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NATIONAL MARINE FISHERIES SERVICE
SOUTHWEST FISHERIES CENTER
P.O. Box 271
La Jolla, California 92037

DIRECTOR'S REPORT

to the

TWENTY-FIFTH TUNA CONFERENCE

on

TUNA-RELATED ACTIVITIES
at the
SOUTHWEST FISHERIES CENTER

HONOLULU LABORATORY
LA JOLLA LABORATORY

FOR THE PERIOD

OCTOBER 1973 TO SEPTEMBER 1974

SEPTEMBER 29-OCTOBER 2, 1974

CONTENTS

INTRODUCTION

Since 1971, much of the tuna research in the National Marine Fisheries Service (NMFS), an agency in the U.S. Department of Commerce' National Oceanic and Atmospheric Administration, has been centered within the Southwest Fisheries Center in La Jolla, California.

The report which follows is a summary of those tuna-related activities, at both the Honolulu and La Jolla Laboratories, for the period October 1973 to October 1974.

ALBACORE - SOUTH PACIFIC

The South Pacific Albacore Fishery Provided Material for Various Studies Throughout the Reporting Year

The Fishery Analysis Program at the Honolulu Laboratory, under the leadership of Dr. Robert Skillman, continued the assessment of the South Pacific albacore fishery using data collected at the canneries in American Samoa. With the receipt of the final CY 1972 data, a total albacore catch for 1972 was determined to be 20,168 metric tons, less than the 1970 and 1971 catches of 23,876 and 22,193 metric tons, respectively. Effort expended by the fleet based in American Samoa increased slightly.

Dr. Skillman's group also worked on an analysis of the albacore size-frequency data collected from that part of the South Pacific albacore fishery based in American Samoa. These data were used to separate areas of homogeneous-sized fish in order to describe the size structure of the catch and to convert Japanese catch data in numbers to catch in weight. This analysis revealed a significant latitudinal effect on average size of albacore, with the largest fish occurring in the 15° to 20° S latitudinal band.

A sensitivity study of a recently developed generalized production model for the South Pacific albacore fishery was completed during the year. Data used in the study were the catch data from the fishery based in American Samoa, the non-Samoan catches for Japan as recorded in "Annual report of effort and catch statistics by area on Japanese tuna longline fishery," and refined estimates of the non-Samoan catches for Korea and Taiwan. This study concluded that the maximum sustainable "average" yield (MSAY) for the South Pacific albacore fishery as it is now carried out is about 35,000 metric tons.

ALBACORE - NORTH PACIFIC

Joint NMFS-American Fishermen's Research Foundation Albacore Studies Continue

Since 1972, the La Jolla Laboratory and the American Fishermen's Research Foundation (AFRF) (founded by the albacore tuna fishing industry to administer a fund derived from an assessment paid by the canners on albacore landed by U.S. vessels) have cooperated in an early-season albacore research survey. The purposes of these surveys were to study the shoreward migration of albacore tuna into the North American west coast fishery and the associated marine environmental factors that could influence the migration, and to study the early season distribution of albacore in the offshore and nearshore regions.

The work with AFRF continued in 1974 but initial findings differ in major aspects with surveys conducted in the two previous years. In the offshore areas the temperature and salinity structure revealed that fronts which have characteristically delineated the boundaries of the Transition Zone were poorly formed. Considerable lateral mixing of the major water masses occurred and many minor fronts were found. Trolling efforts by the NOAA research vessel, Jordan, provided valuable information. Repeated crossings of fronts frequently revealed albacore to be concentrated on one side and/or very near the front (i.e. near the surface temperature and salinity break). The cooperation between the research charter vessels, the independent fishing vessels, and the Jordan was highly effective. In addition, the fishing vessels tagged 1,369 albacore.

As part of an evaluation of the albacore seasonal forecasts, efforts were made during the 1974 season to determine the availability of albacore in northern Baja-southern California waters. Fish scouting/oceanographic observations were conducted by three commercial albacore jigfishing vessels on charter to AFRF working cooperatively with the Jordan during July and August 1974. No commercial concentrations of albacore were found either by the fishing vessels or the Jordan.

As of this writing the staff of the Albacore Fisheries Investigations is processing the data collected during the cooperative work in 1974 and a report is in preparation covering all joint research programs with the AFRF.

Albacore Fishery Forecast

In May 1974, the staff of the Albacore Fishery Investigations issued the 14th annual forecast of the location of the 1974 albacore fishery, based on predictive indices developed at the La Jolla Laboratory relating north-south geographic variations in the fishery with oceanographic and meteorological conditions during the spring months in certain offshore waters through which albacore migrate in their travel to the waters off North America. According to the 1974 forecast, approximately 60% of the catch would be taken in waters north of San Francisco and 40% in waters to the south.

As the fishery developed in 1974, however, the bulk of the albacore catch was being taken north of San Francisco. In mid-September catches were being reported off central California and there were indications that substantial amounts of albacore might still be caught in southern waters before the end of the season - about mid-November.

Although the 1974 fishing season is nearing its close, no albacore price settlements has been negotiated and no firm estimate of landings can be made at this time since some of the fish has not been sold and is still in cold storage.

Albacore Tagging Studies

A summary of the results of the albacore tagging study conducted cooperatively by the La Jolla Laboratory and AFRF from 1971 through 1973 has been completed. A total of 1,738 albacore was tagged and released during the 1973 charter operations of the joint tagging project, and more than 6,000 fish tagged and released since the start of the tagging study.

Further Developments in Northern Albacore Research

During the past year, further developments in northern albacore research included revision of the uniform west coast albacore logbook developed in cooperation with California, Oregon, and Washington. The log is now easier for fishermen to use, and the resulting data are easier to handle and process.

A project to merge and standardize historical albacore catch and effort data for 1961-70 from the Pacific coast states was completed this year. These results make it possible to examine the between-season and within-season variations in catch per unit effort for the first time for the entire U.S. West Coast North Pacific albacore fishery. Excellent cooperation received from the California Department of Fish and Game (CFG) and Oregon Fish Commission (OFC) made the project possible; the results will be published collaboratively by scientists from these research organizations.

An interesting experiment was conducted during the July-August cruise of the Jordan when efforts were made to evaluate the feasibility of collecting and holding live albacore aboard the vessel, for possible future studies on the response of live animals to their environment under controlled conditions. Results indicated that it is feasible to hold and transport albacore tuna under anesthesia and that the life support system designed for this aboard ship is suitable with minor modifications.

