

It is thus, important that the research evaluate these supereconomic potentials of each of the resources considered, not only as extended economic opportunities for California entrepreneurs but as scientific and industrial contributions to the worldwide humanitarian development of marine food sources.

PROPOSED RESEARCH

In order to accomplish these objectives the following program is proposed:

Phase 1

This phase is a preliminary study, coalescing existing, available information on the principal undeveloped and underdeveloped pelagic fishery resources of the California Current system. The primary question is "What restricts the proper utilization of these resources?" To answer this question, this study will attempt to determine the probable size, value, and utilization of the resources.

The study will include the following elements:

- a. Estimate from available data the probable population size, stability, and distribution of the undeveloped and underutilized pelagic fisheries including the hake, jack mackerel, saury, squid, elasmobranchs, etc., and further perfect estimates of the population size of utilized species.
- b. Elucidate the probable inter-relation of these species with the preferred sport species and with each other.
- c. Appraise availability of these species to present and eventual fishing potentialities.
- d. Investigate the utilization of similar species elsewhere.
- e. Understand the present and future demand, and market for these species, and their value.
- f. Understand the legal and institutional problems of developing a fishery, including both domestic and foreign aspects.
- g. Estimate the probable influence on the preferred fish stocks of a fishery supported by these unsought species.

It is proposed that Phase 1 be directed by the CalCOFI Committee and coordinated by a fisheries biologist of senior standing, with technical assistance added to each of the three CalCOFI agencies of Scripps, B.C.F., and California Fish and Game, for

the purpose of extracting and consolidating the information that exists at these agencies. It is proposed that the research in which the CalCOFI agencies possess no especial competence be carried out as direct contracts or grants by the MRC and supervised by the coordinator, who would then serve to represent these programs in the CalCOFI and to the MRC.

These programs would include the portions of the work dealing with the social and institutional factors, such as economic, legal, and ethological problems; some of the industrial problems of processing, etc.

It is proposed that these latter programs also be guided by the CalCOFI Committee under the Marine Research Committee, because of the close relationship of the proposed work with the CalCOFI, and the success of this committee organization.

Phase 2

A specific research program should follow the elements listed above, as a profitable program emerges from Phase 1.

We have tabulated what appear to us to be the sub-disciplines of fishery research in the broad sense, and we feel that eventually, for each resource, all these topics will have to be considered. This tabulation is attached as an Appendix to this paper.

It is clear that in the context of the present-day situation in the California fisheries not all of these topics have the same urgency, and priorities may differ from resource to resource. We have identified, and listed below, what seem to us to be the urgent fields of study for each of the main resources that previous work has identified. We do not feel that within these listings further relative priorities can be set, and the sequence the problems are listed in does not imply priority.

By excluding a problem from our listing we do not mean to imply that work on it should be halted, or not started if it seems appropriate and funds and facilities are available. This statement is particularly intended to apply to new or continuing long-term projects whose value may be enhanced as the period of their operation increases.

In particular, we recognize that multi-species fish population dynamics represents the scientific core problem and is properly the subject of greatest concern to fisheries laboratories, even though it is not generally included in the priority problems listed below.

It is important to remember that many of the sorts of data which we recognize to be essential to regulating a fishery properly will not become available until after a fishery develops and its effect on the total mortality and other dynamic parameters of the population can be measured.

I. Northern Anchovy

a. Stock identification and estimates: How many distinct genetic stocks are there and what is the distribution, abundance and migration patterns of each.

b. Availability and vulnerability: Proportion of each subpopulation that is available during all or

part of its migration pattern; seasonal differences in availability as influenced by environment; vulnerability (catchability) in relation to differential behavior patterns of fish at different times of the year and to their varying environment.

c. Food chain studies and interspecific competition: Analysis of stomach contents to determine kinds and amount of food consumed in different areas and seasons with comparable studies of what was available in the environment; possible competition for food with other plankton-feeding fish, particularly sardines. Role of anchovy as a forage species.

d. Management problems: Multiuse, especially use of anchovy for bait by sportfishermen and role played by anchovy as forage for game fishes; need of a comprehensive management program for the balanced use of all ocean resources.

e. Market economics: Investigations of possible use of fish in forms other than fish meal, and consideration of the needs of reduction plants for modernization on setting catch quotas.

