

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
MARINE RESEARCH COMMITTEE

CALIFORNIA COOPERATIVE SARDINE RESEARCH PROGRAM



Progress Report 1950

By
CALIFORNIA ACADEMY OF SCIENCES
CALIFORNIA DIVISION OF FISH AND GAME
SCRIPPS INSTITUTION OF OCEANOGRAPHY
U. S. FISH AND WILDLIFE SERVICE

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STATE OF CALIFORNIA

Department of Natural Resources

MARINE RESEARCH COMMITTEE

Pier 47, Foot of Jones Street
San Francisco 11, California
December 1, 1950

His Excellency Earl Warren
Governor of the State of California
Sacramento, California

Sir:

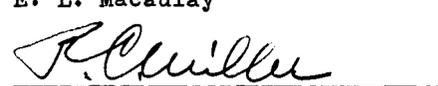
Three years ago, when sardine landings had unaccountably sunk to the lowest point in recent history, the State of California embarked on a remarkable experiment in scientific research. Under the sponsorship of the Marine Research Committee, four agencies -- the California Academy of Sciences, the California Division of Fish and Game, the University of California's Scripps Institution of Oceanography, and the U. S. Fish and Wildlife Service -- were asked to apply their resources and scientific skills to the sardine problem. The scientists have been at work for almost three years; for the past two years they have conducted oceanographic surveys off our coast that are unparalleled in scale. In this paper they report their findings to date. We of the Committee feel their work deserves the attention of everyone interested in preserving and better utilizing an incalculably valuable natural resource.

Respectfully,

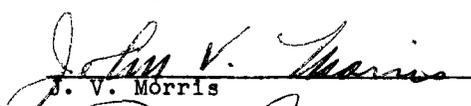

J. G. Burnette, Chairman


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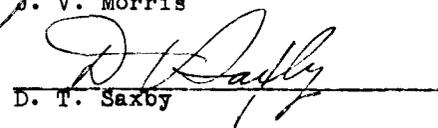

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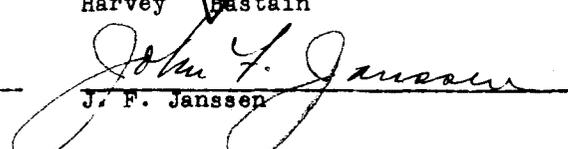

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THE PROBLEM

In order to develop plans for the responsible management of the sardine resource and to attempt to derive workable methods of predicting where sardines will be found and in what quantities, it is imperative to know certain underlying principles which govern the sardine's behavior, availability, and total abundance. Work under the California Cooperative Sardine Research Program is aimed at determining those principles.

METHOD OF ATTACK

The four agencies participating in the program are investigating the Pacific sardine in relation to its physical and chemical environment, its food supply, its predators and its competitors, and attempting to evaluate the findings in terms of the survival of young and in terms of the distribution and availability of the sardines when they reach commercial size.

RECENT FINDINGS

The 1950 cruises have confirmed the 1949 finding that there are at present two centers of heavy sardine spawning off our coast. The first is in the vicinity of Cedros Island, off Baja California, and is relatively restricted in area; the second is off Southern California and northern Baja California. It covers the larger area; within it, though, spawning is more diffuse than near Cedros Island.

During the spring of 1950, surface temperatures were lower than they were in 1949, which may indicate more intense upwelling during the season.

The cruises for 1949 and 1950 have shown that most sardine spawning takes place within narrow temperature ranges. During the 1950 spawning season 98.4 percent of all sardine eggs sampled were taken in waters between 12.5° and 16°C. (54.5° and 60.8°F.).

Under laboratory conditions, sardines have been shown to exhibit predictable behavior patterns in the presence of electrical fields. Larger-scale studies of this subject are planned.

Length and age studies of the commercial catch show that during both the 1948-49 and 1949-50 seasons the major support of the fishery came from the 1946 and 1947 year classes. There are no indications as yet that the 1948 and 1949 year classes will appear on the fishing grounds in exceptional numbers. It is still too early to attempt to assess the 1950 year class. The 1946 and 1947 groups will presumably have to supply much of the tonnage taken in the next two or three years.

Studies of the mechanism of upwelling, a factor that may be of great importance in the sardine problem, have shown that spring and summer upwelling off Cape Mendocino and Point Conception can be correlated with weather conditions.