Also continuing were the fishery advisory services provided to albacore fishermen. These include sea surface temperature charts, the annual albacore seasonal forecasts, narrative albacore fish bulletins, daily broadcasts of albacore fishing information over marine bands, and transmission of weekly charts of thermocline depth via radio facsimile and transmission via facsimile of weekly sea surface temperature charts to albacore fishermen on the fishing grounds. In addition, a series of meetings was held during the year with albacore fishermen at several ports along the U.S. west coast.

SKIPJACK - CENTRAL PACIFIC

Design and Construction of the Tuna Behavioral Thermoregulation System (the Doughnut Tank) Completed During the Reporting Period

During the reporting period Drs. William H. Neill and Andrew E. Dizon of the Honolulu Laboratory continued development of a unique apparatus for the study of tuna behavior in gentle temperature gradients like those encountered in much of the open sea. This apparatus, termed the tuna behavioral thermoregulation system, consists of a doughnut-shaped tank (8,000 liters) whose temperature is controlled automatically by a tuna's direction and speed of swimming in the circular channel. By reversing swimming direction in the tank, the tuna can keep the water within a preferred range of temperature. Anticipated results of these studies include the behavior of tunas in different temperature regimes and tunas' preferred temperatures, a set of parameters with high potential value in predicting tuna distribution in the ocean.

First Output Obtained From a Simulation Model for the Responses of Fishes to Temperature

The long-range goal of the Honolulu Laboratory's program on Life Studies of Tuna and Tunalike Fishes is to generate a predictive model of tuna distribution, abundance, and availability to fisheries. The basis of the model is to be the joint physiological and behavioral responses of tunas to environmental variables, as determined in part through experimental work with captive fishes. To explore the potential value of such a modeling approach and to provide an objective framework for further experimental work, Drs. William H. Neill and Andrew E. Dizon have developed a simulation model for the responses of fishes to temperature, a variable of recognized importance in the ecology not only of tunas but also of fishes in general.

First runs of the model (without any a posteriori manipulation of process functions or input parameters) suggested a number of similarities between the behavior of the model and that of real tunas as observed at sea:

Hypothetical 50 cm long fish weighing 2 kg

1) tended to "seek out" and remain within a few degrees of their preferred temperatures in a linear gradient as steep as 1° C/km but to randomly disperse in gradients of 0.1° or 0.01° C/km until encountering temperatures near the upper or lower lethal limits;

2) tended to "aggregate" at randomly encountered thermal fronts, regardless of temperature;

3) would tend to become "trapped" and concentrated in areas of unfavorable temperature under certain conditions of temporal change in the distribution of temperature; similarly, would tend to be absent from areas of favorable temperature under certain conditions of temporal change in the distribution of water temperature;

4) would tend to be distributed within narrower thermal limits than conspecific fish of smaller size.

Doughnut Tank Experiments Investigate the Activity of Tunas in Rapidly Cooling Water

One notion implicit in the simulation model is that the likelihood of fish responding to a gradient of temperature depends both on the level and the rate of change of temperature. The faster the rate of change of temperature ($^{dT}/_{ds} \cdot {}^{ds}/_{dt} = {}^{dT}/_{dt}$) and the nearer the temperature to the lethal, the more likely is the fish to respond.

Drs. Neill and Dizon conducted a series of cooling experiments in the doughnut tank to establish such responses for tunas; experiments with eight skipjack and two yellowfin tunas have been conducted. Both species consistently and dramatically increased their rate of turning when tank temperature decreased from 21.5° to 20.5° C. However, swimming speed of skipjack tuna tended to be almost constant between 27° and 19° C, whereas yellowfin tuna swam slower ($Q_{10} \cong 2.2$) as the water cooled.

Implications of Thermal Physiology on Distribution of Skipjack Tuna

In June, Dr. William H. Neill of the Honolulu Laboratory constructed a tentative energy budget for central Pacific skipjack tuna, in collaboration with Drs. James F. Kitchell and John J. Magnuson of the University of Wisconsin. The energetics model suggested the following ecological proposition: Skipjack tuna smaller than about 12 kg are growing at rates substantially less than

maximal, being limited by availability of food and/or predatory efficiency; skipjack tuna larger than about 15 kg obtain a maximum daily ration but are limited in further growth by a physiological constraint of large size coupled with an effective mechanism of heat retention - overheating of the muscle mass, especially during bursts of feeding activity.

Dr. Neill has now completed a preliminary analysis of the overheating problem which suggests the following conclusions: Skipjack tuna larger than 12.5 kg cannot indefinitely sustain minimum activity in waters warmer than 30° C. At 5 kg, the critical temperature for minimum activity is about 31.5° C. But of more concern are the water temperatures critical for normally active fish, whose red muscle may metabolize at about 3 mg - O_2 g^{-1} hr^{-1}: 30° C at 1 kg, 25° C at 5 kg, and 20° C at 12.5 kg.

These calculations imply that large fish must seek out cooler waters if they are to be as active as smaller fish. This could be achieved by large fish living at higher latitudes or at greater depths than smaller fish. Low rates of heat exchange in large skipjack tuna permit forays of several minutes' duration into surface waters warmer than the critical temperature if the fish is initially at thermal equilibrium with deeper, cooler water.

Effects of Temperature on Routine Metabolism of Skipjack Tuna

Productivity of the seas in terms of tuna flesh must depend on whether food supplies are adequate to provide the energy required by tunas for activity and growth. Research Assistants Randolph Chang and Bernard Ito, under the supervision of Dr. Neill, all of the Honolulu Laboratory, are extending previously completed experiments on routine metabolism of skipjack tuna at a single temperature (24° C) to temperatures throughout the skipjack tuna' zone of thermal tolerance. This will permit estimation of the energy required for minimum activity in skipjack tuna at all temperatures where the fish are likely to occur.

Experiments at 18°, 24°, and 29° C have now been completed. Results can be summarized as follows:

Temperature (°C)	Number of tests	Respiration rate (mg - O_2 g^{-1} hr^{-1})	
		Median	Range
18	14	0.66	0.42-1.03
24	6	0.71	0.58-0.79
29	10	0.78	0.64-1.25

Thus, routine metabolism of skipjack tuna appears only weakly temperature-dependent, the Q_{10} value being between 1.1 and 1.2.