II. Hake

a. Stock identification and estimates: Need to determine distinct genetic stocks, if any, and the distribution, abundance and migration patterns of each—the latter by a tagging program.

b. Availability and vulnerability: Marked seasonal migrations, made by each subpopulation of hake, seasonal differences in availability as influenced by environment; vulnerability in relation to different behavior patterns of fish at different times of the year and to their varying environment; need to establish techniques for capture in commercial quantities off southern California.

c. Food chain studies: Analysis of stomach contents to determine kinds and amounts of food consumed in different areas and seasons; role as predators on other marine fishes and as a prey species.

d. Marketing problems: Technological problems in handling hake for fresh market use; the microsporidium problem; development of MPC processing plants adjacent to fishing grounds.

e. Relationship with foreign fishery for this species.

III. Jack Mackerel

a. Stock identification and estimates: Need to determine whether jack mackerel stock is made up of one or more genetic subpopulations and what is the distribution, abundance and migration patterns of each.

b. Differential distributions and habits of age groups: Older fish distributed offshore—fishery depends on younger age groups, which are available inshore, but what portion of the total are available to the fishery has yet to be determined. How much is the varying abundance of young fish dependent on year class strengths?

c. Analysis and publication of age composition data collected from jack mackerel fishery since 1947 (in progress but not yet available).

d. Processing and related problems, especially with regard to the utilization of older size groups of fish.

IV. Pacific Sardine

a. Competition (food chain studies): Interaction between this species and other plankton-feeding fish, especially the northern anchovy.

b. Scientific management: Problems arising from fishing on this species in adjacent countries; continuous monitoring of status of populations in light of regulations recently applied to fishery.

V. Pacific Mackerel

a. Scientific management: Problems arising from drastic reduction in population abundance and competitive fishery in Baja California which accentuates need for management, including the need for international agreements.

b. Food chain studies: Analysis of stomach contents to determine food preference at different stages of the life history and proportion of plankton versus nekton in diet.

Parenthetically we note that the stakes in scientific management are greater than the potential yield of the Pacific mackerel fishery. Despite scientific evidence attesting to the Pacific mackerel's decline, presented over many years, no action has yet been taken which might rehabilitate this resource. This prima facie evidence substantiates allegations that the State cannot manage its resources on a scientific basis. The failure of the State to do so could vitiate this entire proposal for research.

VI. Squid

a. Resource identification: Studies to determine what part of the total resources in the California Current is made up of the single utilized species, *Loligo opalescens*.

b. Racial studies in *L. opalescens* to determine if the stocks that are known to spawn in definite localities such as La Jolla, Catalina, Hueneme, and Monterey, are discrete or intermingling populations.

c. Studies of the feeding habits of squid and their role as predators or prey in the marine food chain.

d. Fishing operations research to develop understanding which might lead to year-round operations and to extend known areas of fishing.

e. Market: Need to explore the possibilities of a greater market and need to investigate new products.

VII. Saury

a. Problem of sampling juveniles: Few larvae are now taken in oblique plankton hauls; we further need to test surface hauls as a means of sampling relative abundance of larvae and young juveniles.

VIII. Other Abundant Resources

Included in the group are the abundant mesopelagic fishes (myctophid lanternfishes and deep sea

smelts), sharks and rays, and abundant small crustaceans such as red crab, *Pleuroncodes planipes*.

a. Fishing operations research to determine how mesopelagic fishes might be caught in commercial quantities.

b. Processing and related problems: Research is needed in possible uses for bathypelagic fishes (which may or may not be catchable in quantity), for *Pleuroncodes*, which certainly can be caught in quantity, and for sharks and rays.

Tabulation of the Subdisciplines of Fisheries Research

Environment

- Physical Oceanography
- Chemical Oceanography
- Phytoplankton—biogeography
 - dynamics
- Zooplankton—biogeography
 - dynamics
- Food Chain Studies and Interspecific Competition
- Historical Studies
- Correlations

Primary Resource Estimates

- Eggs and Larvae
- Fish Surveys

- Exploration
- Availability

Behavior and Physiology

- A. Physiology
 - Metabolic Studies
 - Gonadal Studies
 - Developmental Studies
- B. Behavior
 - Feeding
 - Migration and Distribution
 - Spawning Behavior
 - Schooling
 - Environmental Response

Fisheries Population Dynamics

- Age, Weight and Growth Studies
- Fecundity
- Recruitment
- Mortality—Natural, Fishing, Fishing Associated, and Total
- Fishing Effort and Statistics
- Stock Identification

Problems of Resource Development

- Multiple Use
- Legal Restrictions
- Fishing Operations Research
- Scientific Management Strategy
- Market Economics
- Processing and Related Problems
- Exploitation of Resources by Foreign Fisheries

—J. L. Baxter, J. D. Isaacs, A. R. Longhurst and P. M. Roedel, February 1968