

SOULERIES CENTE SUTIMEST FSHERES FURTH DIRECTOR'S REPORT THIRTY-FIRST TUNA CONFERENCE ON TUNA AND TUNA-RELATED ACTIVITIES AT THE SOUTHWEST FISHERIES CENTER LA JOLLA, CALIFORNIA FOR THE PERIOD APRIL 30, 1979 TO MAY 1, 1980

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WATTING MARTINE FISHERES SERVICE

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INTRODUCTION

Since 1971, tuna research in the National Marine Fisheries Service (NMFS), the Federal fisheries agency in the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, has been mainly centered within the Southwest Fisheries Center and its laboratories in Honolulu, Hawaii and La Jolla, California.

At the Honolulu Laboratory, principal effort is devoted to the assessment and understanding of the skipjack tuna resources of the Pacific and Indian Oceans. Because of its location and the unique capability of holding large tropical pelagic fishes at the laboratory, scientists study the sensory and physiological reactions of tunas to their environment. Other tuna-related programs include assessment of the South Pacific albacore populations and recreational fisheries research, principally the sport fishery for billfishes. Results of this research are provided for fishery management consideration in international forums such as the Indo-Pacific Fisheries Council and the Indian Ocean Fishery Commission and domestic forums, such as the Western Pacific Fishery Management Council.

At the La Jolla Laboratory, the staff of the Oceanic Fisheries Resources Division provides basic fishery analysis and management information on tunas and billfishes to international fisheries bodies and commissions, conducts studies on the status of porpoises involved in the eastern tropical Pacific tuna purse seine fishery, and operates a fishing information system for the eastern tropical Pacific tuna fisheries. The staff of the Coastal Fisheries Resources Division at the La Jolla Laboratory conducts biological research on North Pacific albacore directed toward fishery prediction and operates a fishery forecasting/advisory service for the albacore tuna fishery off the Pacific west coast.

With the exception of research on the Atlantic billfishes and bluefin which is carried on in the Southeast Fisheries Center in Miami, Florida, fishery biologists at the Honolulu and La Jolla Laboratories of the Southwest Fisheries Center are heavily involved in population dynamics studies of most other species of tuna on a worldwide basis.

In 1979, I convened the Workshop on Tuna Research Planning (see page) in an effort to examine critically the current status of tuna and billfish stocks of importance to the U.S. and to improve the Center's capability to conduct tuna research for the near term and to formulate long-range plans for tuna work.

As a general policy statement, I want to reaffirm my commitment to support the required generic research for developing new analytical methods and models useful for stock assessment or fishery management. Although we will not receive additional funds or personnel ceilings in this fiscal year, I believe we can make some important progress in research within our current resources. Whatever activities are delayed or modified to provide resources for the required research projects, the SWFC must maintain its basic capability to respond adequately to the needs for management advice. Based, in part, on the general conclusions reached by the Workshop, we plan in the ensuing months to review our current billfish activities, improve our stock assessments for central and western Pacific skipjack and yellowfin, monitor the negotiations for establishing a new tuna management regime in the eastern Pacific, analyze existing data to investigate the relationship between surface fisheries and longline fisheries, design a work plan that will lead to measurement of fishing effort in surface fisheries and critically evaluate efforts to model fish, fishery, and environmental interactions for improved management and fishery forecasting.

The report which follows presents only the highlights of our many and varied activities in tuna and tuna-related research at the Southwest Fisheries Center during the past year and is not intended as a comprehensive account of the accomplishments of our many programs.

Izadore Barrett, Director Southwest Fisheries Center

May 1980

IN SUPPORT OF EXISTING INTERNATIONAL AGREEMENTS

NMFS/SWFC. COOPERATION WITH THE INTER-AMERICAN TROPICAL TUNA COMMISSION

The historical commitment of Federal agencies to the Inter-American Tropical Tuna Commission is set out in the enabling legislation (Tuna Conventions Act of 1950)..."All agencies of the Federal government are authorized on request ... to cooperate in the conduct of scientific and other programs, or to furnish facilities and personnel for the purpose of assisting the Commission in the performance of their duties."