Physiological Data Suggest Definition of Limits of Skipjack Tuna Habitat

Physiological data obtained recently in experiments and simulation studies conducted by the Life Studies Program of the Honolulu Laboratory are being used to shape answers to the long-standing question of why there are no big skipjack tuna in the eastern Pacific Ocean. These data are being used to define the geographic areas the skipjack tuna can be expected to inhabit on the basis of extremes in tolerance. Results so far indicate that the smaller skipjack tuna, less than 3 kg or 50 cm in size, can inhabit virtually all of the eastern tropical Pacific above the oxycline. Areas from which larger fish are excluded increase in size with the size of the fish. Fish weighing 8 kg, 70 cm long, are excluded from an area which extends from Cabo Corrientes or San Blás to 145° W, 10° N, and from there to Panama. Fish of intermediate size are excluded from most of this area, but can move north-south along a 100-mile corridor slightly offshore of Mexico, between the Gulf of Tehuantepec and the Gulf of California. This corridor probably closes seasonally and may close entirely in some years.

Expansion of Skipjack Tuna Fisheries in the Southwest Pacific and Around Adjacent Indian Ocean Islands Described

Fishery Biologist Richard Uchida completed an extensive literature search for data and information on the development or potential development of skipjack tuna fisheries, particularly in the southwest Pacific and around the islands of the Indian Ocean which are contiguous to the southwest Pacific. Gathered was catch, effort, and catch per effort information that was subsequently used to describe the expansion of the skipjack tuna fisheries in these areas.

Two Skipjack Tuna Tagged and Released in Eastern Pacific Recovered near Hawaii

A tagged 8.38-kg skipjack tuna was recaptured in Hawaiian waters by the M/V Sunfish on June 21, 1974. The fish had been tagged and released by the IATTC on June 5, 1973 at latitude 22°00' N, longitude 111°25' W. On August 30, 1974, about 30 miles south of Honolulu, the M/V Buccaneer recovered a tagged skipjack tuna weighing 9.68 kg and measuring 75.0 cm FL. This second fish had been released by the IATTC at latitude 22°18' N, longitude 111°39' W on June 8, 1973, at which time it measured 47 cm and weighed an estimated 2.03 kg (by Magnuson 1973 regression). The growth of the second skipjack tuna closely approximates the growth curve for skipjack tuna in the central Pacific as derived from Honolulu Laboratory measurements of skipjack tuna otoliths.

Prediction of the 1974 Skipjack Tuna Catch in the Hawaiian Fishery

In April, Dr. Robert Skillman issued the 1974 Hawaiian skipjack tuna catch prediction of 3,800 metric tons. This estimate was based on a multiple linear regression model combining two earlier models, one based on the change in salinity from January 1 to March 1 of the year the catch is made, and the other on the time of minimum sea-surface temperature, all values collected at Koko Head, Oahu. Estimated cumulative state landings through September 16 were 2,596 metric tons.

Techniques of Otolith Reading Developed and Applied to Tuna Otoliths in Growth Rate Studies

Skills and techniques of otolith reading were developed at the Honolulu Laboratory in the first part of the reporting year with the reading of the presumed daily growth layers in sagittae of nehu, Stolephorus purpureus, from Pearl Harbor and Kaneohe Bay. Techniques thus developed were applied to the reading of otoliths taken from skipjack and yellowfin tunas of the central Pacific to determine early growth rates of these species. Skipjack tuna otoliths from the Papua New Guinea region were also examined in order to compare the growth rates of the geographical population from that area and the one from the central Pacific. Preliminary results suggest a slower growth rate for skipjack tuna from the Papua New Guinea area. A manuscript dealing with this subject is in preparation.

YELLOWFIN-SKIPJACK - EASTERN PACIFIC

SWFC Fishing Information System (FIS)

The FIS at the Southwest Fisheries Center encompasses three principal activities: 1) the radio facsimile (FAX) program, 2) the publication of "Fishing Information," and 3) the XBT ship-of-opportunity program.

The FAX program evolved out of the need to supplement the existing environmental monitoring effort in the eastern tropical Pacific. It was apparent that the tropical tuna fishing fleet afforded the best opportunity for obtaining environmental observations in the tuna habitat.

Facsimile recorders, procured from government surplus and adapted for use with shipboard communications equipment, are presently installed on about 58 participating vessels under a reciprocal agreement providing for daily data transmissions from the fishing grounds. In addition, SWFC has adapted and installed independently procured units on 11 other ships. All participating

vessels take and transmit surface weather observations, including wind speed and direction, weather, cloud cover, barometric pressure, air temperature, sea surface temperature, swell direction, and wave height. Some 20-25 vessels in the tropical tuna fleet are also equipped with XBT systems and report subsurface temperatures in the BATHY message format. BATHY messages include temperatures and depths at significant points down to 500 m, extracted from XBT analog traces. Maintenance of the XBT equipment is performed by the SWFC.

During the period October 1973-September 1974, an estimated 750 XBT observations and 3200 surface weather observations have been received from participating tuna boats in the eastern tropical Pacific. Since the beginning of the program in 1971 to the present time, about 14,000 observations have been received from facsimile-equipped tuna vessels.

The weather advisory charts developed by the FAX program at the SWFC consist of a wind and weather forecast and a sea state forecast. Prior to August 1974, these charts were transmitted from NMFS-licensed radio station WWD daily except Saturday and Sunday. In addition to expected wind speeds and directions, they depict the configuration of the Inter-Tropical Convergence Zone (ITCZ) and the locations of incipient tropical storms, which tend to develop along it.

The National Weather Service extended its participation in the program in June 1974, pursuant to agreement reached between the respective directors of NMFS and NWS. A data line was established from the NWS Forecast Office, Redwood City to radio station WWD and to the SWFC, La Jolla, to be used for transmission of wind and weather, and sea state forecasts charts prepared by NWS. Since August 1974, the NWS FAX charts have been broadcast from WWD daily.

In addition to the daily wind, weather and sea state FAX advisories, three charts depicting ocean conditions are also prepared at SWFC and transmitted by radio facsimile weekly. These are a sea surface temperature analysis, a mixed layer depth (MLD) analysis and a sea surface temperature difference charts which compares present conditions with those in the corresponding week of the previous year.

Fishing Information Publication

Charts of the sea surface temperature for the eastern North Pacific have been published by the Honolulu Laboratory of NMFS from 1957 through 1959 and since 1960 by the La Jolla Laboratory (and its precursor agencies) in connection with a study of the distribution of North Pacific albacore.