The first two full years of work under the program have brought the development of important new instruments for oceanographic research, the accumulation and partial analysis of a great mass of data on the offshore waters, the development and refinement of the techniques of collecting and processing the data.

PLANS FOR 1951

In the main, work under the California Cooperative Sardine Research Program will continue along the present lines during 1951. The seagoing work cannot as yet be curtailed or simplified without running the risk of failing to obtain information of basic importance. Any changes will be those dictated by the necessity of studying changing oceanographic and biological conditions. Both at sea and ashore, several new studies that promise to enlarge our understanding of the Pacific sardine will be pursued.



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Introduction

Although the California Cooperative Sardine Research Program has now been under way for almost three years, few attempts have been made to review the work as a whole. Papers on separate phases have been published in the scientific journals (more are to come), and brief, condensed progress reports have been issued quarterly since early in 1949, but the present report is one of the first to try to present an over-all picture of the program. This we hope to do by telling how the work is done, what has been accomplished so far, and what in the way of research is planned for next year.

When the annual sardine conference was held this summer in La Jolla (it was the 15th such meeting, by the way; sardine research on the coast has a considerable history), three crowded days of discussion were needed to review the year's progress in the field. Yet the aim of all the work on the sardine can be stated quite briefly. It is:

To seek out the underlying principles that govern the Pacific sardine's behavior, availability, and total abundance.

(If those principles were known, it should be possible to forecast, within reasonable limits of accuracy and some months or years in advance, where sardines will be found and how many will be found.) Scientists are investigating the sardine in relation to its physical and chemical environment, its food supply, its predators and its competitors, and attempting to evaluate the findings in terms of the survival of the young and in terms of the distribution and availability of the sardines when they reach commercial size. The pursuit of these studies has occasionally led researchers into some fields that may seem, at first glance, to have little to do with sardines. Investigations have been undertaken that were impracticable a few years ago. But the integrating principle of them all is the patient quest for more knowledge of the Pacific sardine.

No great program of scientific research comes—to put it bluntly—out of a hat. Sardine studies are not new in California; that patient quest started many years ago. What the Marine Research Committee is sponsoring today is an expansion and acceleration of investigations which have been carried on for several decades. Those early studies laid the solid foundation of careful observation and long-considered theory upon which the present program has been built.

The early work had to be done; if it had not been done then, it would remain to be tackled today. Its existence meant that when the California Academy of Sciences, the California Division of Fish and Game, the University of California's Scripps Institution of

Oceanography, and the U. S. Fish and Wildlife Service were called upon in 1947 to coordinate and intensify their sardine investigations they were able to get to work with little waste motion. They knew what they were after and the best way to get it.

Until the present program began, it was not possible to investigate adequately how the sardine is affected by its environment. Such an investigation is necessarily a long-term project, requiring the simultaneous employment of a number of vessels gathering data at sea. It has been approached at times by the Division of Fish and Game and the U. S. Fish and Wildlife Service. The Scripps Institution of Oceanography, a department of the University of California, entered sardine research some years ago by investigating oceanographic conditions in the spawning areas off Southern California. Scripps scientists cooperated in cruises on the Division of Fish and Game's vessel *Bluefin* in 1937, making oceanographic observations while the Division of Fish and Game personnel conducted drift-bottle experiments. The work with drift bottles and the analysis of the oceanographic data brought to light new knowledge on currents off Southern California. The Scripps Institution conducted a second cruise in 1938. From 1939 through 1941, when the outbreak of war in the Pacific stopped all nonmilitary oceanic investigations, the Scripps Institution and the U. S. Fish and Wildlife Service cooperated on further cruises in the spawning areas.

Although it is reasonable to suppose that changes in oceanographic conditions must profoundly affect sardine life, just how they do has never been very fully explained. As yet not much is known of the annual variations in the physical properties of the ocean. Scientists have not had enough information available on which to establish that immensely useful fiction, the "normal" year. For that, the data from many years of frequent survey cruises are needed.

Under the California Cooperative Sardine Research Program, those data are being accumulated. It was, in fact, the possibility that changing oceanographic conditions were mainly responsible for the decline in sardine landings that led to the establishment of the present program.