During the past year, the Southwest Fisheries Center reviewed the scientific work of the IATTC in order to give management advice to the U.S. Commissioners on IATTC.

The Center also funded a contract to the IATTC for the provision of assistance in data processing and research with meteorological and oceanographic data from the eastern tropical Pacific Ocean. Environmental data, especially sea surface temperatures, have been important to studies of the yellowfin and skipjack fisheries of the eastern tropical Pacific.

At the 33rd meeting of IATTC in October 1976 it was agreed that the IATTC should concern itself with the problems arising from the tuna/porpoise relationship in the eastern Pacific Ocean, and some aspects of this work are carried out in cooperation with NMFS. The most recent SWFC aerial and research vessel surveys on porpoise were conducted during the first part of 1979. A Commission scientist participated as an observer on two of the flights of the aerial survey to gain first-hand experience of the techniques employed. This provided valuable insights into the effect of sea state and sun angle on the probability of detecting porpoise schools. In addition, a Commission scientist evaluated sea surface temperature data recorded along flight tracks with the NMFS infrared radiometer during the 1977 and 1979 porpoise aerial surveys.

The Commission also participated in an SWFC workshop designed to examine analyses of the data from the 1979 aerial and research vessel porpoise surveys. These data were combined to make overall population estimates of the various species of porpoise in the eastern tropical Pacific Ocean.

INTERNATIONAL COMMISSION FOR THE CONSERVATION OF ATLANTIC TUNAS

As a member of the International Commission for the Conservation of Atlantic Tunas (ICCAT), the United States has direct responsibility for Atlantic tuna stock assessment work and for tuna management recomendations. Determination of the status of albacore, yellowfin, skipjack and bigeye tuna stocks of the Atlantic Ocean in support of ICCAT is a principal task of the Tuna and Billfish Resources program, headed by Dr. Wesley Parks at the La Jolla Laboratory. In 1979 during the sixth regular meeting of ICCAT held in Madrid, Spain, November 5-20, 5 papers by members of the program staff were presented. The Madrid meeting was in two parts: the meeting of the Standing Committee on Research and Statistics (SCRS), November 5-13, and the meeting of the Commission, November 14-20. Scientists of the Southwest Fisheries Center participated in both sessions.

SWFC scientists attending the SCRS meeting were Dr. Gary Sakagawa, Chief, Oceanic Fisheries Resources Division and Leader of the U.S. scientific delegation, Dr. Wesley Parks, Dr. Norman Bartoo, Fishery Biologist and Atilio Coan, Mathematician. Scientists from 12 of the 19 member countries attended the SCRS meeting, reviewed 115 documents, and prepared status of stock reports on Atlantic tuna and billfish stocks to assist the Commission to identify needed conservation measures.

The SCRS's appraisal of yellowfin tuna stocks was unchanged from that in 1978. Stocks are heavily fished, particularly in the eastern Atlantic, where recent catch increases appear to be the result of offshore expansion of the fishery. Recent catches are within the range of estimated maximum sustainable yield. Any increases in equilibrium yield-per-recruit will depend on effective application of the 3.2 kg minimum size limit and availability of large fish. The SCRS recommended that every effort be made to apply the minimum size limit regulation.

The SCRS found skipjack tuna in the eastern Atlantic to be fished at a high level. Evidence continues to indicate the presence of a significant underexploited western Atlantic stock. The results of developing a western Atlantic fishery depend on stock structure of the population in the Atlantic. If there are separate eastern and western stocks, increases in western Atlantic effort could result in sharp increases in total catch. If there is one Atlantic-wide stock, effort increases may only lead to small increases in total catch.

The SCRS assessed bigeye tuna stocks to be in good condition. Stocks appear to be fished at a high level and recent catches are within the range of estimated maximum sustainable yield. Increasing age-at-firstcapture would increase equilibrium yield-per-recruit. However, the benefit of regulations to increase bigeye and skipjack are often taken in mixed catches. The SCRS reiterated its 1978 recommendation for a common 3.2 kg bigeye/yellowfin minimum size limit. Such regulation would increase bigeye yield-per-recruit, and since small yellowfin are sometimes landed as bigeye, the bigeye regulation would facilitate effective application of the 3.2 kg yellowfin size limit.