Fishing Information, published monthly, now contains the following charts:

1) sea surface temperature for the eastern North Pacific;

2) sea surface temperature for the western North Pacific;

3) sea surface temperature for the eastern tropical Pacific;

4) deviations from long-term means of 1), 2), and 3);

5) difference between 1) and the corresponding SST field 1 year earlier;

6) sea level pressure and resultant wind (both current month and long-term monthly means) for the eastern North Pacific.

Semi-monthly SST charts are now published year-round as the Fishing Information supplement. During the albacore fishing season, they are accompanied by the Albacore Bulletin which contains timely information on fishing conditions and on the progress of the fishery. The distribution of the semi-monthly and monthly environmental charts runs over 2000 copies each month.

Ship-of-Opportunity Program

Monitoring of subsurface temperature conditions in the equatorial and North Pacific Ocean from merchant ships equipped with expendable bathythermographs (XBT) has continued at the La Jolla Laboratory in cooperation with the NMFS Pacific Environmental Group at Monterey, California, and the SWFC's Laboratory in Tiburon. Selected subsurface temperature sections along three shipping routes, Hawaii-Los Angeles, Hawaii-San Francisco, and Hawaii-Seattle, are now being published regularly with descriptive material in Fishing Information. In December 1973, the format was changed to show the vertical profile for each observation in the section. Particularly good coverage was obtained during the summer of 1974 of subsurface temperature conditions in the northeast Pacific albacore fishing areas from May through August with one section per month on the Seattle route, six or seven per month on the San Francisco route and two or three per month on the Los Angeles route.

During the 1974 albacore fishing season, ocean conditions were noticeably different than in the previous 2 years. Two readily identifiable sharp boundaries, particularly surface salinity, marked the Transition Zone in 1972 and 1973 as a separate region between the modified subarctic waters of the California Current region and the eastern North Pacific central waters. Such sharp boundaries were not observed this year. On the Hawaii end of the section the normal spring time drop in salinities appeared in February, about 2 months early and persisted

through August. The salinity maximum in mid-section of the Hawaii-San Francisco route shifted about 100 to 200 nautical miles toward the west coast. Temperatures in the western half of the section are about 1° C higher than in the previous 2 years, while along the California coast they are as cold or slightly colder. These features are consistent with the observed northeastward shift of the North Pacific anti-cyclone, stronger trade winds at higher latitudes and persistent northwest winds along the California coast.

Tuna/Porpoise Research and Development

In response to the requirements of the Marine Mammal Protection Act of 1972, an expanded research program was undertaken at the La Jolla Laboratory to reduce the mortality of porpoise taken incidentally in the eastern Pacific yellowfin tuna purse seine fishery. In developing this program, NMFS was guided by the objectives, general philosophy, priorities, and organizational structure outlined in the "Report of the NOAA Tuna/Porpoise Review Committee" of September 1972. Work was undertaken to reduce porpoise mortality incidental to tuna purse seining as extensively and quickly as possible, to back this up with efforts to establish definitive information on the status of the porpoise populations in the eastern tropical Pacific, and to accomplish, within the objectives of the Act, long-term maintenance and viability of the tuna fishery.

The research program is conducted in two major areas: 1) gear dynamics and development, and 2) biology and stock assessment, further subdivided into such task elements as the observer program, life studies, population dynamics, behavioral studies and assessment surveys.

Much of the effort and funds during this reporting period were channeled into gear research and development since it appeared to offer the greatest promise of a speedy route to a short-range solution. In October 1973, an 850-ton purse seiner was chartered by NMFS to conduct trials of the tuna seining system designed by R. McNeely and his staff at the Northwest Fisheries Center, Seattle, to minimize porpoise mortalities. These included anti-torque cable to help prevent roll-ups of the net, differential current indicators to indicate direction and magnitude of wind and surface currents for advantageous deployment of the gear, techniques for using speedboats and towing harness which can function as "work horses" to hold the net open, and trials of a porpoise escape gate. A large-volume, tapered purse seine net, designed to aid in preventing the purse seine from closing at sea, one of the primary reasons for porpoise mortality in the net, was built and then tested at sea during a charter cruise in November-December 1973, and during a commercial cruise in late summer, 1974. As the program developed, workshops and study groups were held with tuna fishermen and members of the industry to solicit their ideas and inform them of the progress of the work.

The life studies phase is essentially a continuation of on-going studies of taxonomy, geographic distribution, life histories, growth, reproductive rates, and major causes of natural mortality of eastern tropical Pacific delphinid species. The essential data have been obtained from porpoise specimens obtained in the vessel observer program, and the results have contributed to development of a population dynamics model. A manuscript on the growth of the spotted porpoise in the offshore eastern tropical Pacific, which treats such matters as gestation period and fetal growth, age determination, length-weight relationships, geographical variation, etc., was completed for publication.

The porpoise observer program has thus far provided most of the vital information on porpoise-tuna interaction. Under the provisions of the Marine Mammal Act, and with the cooperation of the U.S. tuna fleet, NMFS observers go to sea aboard U.S. tuna purse seiners, where they count porpoises killed incidentally in the fishing operations, record statistics on size and makeup of the catch, collect specimens to be used in life history studies and stock assessment, make detailed observations of the rescue operations during each tuna set, and make other observations on cetaceans and birds. During the 1974 fishing year, 45 observer trips will have been completed.

Aerial observations represent the best approach to a rapid census of cetacean populations over vast oceanic areas. Dr. John Taylor of the University of California, San Diego, received a NMFS contract to assess the feasibility of an aerial assessment survey. A survey to obtain estimates on the size of the porpoise population in the eastern tropical Pacific, using both aircraft and the NOAA research vessel, David Starr Jordan, was carried out in January-February 1974. The aerial survey to count porpoise covered more than 12,000 miles in the yellowfin tuna fishing grounds off the Pacific coast from Mexico to Panama. Seventeen flights were made in all, ranging from 800 to 1000 miles. The survey plan involved flying fixed transects at altitudes of 500 to 1500 feet from Mazatlan, Puerto Vallarta, Acapulco, and Tapachula, Mexico; San Jose, Costa Rica; and Balboa, Canal Zone seaward an average of 500 nautical miles. The aerial survey technique seems to be a quick and reliable method for obtaining valid estimates of the density of porpoise populations in conjunction with other techniques, such as the data from the porpoise observers on tuna boats and shipboard observations from the NOAA research vessel, Jordan, which returned to San Diego on February 6, 1974, after making 105 sightings of marine mammals during a specially-designed cruise.