What might be called the oceanographic approach to the sardine problem is the feature which makes the present work unique; it has never been tried on such a scale before anywhere in the world. What—very briefly—the scientists hope to do is to correlate changes in water conditions with sardine spawning, availability, and abundance. The work on the sardine's environment is, beginning on page 23, described in detail. The efforts

made towards the correlation of oceanographic conditions with other factors are mentioned in other sections.

Only when a child is born, or when the census taker comes around, do most of us become even momentarily aware of the science of vital statistics. Yet one of the outstanding (and, scientifically speaking, one of the most exciting) achievements of our century has been the rapid growth and refinement of methods of studying populations—human and otherwise—by such means. The bulk of the classical work in fisheries research has been based on the painstaking collection and analysis of vital statistics. The best way to get vital statistics of fish is by sampling the commercial catch. In California, this work has been carried on continuously since 1919 by the Division of Fish and Game, assisted since 1941 by the U. S. Fish and Wildlife Service. This is continuing work. It cannot be allowed to lag. In the past some special studies have had to be dropped or conducted on a part-time basis because of the pressure of keeping up with the flood of current data. Expansion of the sardine program meant that people could be hired to cope with current material, leaving more experienced investigators free to concentrate on special aspects of the work. It meant too that previously planned studies could be undertaken. Some of these are described in this report, as are recent results of the continuing studies.

From sampling of the commercial catch come the statistics on the size and age distribution of the sardines. The Division of Fish and Game has accumulated almost half a million individual observations on the size of sardines. The ages are determined by a technique first successfully applied in sardine work by the U. S. Fish and Wildlife Service a few years before World War II. The size and age data form the basis for several other studies, some of which are discussed in this report.

Vital statistics on the birth rate can be gathered only on spawning surveys. The amount of spawning, the areas in which it occurs, the oceanographic factors that influence its comparative success or failure—information on all these topics is badly needed. The pre-war surveys did not cover all the areas then suspected and now known to be centers of intense spawning. One of the prime objectives of the present program is to gather more information on spawning. The U. S. Fish and Wildlife Service is doing the work. Beginning on page 37, the progress of the past two years, which is of wide interest both to scientists and the industry, is reported in detail.

One problem in sardine research—this a particularly tough and vitally important one—is availability, the determination of how many fish are where the fishing boats can get them. This problem is being attacked with statistical methods by scientists of the U. S. Fish and Wildlife Service and the Division of Fish and Game, and is being investigated in the field by Division of Fish and Game personnel aboard the *Yellowfin*. On page 44

will be found a review of what has been learned about the subject during the past two years.

Between the first month or two of life and the time the fish is caught there lies a period of the sardine's life of which next to nothing is known. Yet it should be possible to make a fairly good estimate of year-class strength at least some months in advance if enough schools of young fish are located and counted. This important work is being done by the Division of Fish and Game. The findings of the 1950 survey are summarized on pages 43-44.

If many periods of the sardine's life are little understood, one reason is the lack of factual knowledge of the individual sardine, its behavior and physiology. The California Academy of Sciences is working on behavior and physiological studies. On page 46, the results, which are very interesting ones, are described.

We have mentioned the main lines of attack on the sardine problem. It might be well to summarize:

(1) The California Division of Fish and Game is working on its continuing statistical studies, on young fish surveys, and on methods of locating and identifying sardine schools.

(2) The U. S. Fish and Wildlife Service is also working on the continuing studies, and on the spawning surveys and recruitment research.

(3) The Scripps Institution of Oceanography is working on oceanographic surveys, including studies of plankton and marine vertebrates.

(4) The California Academy of Sciences is working on behavior and physiological studies.

Fortunately, the division of work is not quite as rigid as, so summarized, it might appear. Oceanographic observations are made on all cruises of all ships; personnel from two or more agencies frequently work on specific projects together.

The sardine is a restless and far-traveling creature. When California, Canada, Washington, and Oregon were conducting tagging operations, large sardines tagged off Southern California in February were retaken off British Columbia in the following July. Fish tagged in Sebastian Viscaino Bay were found as far north as the Columbia River. The same experiments showed that sardines released off British Columbia were taken in Central and Southern California, and some fish released off Central California ended up in British Columbia, and others in Southern California. The fact is, the sardine respects neither state lines nor national boundaries. It is of interest not only to California but also to Washington, Oregon, and Canada, and they have for many years engaged in sardine research. Consequently the Fish Commission of Oregon, the Washington Department of Fisheries, and the Fisheries Research Board of Canada, though not participating directly, have shown keen interest in the present program.