As in 1978, the SCRS found albacore to be harvested at about the level corresponding to maximum sustainable yield. Changing fishing patterns toward larger fish in the fishery for the north Atlantic stock may be increasing equilibrium yield-per-recruit. The SCRS in 1978 expressed concern over possible recruitment failure due to the apparently very reduced spawning stock and increasing variable recruitment. New analyses alleviate some of this concern suggesting that the probability of recruitment failure is low. However, the committee recommended that stock condition be closely monitored since adult stock is still estimated to be low.

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The SCRS found bluefin tuna abundance in the eastern Atlantic and Mediterranean Sea to be increasing. In the western Atlantic apparently weak recent year classes suggest that juvenile abundance is probably depressed. Western Atlantic adult abundance is expected to increase. The 6.4 kg minimum size limit adopted in 1975 has probably increased potential yield-per-recruit. Further increases in minimum size could further increase yield. The limit on fishing mortality, also implemented in 1975, appears to have stabilized fishing mortality rates. The SCRS recommended retaining both minimum size and mortality limit regulations.

The Atlantic-wide white marlin stock appears to have been exploited in recent years at levels at or above that corresponding to maximum sustainable yield. Blue marlin stocks appear to have been overexploited since the early 1970's. No management measures were recommended. However, the SCRS recommended that the fisheries be closely monitored and methods to reduce effort be considered should further analysis continue to show overfishing.

Sakagawa and Parks attended the Commission meeting as advisors to United States Commissioners Carmen Blondin and Dr. Frank Carlton. Seventeen of the 19 member countries were represented at the Commission meeting.

The Commission's 1978 adoption of a recommendation for a bigeye minimum size limit, subsequently found to be invalid, was reviewed. A slightly altered version prohibiting the taking of bigeye less than 3.2 kg until December 31, 1983 was adopted. The Commission's recommendation to limit fishing mortality on northern bluefin tuna to recent levels, due to expire in October 1980, was extended an additional two years.

The Commission reviewed the special skipjack research program budget. Proposed 1980 budget increases to account for inflation were approved. In order to review the regular Commission and skipjack program budgets for 1981, the Commission decided to hold its second special meeting in 1980. The meeting is scheduled for the week beginning on November 12, 1980 in Madrid.

INTERNATIONAL SKIPJACK YEAR PROGRAM

During the past year Center scientists continued their involvement in the development of an intensified Atlantic-wide skipjack tuna research program sponsored by the International Commission for the Conservation of Atlantic Tunas (ICCAT). Almost three years in the planning, the program, now known as the International Skipjack Year Research Project, was developed and is being coordinated by ICCAT. The rationale for the research--scientists believe that skipjack tuna is the most abundant of the commercial species of tuna in the Atlantic. It was not exploited on a large scale until recently, but since 1961 catches have increased rapidly, reaching a maximum of 117,000 tons in 1974, of which 19,973 tons were taken by United States flag fishing vessels. This catch represents a revenue of more than 2 million dollars to U.S. fishermen at today's prices.

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With growing world demand for tuna and the fact that little increase in catch can be expected from the larger species of tuna from any ocean, including the Atlantic, there is an obvious opportunity for expanding production from Atlantic skipjack tuna. However, apart from a general feeling among fishery scientists that these stocks are not yet fully exploited, there is at present insufficient information to plan this expansion in a rational manner, avoiding on the one hand any failure to take advantage of opportunities where they exist, and on the other hand, damaging the stocks and the fisheries on them through overdevelopment and overexploitation.

As the program is designed it will extend four years. A planning phase was executed during 1979 and a limited execution phase is in progress during 1980. The "International Skipjack Year" will occur in 1981 when most research will take place. The final year, 1982, will focus on evaluating data collected.

The program is designed not as a fully ICCAT-funded and controlled program but rather as one in which ICCAT coordinates the collective inputs of the 19 ICCAT member countries, who supply vessels, gear and research expertise.