Presently, information derived from the porpoise observer program is integrated with data on the tuna fishery taken by the Inter-American Tropical Tuna Commission, and further treated statistically to derive a first estimation of porpoise stocks. In examining data gathered by NMFS observers aboard tuna

purse seiners, population dynamicists are attempting to establish if these data are representative of the actual population situation. Some useful guides in examining the porpoise problem are the theories already available on the exploitation of such other mammals as deer and whales. Mathematical modeling efforts are underway which place considerable emphasis on the formulation of computer simulation models to test the various theories and as a guide for planning and investigating multi-variable outcomes. With observer data and the results of ongoing life history studies, the first outputs of porpoise stock assessment studies have now been produced in draft form for review.

In August-September 1974, the entire scientific staff pooled its expertise to complete the preparation of a progress report summing up the research undertaken since the beginning of the accelerated porpoise program at the SWFC almost 2 years ago. This report, now under review, will be submitted to NMFS for incorporation in the Secretary of Commerce's report to Congress in conformance with the provisions of the Marine Mammal Protection Act of 1972. Included in this report are results of porpoise life history studies, estimates of porpoise mortality, population estimates derived from the aerial survey and marine mammal watch, development of porpoise-saving fishing gear, and recommendations for future research on porpoise.

BAITFISHES - CENTRAL AND WESTERN PACIFIC

Design, Construction, and Testing of a Bait Transport System - A Major Undertaking at the Honolulu Laboratory This Past Year

A limited supply of skipjack tuna baitfish has curtailed the growth of existing tuna fisheries and the establishment of new fisheries in areas of the Indo-Pacific. The SWFC Honolulu Laboratory is testing the feasibility of transporting baitfish from an area of plenty to one of limited supply. In a project under the leadership of Fishery Biologist Roger E. Green, the Laboratory developed a plan to augment the local bait supply in Hawaii by bringing the northern anchovy Engraulis mordax from California to the Hawaiian Islands using a transport tank via roll-on/roll-off freighter.

Late in October 1973 they acquired a surplus 5000-gallon fuel tank and trailer, and began the design and construction necessary to modify it into a baitfish carrier. Tank modification and repairs were completed in January, as were final plans for the dual life support system, construction and installation of which were finished in March. The transporter was first tested with 45 buckets of threadfin shad, successfully carried from Wahiawa Reservoir to the Honolulu Laboratory's Kewalo Basin facility.

It was shipped to Long Beach in early April for its first load of anchovy. About 100 pounds of fish died during the crossing, but an estimated 500 pounds were delivered to Honolulu alive and well. A discharge system for the removal of dead fish and a new tank draining system were installed after the first load was removed.

For the second shipment the tank was loaded with an estimated 1300 pounds of anchovy - later determined to be an overestimate. Fishery scientists in Honolulu had determined that a break-even payload should be a minimum of 700 pounds of baitfish. Loss during the second trial shipment was 450 to 500 pounds, removed dead and alive by the "vacuum cleaner" system of dead bait removal.

First results of live anchovy as skipjack tuna bait in Hawaii were reported by the skipjack tuna fishing vessel Anela. The anchovy were used to chum and fish 20-pound yellowfin tuna successfully but were felt to be too large for the 5- to 7-pound skipjack tuna in the islands at the time. The vessels selected to receive the second trial shipment reported excellent results chumming 8- to 15-pound skipjack tuna.

The third load delivered to Hawaii was small - the problem of accurately estimating the amount loaded becoming increasingly obvious.

In July a temporary baitfish acclimating facility was set up by SWFC and Southwest Region personnel in the Long Beach Harbor area, and about 2000 pounds of strong, healthy baitfish were available for the fourth shipment. Of the 224 scoops of fish placed in the transport tank, 17 were weighed and a calculated total weight estimated at 1317 pounds. At the completion of the unmonitored voyage to Honolulu, over 400 pounds of anchovy in excellent condition were removed from the tanker. It was estimated that at least 800 pounds were lost overboard during the shipment, probably being expelled live through the after water outlet as the result of a greatly increased pressure head created by the angle of the tanker aboard the Matsonia.

Modifications to the tanker are presently underway in Long Beach, as are bait density tests.

Tuna Baitfish Workshop Held at SWFC Honolulu Laboratory

An invitational tuna baitfish workshop co-sponsored by the National Marine Fisheries Service and the University of Hawaii Sea Grant Program, was held at the NMFS Honolulu Laboratory, June 4-6. A major purpose of the workshop was to bring together all information gathered thus far on baitfish, with emphasis on tuna baitfish of the central and western Pacific, and to explore some of the basic questions needing clarification in the face of the proposed development and expansion of skipjack tuna live-bait fisheries in these areas of the Pacific.

Workshop sessions dealt with natural stocks; cultured species; and baitfish transport, holding, and substitutes, with a discussion of the economics of each method of providing the bait necessary to a particular fishery.

In a final general session, participants established an order of priority for further studies: for Hawaii, the anchovy transport system; for American Samoa, the culturing and sea trials of mollies; initiation of Apogon studies by the Trust Territory of the Pacific Islands; and for other areas, the development of cultured baitfish and natural stocks.

The 35 contributed working papers constitute a valuable collection of current baitfish knowledge, and proceedings and selected working papers of the workshop will be published.

BILLFISHES - EASTERN PACIFIC

Cooperative Tagging

Since 1954, billfish have been tagged by cooperative marine gamefish tagging programs in many of the major sportfishing areas of the Pacific. Major locations of tagging have been off southern California, U.S.A., Baja California and mainland Mexico, Panama, and Australia. Two cooperative marine gamefish tagging programs have operated, 1) the Cooperative Marine Gamefish Tagging Program, sponsored jointly by the Woods Hole Oceanographic Institution, and NOAA's National Marine Fisheries Service, and 2) a cooperative program conducted by the California Department of Fish and Game.

Mr. J. Squire, Fishery Biologist at the La Jolla Laboratory, coordinates the tag returns from the Cooperative Marine Gamefish Tagging Program. He reports that the final count of tags used by marine big-game fishermen during the 1973 tagging program was 835. In February 1974, he prepared the annual tagging report which was distributed to about 1800 marine gamefish anglers participating in the program.