The shape the sardine program has taken represents compromises among the various agencies. Getting it under way has taken much planning and hard work. Decisions on the main lines of research solved only the first of the questions posed. Ways of implementing the program had to be decided.

The spawning and oceanographic surveys demanded the participation of several ships if the area was to be covered frequently. The survey area is just over four times that of the State of California. About 140 stations were planned for each cruise. The U. S. Fish and Wildlife Service had no vessel available for such research until 1949. The *E. W. Scripps* was committed to carrying out other studies under way at the Scripps Institution, and the Division of Fish and Game's *N. B. Scofield* and *Yellowfin*, which had been just recently contracted for, were needed for special studies. New ships were a necessity. The *Crest* and *Horizon* were obtained by the Scripps Institution.

A second need was crews to man the ships and trained technical personnel to assist the scientific staff in the collection and processing of data. The shortage of trained technical personnel was especially acute. Ordinarily such work is done by the scientists themselves, with the aid of highly trained laboratory

assistants. But there were neither enough scientists nor assistants available to carry on the work demanded by a program of this great scope. A training program had to be set up for newly recruited technical personnel.

The instruments ordinarily used in oceanographic research cannot be operated at the speed, and sometimes not with the precision, required by the present program. It was obvious that much attention would have to be paid to the development of instruments. Some of the most ingenious and potentially valuable work to come out of the program so far has originated in the workshops of the Scripps Institution, where there are being developed oceanographic instruments (page 18) which often do their work faster and better than any we have ever had before. Other agencies have also made useful contributions to the improvement of collecting gear.

As has been said, sardine research is not a new thing in California. But sardine research on the scale of the past two years is new not only in California but in the nation. Because it is new, and because the many practical problems of carrying out the work have been adroitly solved, the way the work is done seems worthy of description.