As part of the U.S. contribution to this international program, the Southwest Fisheries Center chartered the 86-foot baitboat, <u>Rhonda Sue</u>, to undertake a 3-month skipjack tuna tagging project in the western Atlantic. The objective was to tag 10,000 skipjack and collect biological information on the fish stocks of that region. On January 12, the vessel left San Diego with fishery scientists from the Center and from Living Marine Resources, Inc. of San Diego, who were under contract to coordinate the logistics of the cruise, aboard.

Preliminary data from the cruise show 143 schools of fish were observed, 1604 tuna were tagged, of which 1,404 were skipjack. One hundred nineteen tuna were double tagged and 207 injected with tetracycline. Biological data were collected on 53 fish and 5 whole-fish samples were taken. Two thousand one hundred twenty-six (2,126) scoops of bait were captured, of which 376 were used in the fishing operation.

The charter ended in Curacao, Netherlands Antilles on April 18. The <u>Rhonda</u> <u>Sue</u> is expected to return to San Diego on or about May 18, 1980.

INDIAN OCEAN TUNA RESEARCH AND DEVELOPMENT

The United States is a member of the Indian Ocean Fishery Commission (IOFC). Matters relating to tunas and billfishes are discussed at meetings of the Committee on Management of Indian Ocean Tuna. This special committee usually meets jointly with its counterpart, the Special Committee on Management of Indo-Pacific Tuna of the Indo-Pacific Fishery Commission (IPEC). The 6th Joint Session was held in Perth, Australia on 20-22 February 1980. At this meeting the results of the Shimizu tuna

and billfish assessment workshop were reviewed. The Shimizu workshop was held in June 1979 and was co-sponsored by the Far Seas Fisheries Research Laboratory and the Southwest Fisheries Center. A final report of the workshop proceedings will be published shortly by FAO in their fisheries series.

For the Indian Ocean tuna resources the workshop results suggested that while there is considerable opportunity to expand tuna catches in the Indian Ocean and western Pacific, some stocks are already heavily fished. Most of the stocks of large tunas exploited by the longline fishery in the Indian Ocean have been exploited to an extent such that little, if any, further increase in catch can be expected from further increases in longline fishing effort. For some species such as the yellowfin tuna, total catches could be considerably increased above the current levels if the effort on medium sized fish were increased.

REPORTS PREPARED FOR IPFC AND SPC

A report has been prepared by Howard O. Yoshida and Hazel E. Nishimura of the Honolulu Laboratory entitled "The costs of primary journals: A review." The report will be presented as a background paper for the 19th Session of the Indo-Pacific Fishery Commission (IPFC) scheduled to be held in Kyoto, Japan from 21-30 May 1980. It is expected that the paper will serve as a basis of discussions to review the desirability of establishing an IPFC journal to publish research results of member country scientists.

Richard N. Uchida, Leader, Insular Resources Task, Honolulu Laboratory attended the South Pacific Commission's 11th Regional Technical Meeting of fisheries officers, which was held in Noumea, New Caledonia December 5 to 10, 1979. While much of the discussion dealt with nearshore fishery resources, a status report of the skipjack tuna tagging program was presented at the meeting by Dr. Robert Kearney of SPC. IN SUPPORT OF POSSIBLE FUTURE INTERNATIONAL AGREEMENTS

Fourth North Pacific Albacore Workshop

As part of a continuing informal agreement established in 1974 between the Far Seas Fisheries Research Laboratory (FSFRL) of Japan and the Southwest Fisheries Center (SWFC), the Fourth North Pacific Albacore Workshop was held at the FSFRL in Shimizu, Japan, June 25-27, 1979. The purpose of the workshop series is to promote and accelerate investigations of the biology, ecology, and population dynamics of North Pacific albacore, Thunnus alalunga.