Of the 835 fish tagged in 1973, billfish accounted for 747 of the total. Although the amount of tagging was down by about two-thirds in 1973, the number of tag recoveries reached an all-time high of 35. Seven black marlin tags were returned from fish tagged off Cairns, Australia. Most were short-term recoveries from 1973 tagging in the Cairns area. However, one fish was recovered near the point of tagging 400 days after being released, and another was recovered 141 days after tagging north of Wewak, North New Guinea, located more than 1000 miles north of Cairns, Australia.

YELLOWFIN-SKIPJACK - ATLANTIC

Tuna Population Dynamics and Management Studies

During the past year, a number of papers were prepared for the International Commission for the Conservation of Atlantic Tunas (ICCAT) meeting in Paris in November 1973. With Mr. A. Fonteneau, visiting scientist from Abidjan, Ivory Coast, Dr. W. Lenarz, at the La Jolla Laboratory, prepared a paper, "Cohort analysis of the eastern Atlantic fishery for yellowfin tuna." They found that the strength of the 1968 year-class of yellowfin was about half the strength of adjacent year-classes. There was no indication that recruitment to the population has been affected by the fishery.

Drs. Fox, Lenarz, Sakagawa and Mr. Coan completed two additional papers for presentation at this same meeting: 1) a production model analysis of the status of Atlantic yellowfin tuna, and 2) a review of some aspects of the bluefin tuna (Thunnus thynnus thynnus) fisheries of the Atlantic Ocean.

At the 1973 ICCAT meeting in Paris, Dr. B. Rothschild, SWF Center Director, was unanimously elected Chairman of the Standing Committee on Research and Statistics for the next 2 years. This is the Committee that advises the ICCAT Council on the scientific basis for management and status of fish stocks.

Information on U.S. Participation in 1973 Atlantic Tuna Fisheries Summarized

The IATTC, Woods Hole Oceanographic Institution (WHOI), and NMFS personnel annually collects and processes logbook and size-frequency data from U.S. tuna vessels that fish in the Atlantic. This work is sponsored under NMFS contracts and the data are submitted to the La Jolla Laboratory for merging with other data collected by NMFS personnel and for use in analyses. These data have now been summarized as follows: In 1973, an American fleet of U.S., Canadian, and Dutch (operated by U.S. citizens) tuna vessels caught about 3000 metric tons of yellowfin tuna, 21,300 metric tons of skipjack tuna and 116 metric tons of other species of tuna from the eastern tropical Atlantic off Africa. The fleet consisted of 24 purse seiners and six baitboats. The overall catch rate for seiners was about 17 metric tons of skipjack tuna/day's fishing and 2 metric tons of yellowfin tuna/day's fishing, or a total of 19 metric tons of tuna/day's fishing. The total catch rate was the second highest for the fleet since 1967 when significant numbers of American vessels entered the fishery. The yellowfin tuna caught by the purse-seine fleet average 76 cm long and the skipjack, 45 cm long.

In the northwest Atlantic, a fleet of three U.S. seiners and four Canadian seiners constituted the 1973 purse-seine fishery for bluefin tuna. Preliminary figures on the total purse-seine catch for 1973 are 1781 metric tons of bluefin tuna and 35 metric tons of skipjack tuna. About 1500 metric tons of the bluefin tuna catch were schooled fish of 88 cm average length. The remaining tonnage consisted of large fish of about 233 cm average length.

American Catch at Various Distances off West Africa Estimated

As of September 16, 1974, 19 U.S. purse seiners reported catching 8700 metric tons of tuna off West Africa. Early landings have been about 50% skipjack and 50% yellowfin and bigeye. Fishing success appears to have been about average for this fishery (10 to 15 metric tons/day).

Virtually all the U.S. catch of Atlantic tropical tunas (yellowfin and skipjack) are annually made off West Africa. Fishery Biologist G. Sakagawa, at the La Jolla Laboratory, reports that estimates of Atlantic tropical tuna catches made by American vessels in 1968-72 at various distances off West Africa have been made, in order to understand the population biology of the tunas and to formulate management strategies. The estimates in terms of percentage of total catch for three zones - 1) shore to 12 miles, 2) shore to 100 miles, and 3) shore to 200 miles - are

Zones	Range of percent catch by species	
	Yellowfin	Skipjack
1	11-30	15-31
2	50-77	60-86
3	74-94	82-98

In all years a greater percentage of skipjack tuna than yellowfin tuna was caught close to the West African shore and a high percentage of the American catches was made within 100 miles of the coast.

Production Model Methodology Completed

Dr. W. Fox, Leader of the Stock and Recruitment Investigations at the La Jolla Laboratory, has completed revision of a manuscript describing a least-square method for fitting the generalized stock production model. The method uses John Gulland's concept of equilibrium approximation but involves a new weighting procedure for estimating equilibrium levels of fishing effort. Variability indices of the parameter estimates were also worked out.

In the manuscript, simulated data from a pandalid shrimp fishery were utilized to illustrate the efficacy of the fitting method. The results indicated that the methodology can be useful for analyzing the status of a particular fish stock; however, the assumptions and limitations were also discussed. Documentation on use of the computer program, PRODFIT, which performs the calculations has been completed.

Multiple Gear Yield Per Recruit Model Documented

Dr. W. Lenarz, Fishery Biologist at the La Jolla Laboratory, has generalized and documented the computer program, MGEAR, so that it may be used by other scientists. The program computes estimates of yield per recruit and several related parameters for fisheries that are exploited by several gears having differing vectors of age specific fishing mortality. Tables of yield per recruit, landings per recruit when fish below a minimum size are caught and discarded dead, average weight of fish in catch, and yield per recruit per effort as functions of minimum size and amount of fishing effort are contained in the output for each gear and the entire fishery. A brief manuscript that describes the program has been prepared by Dr. Lenarz.

Working Papers Prepared for European Tuna Meetings

The staff of the Stock Assessment and Fishery Evaluation Investigations at La Jolla have devoted the past several months to the production of working papers and documents in connection with the meetings scheduled in Nantes, France and Copenhagen, Denmark in September 1974 on matters dealing with U.S. membership in the International Commission for the Conservation of Atlantic Tunas, the Atlantic bluefin fishery, and tuna stock assessment on a worldwide basis.