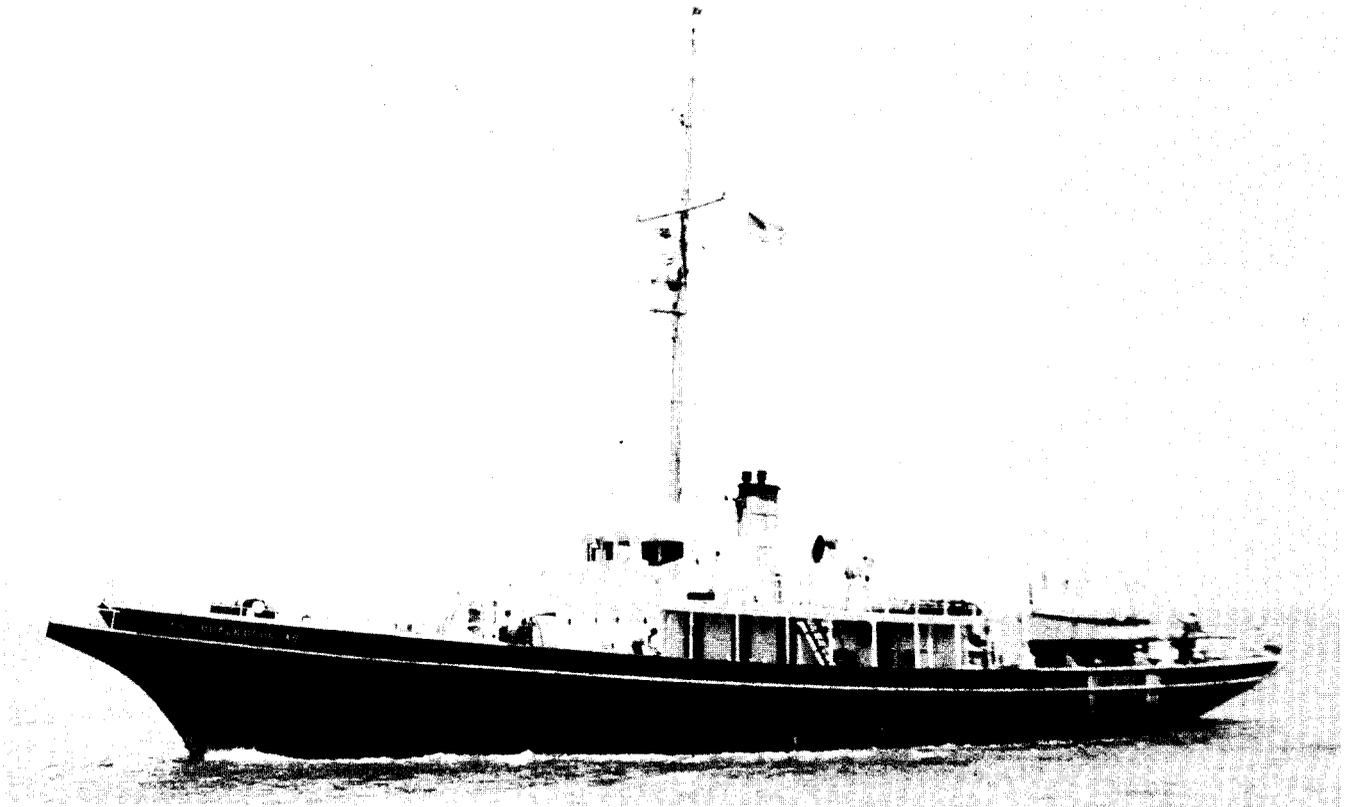
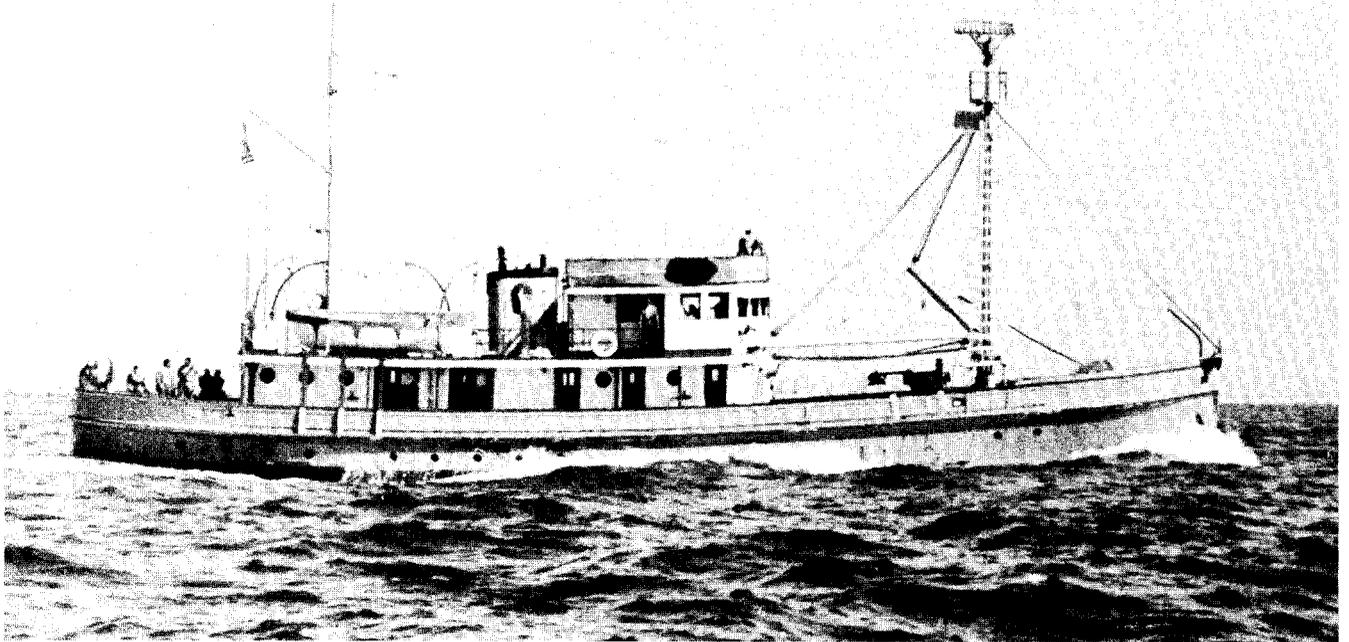


FIGURE 1. (UPPER) The *Yellowfin*, owned by the California Division of Fish and Game, is used for young-sardine surveys and in the collection of samples and oceanographic data from waters where schools containing sardines are present. (LOWER) The *Black Douglas*, owned by the U. S. Fish and Wildlife Service, participates in routine oceanographic-biological surveys of the entire research area.