Attending from the Southwest Fisheries Center were Drs. Gary Sakagawa, Norman Bartoo and R. Michael Laurs of La Jolla and Dr. Jerry Wetherall of the Honolulu Laboratory. The meeting was chaired by Dr. S. Kume of Japan and the 13-man Japanese delegation was led by Dr. S. Ueyanagi. Taiwan and Canada were represented by Drs. R.T. Yang and S. Ketchen, respectively. Bartoo and Dr. S. Kikawa of Japan served as rapporteurs for the workshop. Papers at the workshop by SWFC staff include the following:

A progress report on albacore age-determination was presented at the workshop by R. Michael Laurs and R. Nishimoto who evaluated the otolith daily ring increment aging method by using the otoliths from recaptured tagged fish which had been injected with tetracycline at the time of tagging. Otoliths were examined from 61 recaptured fish for which there was reliable information on the number of days at liberty. Preliminary results suggest that for a period up to 400 days at liberty, the relationship between otolith ring increments and days at liberty is nearly 1:1. Thus, there is considerable promise of being able to use this method to age North Pacific albacore. A disadvantage of the method is the length of time (2-4 hours per otolith) required to make accurate daily ring counts. Further studies are in progress to establish the average length of albacore when they reach their first birthday, and thus resolve a longstanding controversy about the growth of young albacore.

The results of a cooperative albacore tagging program were presented in a paper by Laurs (see also page 11 of this report). This program conducted by the Southwest Fisheries Center, in cooperation with the U.S. albacore fishing industry, has been in existence since 1971. From 1971 to 1978, approximately 15,000 fish have been tagged and released. To date, there have been 861 tag recoveries. Results from this tagging study suggest that there may be at least two substocks of fish that comprise the North Pacific stock of albacore and that these substocks have different migratory patterns. The northern substock makes trans-Pacific migrations between the eastern and western North Pacific resulting in an exchange of fish between the northern area (north of about 40° N) of the U.S. fishery and the Japanese pole-and-line and longline fisheries west of 180°. The southern group of fish has a different migration pattern from the northern group and appears to enter the U.S. fishery south of about 40° N and the longline fishery east of 180°. Only a very small proportion of the southern group appears to migrate between the eastern and western Pacific and enter the Japanese pole-and-line fishery. Also, during a given season, there appears to be little exchange of fish in the U.S. fishery between the northern and southern substocks.

United States consumption and production of albacore were reviewed in a paper by N. Bartoo, N. Beerman, and G. Sakagawa. The statistics show that the United States consumed about 94,000 mt of albacore in 1977, virtually all in canned form. About 13,000 mt of this total was caught by United States fishermen. The remainder was imported from countries such as Japan, Taiwan, and Korea. Japan alone supplied about one-third of the total United States imports. The conclusions show that domestic demand for albacore is substantial and capable of supporting a much larger domestic fishery. However, the United States fishery which extends from Mexico to Canada does not appear to be able to increase production substantially with increased fishing effort with the current mode of fishery operations.

A status report on the North Pacific albacore stock was presented in a paper by N. Bartoo and E. Weber. Data indicate that catch per effort in the North American fishery since 1961 has been stable although slightly lower after 1969 than previously realized. The longline fishery catchper-effort has shown a slow decline since the mid-1950's. The Japanese surface fishery catch-per-effort declined until 1970 when the expansion of fishing grounds caused catch-per-effort to increase. Trends in mean weight of fish were variable between fisheries. Since 1966, the trend in mean weight in the longline fishery has been upward, in the Japanese pole-and-line fishery, the trend has been downward, while no trend is evident in the North American fishery.

Bartoo and Weber examined the albacore yield-per-recruit status under a number of different assumptions such as natural mortality rates, growth rates, etc. in another paper. Their results, combined with results from previous workshops indicate that prior to 1970, the combined North Pacific albacore fisheries realized a yield-per-recruit of about 8 kg. Since 1970 the yield-per-recruit has apparently dropped. The longline fishery appears to have sustained a larger yield-per-recruit drop than the North American fishery while the Japanese pole-and-line fishery yield-per-recruit may have moved upward. No consistent trend in estimated recruitment was observed for the 1953-1973 period although much variability was noted. No clear spawner and recruit relationship was detected.