Dr. Fox prepared a working document entitled, "An overview of production modeling" for presentation to the ICCAT Workshop on the Population Dynamics of Tuna, held at Nantes, France, September 2-13. Dr. Rothschild wrote a draft working paper entitled, "Issues in population dynamics of tunas" for this same meeting. This meeting was held in two sessions - the first, with a selected group of eight specialists in the field of population dynamics to consider present and future studies in the field and the second meeting, with tuna researchers from various countries to whom the results of the first session's deliberations will be presented. Dr. Rothschild, as Chairman of the ICCAT Standing Committee on Research and Statistics (SCRS) was Convenor of the Workshop, and Dr. Fox was a member of the selected group of specialists.

Dr. W. Lenarz, Fishery Biologist and Mr. J. Zweifel, Mathematician, with assistance from Mr. A. Coan, Mathematician, at the La Jolla Laboratory, completed a manuscript entitled "A theoretical examination of some aspects of the interaction between longline and surface fishery for tunas." This paper was presented to the IOFC-IPFC meeting at Nantes by Dr. B. Rothschild.

SWFC's WORLD TUNA SYSTEM STUDY COMPLETED

An analysis of tuna fishing problems, from both a U.S. and world view, was begun in the summer of 1974 at the SWFC in order to clarify existing problems, to decide what could be done about them, and to determine what criteria should be applied in evaluating the wide range of suggested solutions. Included in the study is an examination of the three major surface tuna fisheries, those in the IATTC regulatory area (CYRA), west of the CYRA, and in the eastern tropical Atlantic. With the consultative help of Dr. B. Mar, Professor of Civil Engineering at the University of Washington, a prototype computer model was constructed and utilized to evaluate some potential management problems in terms of the economics of the U.S. fishing fleet. The results of the dynamic modeling effort as well as a discussion of the tuna problems, solutions, criteria, and research needs have been included in a draft report entitled, "Systems analysis of the U.S. and world tuna management problems with some recommendations for the NMFS program." The report is now being reviewed.

SWFC PUBLICATIONS ON TUNA AND TUNA-RELATED STUDIES

October 1973 to September 1974

PUBLISHED

Bayliff, William H. and Brian J. Rothschild. 1974. Migrations of yellowfin tuna tagged off the southern coast of Mexico in 1960 and 1969. Bull. Inter-Am. Trop. Tuna Comm. 16(1): 1-64.

The map method, the Jones method, the variance-covariance method, and the Skellam method were used to study the migrations of tagged yellowfin tuna released off the southern coast of Mexico in 1960 and 1969. The first three methods are all useful, and each presents information which is complementary to that presented by the others. The Skellam method, as used in this report, is less useful.

The movements of the tagged fish released in 1960 appeared to have been strongly directed, but this was probably caused principally by the distribution of the fishing effort. The effort was much more widely distributed in 1970, and the movements of the fish released in 1969 appeared to have been much less directed. The correlation coefficients derived from the variance-covariance method showed that it was not random, however.

The small fish released in the Acapulco and 10°N-100°W areas in 1969 migrated to the Manzanillo area near the beginning of February 1970. The medium and large fish released in the same areas in the same year tended to migrate to the southeast throughout the first half of 1970, however.

Dailey, Murray D. and William F. Perrin. 1973 Helminth parasites of porpoises of the genus Stenella in the eastern tropical Pacific, with descriptions of two new species: Mastigonema stenellae gen. et sp. n. (Nematoda: Spiruroidea) and Zalophotrema pacificum sp. n. (Trematoda: Digenea). Fish. Bull. (U.S.) 71(2):455-471.

Parasite frequencies in 72 spotted porpoise and 19 spinner porpoise are reported and analyzed with respect to age of host. Irreversible lesions in the ventral region of the skull due to infection of the air sinuses by a Crassicauda-like nematode were more frequent in skulls of calves of spotted porpoise than in skulls of subadults and adults, indicating that the parasite, or a condition correlated with its occurrence, is a significant factor in natural mortality of this porpoise in the eastern tropical Pacific.

Hester, Frank J. 1974. Some considerations of the problems associated with the use of live bait for catching tunas in the tropical Pacific Ocean. Mar. Fish. Rev. 35(5): 1-12. (MFR Paper 1060.)

This report provides a summary of the tropical Pacific tuna live-bait fishing methods, identifies the major problems restricting the expansion of live-bait fisheries in the Pacific, and gives references and suggestions on methodology to investigators interested in working on baitfish problems.

Lenarz, William H. 1974. Length-weight relations for five eastern tropical Atlantic scombrids. Fish. Bull. (U.S.), 72(3): 848-851.

Parameters for the allometric length-weight relation were estimated for five eastern tropical Atlantic scombrids: yellowfin tuna, skipjack tuna, bigeye tuna, little tunny, and frigate mackerel. Statistically significant differences were found among samples. However, only minor differences in weight were found for fish of the same length and species.

Lenarz, W. H., W. W. Fox, Jr., G. T. Sakagawa and B. J. Rothschild 1974. An examination of the yeild per recruit basis for a minimum size regulation for Atlantic yellowfin tuna. Thunnus albacares. Fish. Bull. (U.S.), 72(1): 37-61.

Some of the conceptual foundations of yield-per-recruit analysis as a management tool and as applied to the Atlantic yellowfin tuna fishery were critically explored. In employing yield-per-recruit analysis for the Atlantic yellowfin tuna fishery, two approaches were taken--one approach makes use of a wide range of parameter estimates and a number of simplifying assumptions but with little data, while the other approach makes use of considerably more data, but is more confined in the parameter estimates and uses fewer of the simplifying assumptions. The general results of both approaches, assuming no dumping occurs, indicate that only minor increases in yield per recruit would occur if the size at recruitment is increased from the authors' estimate of the present size at recruitment and fishing effort remains constant; an increase in fishing effort without changing other aspects of the fishery would not appreciably increase yield per recruit; and an increase in size at recruitment and in fishing effort would result in modest gains in yield per recruit. Specifically meeting the request of the International Commission for the Conservation of Atlantic Tunas, the authors recommended that a minimum size limit regulation in the vicinity of 55 cm (3.2 kg) be enacted.

Lenarz, W. H., F. J. Mather III, J. S. Beckett, A. C. Jones and J. Mason. 1973. Estimation of rates of tag shedding by northwest Atlantic bluefin tuna. Fish. Bull., (U.S.), 71(4): 1103-1105.