The workshop participants estimated the maximum sustainable yield of albacore to be near 125,000 mt, but due to possible failures of several critical assumptions in the analyses, concluded that the precision and reliability of the estimate were poor. The participants did find that changes in the age structure of the albacore catch since 1971 have apparently caused a substantial decline in the yield-per-recruit, and have produced declines in the indices of spawning stock and possibly recruitment.

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The workshop participants recommended several key areas for research as essential for future stock assessments:

- Some improvements in catch and effort statistics are needed,
- Stock and substock structure should be better defined,
- Questions on age and growth should be resolved,
- Robustness and sensitivity of stock assessment models should be evaluated, and
- Key oceanographic processes and parameters affecting CPUE, vulnerability, etc. should be quantified.

It was agreed that the Fifth North Pacific Albacore Workshop will be hosted by the Southwest Fisheries Center at La Jolla, California, June 28 to July 3, 1980.

Cooperative NMFS-AFRF Albacore Studies

The NMFS La Jolla Laboratory and the American Fishermen's Research Foundation (AFRF) continued cooperative albacore studies designed to obtain information to increase the understanding of the North Pacific albacore resource and to improve harvesting of the resource by U.S. fishermen.

During the 1979 albacore season, joint NMFS-AFRF research activities included (1) an extensive tagging program off northern Baja California and central California of the "southern" group of albacore as part of a study of the migration patterns of this group of fish, and (2) a withinseason exploratory/research survey in waters several hundred of miles off the Pacific Northwest, and (3) tagging in the western Pacific.

Albacore Tagging Studies

During 1979, 1,667 albacore were tagged and released, bringing the total number of albacore tagged since the start of the cooperative NMFS-AFRF tagging program in 1971 to 16,637. A summary by year of the number of albacore tagged, recovered and percent recovery is given in Table 1.

Table 1. Summary by year of number of albacore tagged and percent recovery for joint NMFS-AFRF albacore tagging program.

Year	Number of tagged fish released	Number of tagged fish recovered.	Percent recovery
1971	887	31	2 02
1972	2082	181	2.03 8.69
1973	1805	111	6.15
1974	2486	175	7.04
1975	1349	115	8.52
1976	1581	88	5.57
1977	2061	115	5.58
1978 :	2719	136	5.00
19 79	1667	15	-
Unknown	+	6	0.09
Total	16,637	975	5.86

Albacore Injected with Tetracycline in Age Determination Study

A study intended to determine the rate of layering in the otoliths of albacore so that the ages of individual fish can be accurately assessed is being conducted at the La Jolla Laboratory. The otolith-daily-ring method for aging fishes appears to be a powerful tool holding great potential for solving problems regarding age determination in albacore. Researchers using this method have assumed that there is a daily ring deposition on the otolith. Research underway at the La Jolla Laboratory will test this assumption for North Pacific albacore.

Albacore were tagged and injected with tetracycline, an osteophytic agent which is incorporated into bone and which will fluoresce when the bone is later viewed under ultraviolet light. Injecting a fish with tetracycline marks its otolith at the time of release. For recaptured fish, information on time that the fish is at liberty can be used to determine the rate of ring formation and to test the assumption of daily ring deposition. Information gained from the tetracycline-marked otoliths may then be used for absolute age and growth determination, and possibly to test the assumption that a tagged fish's growth rate is unaltered by the presence of a tag or by the stress imposed in its application.

A total of 2,544 albacore was injected, tagged and released during field operations conducted in cooperation with AFRF in 1977 and 1978. A total of 136 or 5.3% of these fish has been recaptured. However, in 35 cases the otoliths or information on time at liberty were not available or tetracycline marks were not found on the otoliths, leaving samples from 101 fish. The failure to find a tetracycline "mark" on some of the

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otoliths was found to have resulted from a defective tetracycline solution which was used to inject a small number of fish at the start of the experiment, and apparently from improper injection technique where the hypodermic needle was withdrawn too quickly and the tetracycline solution leaked out.