The method of Bayliff and Mobrand (1972) was used to estimate rates of tag shedding from the results of a double tagging study on bluefin tuna off the east coast of the United States. Returns from the four types of tags used in the study were not significantly different. Using the combined data from the four tag releases, the proportion of tags retained after immediate shedding was estimated to be 0.973 and the instantaneous rate of tag shedding was estimated to be 0.310 on an annual basis. These results are similar to those obtained by Bayliff and Mobrand for yellowfin tuna in the eastern tropical Pacific.

Naughton, John J., 1973. Investigations of billfish biology at the Hawaiian International Billfish Tournament. Mar. Fish. Rev. 35(8): 19-25. (Also MFR paper 997.)

Since 1962 the Southwest Fisheries Center's Honolulu Laboratory, National Marine Fisheries Service, has sent an investigating team to the annual Hawaiian International Billfish Tournament. The team collects biological data for marine sport fisheries research. This paper outlines the tournament and NMFS participation, and summarizes data collected there from 1962-72. Results of investigations are discussed, including marlin diet, sex ratio, sexual dimorphism, fishing effort, and marlin movements on the fishing grounds.

Neill, William H., and E. Don Stevens. 1974. Thermal inertial versus thermoregulation in "warm" turtles and tunas. Science (Wash., D.C.) 184(4140): 1008-1010. (No abstract.)

Matsumoto, Walter M. 1974. The skipjack tuna, Katsuwonus pelamis, an underutilized resource. U.S. Natl. Mar. Fish. Serv., Mar. Fish. Rev. 36(8): 26-33. (MFR paper 1077.)

The skipjack tuna is the only species of tuna presently exploited commercially that can withstand large increases in fishing pressure. This article describes the biology and ecology of the skipjack tuna in the Pacific Ocean and the distribution of skipjack tuna fisheries, giving recent catch statistics and including assumed movement patterns of Pacific stocks. Opportunities exist for the increased development of the skipjack tuna resource, a benefit to the economy of the developer nation.

Perrin, W. F., R. W. Warner, C. L. Fiscus and D. B. Holts. 1973. Stomach contents of porpoise, Stenella spp., and yellowfin tuna, Thunnus albacares, in mixed-species aggregations. Fish. Bull, (U.S.) 71(4): 1077-1092.

Haul-by-haul analysis of stomach contents of spotted porpoise (Stenella attenuata), spinner porpoise (S. longirostris), and yellowfin tuna (Thunnus albacares) from six net hauls made on

mixed-species aggregations in 1968 indicates that a squid (probably Dosidicus gigas) was the most important food item in terms of co-occurrences in the three species and in terms of volume and number. In addition to the squid, the small scombrid Auxis sp. and the epipelagic exocoetids (flying fish) were important to both. The portunid crab, Euphaylax dovii, was very important in the tuna but absent in both species of porpoise. Onychoteuthid and enoploteuthid squids were important in some hauls in both species of porpoise but were all but absent from the tuna stomachs. Small mesopelagic fishes, mainly myctophids (lanternfish) and Gonostomatidae (light fish) were important in the spinner porpoise, but not in the spotted porpoise or the tuna. Relative frequencies of empty stomachs and state of digestion of stomach contents indicated that the spinner porpoise does not feed at the same time as do the spotted porpoise and tuna. In spite of overlap among the three species in nearly all of the food components, these results suggest that the tuna and spotted porpoise feed together largely on epipelagic prey, whereas the spinner porpoise for the most part feeds deeper and at different times of day; furthermore, only the tuna eats crustaceans.

Sakagawa, Gary T. 1974. Participation by Panamanian and U.S. seiners in 1972 tuna fishery of the eastern tropical Atlantic. Mar. Fish. Rev., 36(3): 10-13.

American participation in the 1972 eastern tropical Atlantic tuna fishery is reviewed. For the American fleet (Panamanian and U. S. seiners) the 1972 season was successful in terms of total catch of 24,200 metric tons of tuna, second highest recorded (highest was the 1969 catch of 24,300 metric tons) since significant numbers of American vessels first participated in the fishery in 1967. Catches, catch rates, fishing areas, and sizes of yellowfin and skipjack tunas caught by the American fleet in 1972 are discussed.

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Horikawa, Akio. 1974. Japan's tuna production (Waga kuni no maguro gyogyo seisan). Suisan Shūhō (The Fishing and Food Industry Weekly) 707:16-19. March 25, 1974. Suisansha K.K. (Translated from Japanese by T. Otsu, 1974, 7 p.)

Katsuo-Maguro Nenkan. 1973. Japanese skipjack tuna fishery development in foreign areas (Katsuo kaihatsu--kaigai katsuo-zuri gyogyo). Katsuo-Maguro Nenkan (Skipjack-Tuna Yearbook). Suisan Shinchōsa K.K., Tokyo, p. 151-158. (Translated from Japanese by T. Otsu, 1974, 12 p.)

Kikawa, Shoji. 1971. Shunyo Maru's third bait survey in the Papua New Guinea area (Shunyo Maru ni yoru dai-san-ji Papua New Guinea jiryogyo chosa). Proceedings of the 1970 Japanese Tuna Fishery Research Conference, Shimizu, Japan, February 3-5, 1971, p. 255-262. Fisheries Agency of Japan, Far Seas Fisheries Research Laboratory. (Translated from Japanese by T. Otsu, 1974, 10 p.)

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Suisan Shūhō. 1973. The slow progress in skipjack tuna live-bait development (Nakanaka susumanai katsuo no esa kaihatsu). Suisan Shūhō (The Fishing and Food Indistry Weekly) 693:30-31. October 5, 1973. (Translated from Japanese by T. Otsu, 1973, 4 p.)

Tohoku Regional Fisheries Research Laboratory. n.d. Atlas of skipjack tuna fishing grounds in southern waters, 1973 fishing season (July 1973-May 1974) (Showa 48 nendo nanpō katsuo gyokyō). (Five pages test, 14 charts.) (Translated from Japanese by T. Otsu, 1974, 22 p.)

Urabe, Shiro (interviewer). 1974. There's a keen interest in developing new skipjack tuna fishing grounds (Shingyojo no kaihatsu ni iyoku wo moyasu). Suisan Sekai 23(1):84-93. [Interview with two brothers, both fishing masters on vessels belonging to the Abekane Suisan K.K.] (Translated from Japanese of selected portions of article by T. Otsu, 1974, 17 p.)