Otolith ring increments on 62 tetracycline injected albacore have been counted, 57 from albacore that were tagged and recovered during the same season, and 5 that were at liberty for approximately one year. These counts indicated that the otolith ring increments for albacore are deposited daily. However, because most of the otoliths were from albacore that were out for less than 100 days, there is still some question as to whether the increments are formed daily over longer periods of time. Therefore, the remaining 39 albacore that were out 1 to 2 years will prove to be very important. Recoveries from American, Canadian and Japanese fishermen in 1979 will help to determine the rate of ring formation over long periods and the great distances of migration. This is expected to be completed by the end of June 1980. The otolith counts are being made by R. Nishimoto with assistance from IATTC scientists; and the project is under the direction of Dr. R.M. Laurs, Leader of the Albacore Fishery Program at the La Jolla Laboratory.

Albacore-Oceanography Survey Cruises

A 29-day albacore-oceanography survey was conducted during November 1979 with La Jolla Laboratory Oceanographer Ron Lynn as the cruise leader aboard the NOAA research vessel <u>David Starr Jordan</u>. During this cruise vertical longline gear, recently developed in Japan, was first used in a fisheries research program in the eastern North Pacific. Numerous problems were encountered with the gear, in part due to the severe weather conditions. Lynn cancelled further fishing effort after five sets were attempted. Five fish were caught, one of which was an albacore.

An objective of this cruise had been to locate and map the subtropic front and test for the presence of albacore, especially in regions about the front where the subsurface thermal structure appears to favor their presence. Vertical longline gear was selected in order to reach the deep temperature layer preferred by albacore (albacore are not found in the surface waters which are above 20° C at this time of year). This objective was established as a test of the hypothesis that the albacore taken in the U.S. west coast fishery south of 40° N follow a separate migration pattern than those in regions to the north of 40° N. Further, the theory has it that the albacore may winter in a zone in and about the subtropic front (near 32° N) in the central and eastern Pacific. In part, this hypothesis is based on the finding that 17 albacore tagged and released in the U.S. west coast fishery by personnel of the Southwest Fisheries Center have been recovered by Japanese longline fishermen operating in winter months within the region of the subtropic front. Most of the recoveries were made within a degree or two or 32° N and between 135° W and 180° W.

The albacore caught by scientists on the <u>Jordan</u> were taken at a depth of 200 m in 12° C water near 31°45' N, 144° W, a short distance south of the subtropic front. The fish weighed 19.2 kg and had a fork length of 100 cm. One mahi-mahi, one blue shark, one opah, and one snake mackerel were also taken during the cruise.

Problems were experienced in safely deploying and retrieving the gear and there were frequent entanglements of the branchlines (those lines that carried the baited hook). In retrospect it is not surprising that problems were encountered in initial use of unfamiliar and specialized gear. Aside from unfamiliarity with the gear, a large share of the difficulties was caused by extremely poor weather conditions. Strong winds and heavy seas and swell were common throughout the cruise. The frequency and duration of gales and storms were greater than average November patterns suggest as typical. Also, the line and swivels chosen to complete the longline were not fully adequate for the conditions encountered. On the first set residual twist in the brand new line and the method of deployment caused 60 of 80 baited lines to tangle. In subsequent sets this record improved to only 17 of 96 lines. Heavy swells, occasionally exceeding 18 feet, during the last set caused 73 of 88 lines to entangle. Further fishing effort was cancelled at that point. As an experiment, a vertical longline was assembled with modifications and deployed and worked satisfactorily. Clearly, the gear can be made to work once changes are made. Additional changes are needed in fairleads, blocks and reels to aid deployment and retrieval.

A second objective was to study and describe the subtropic front in a contrasting season of the year from spring-summer for which we have considerable measurements. The description will provide an understanding of the seasonal changes in the frontal system which is believed to influence the shoreward migration of albacore in spring. Additionally the oceanographic observations will provide ground truth for examining remote observations of frontal surface gradients via satellite.

According to Lynn, the oceanographic study was successful despite recurrent equipment problems throughout the cruise. Observations indicated there was a sharp division of the surface layer and deeper waters; thus the front was divided with the shallow and deep portions offset from one another. A very large north-south meander was observed in the frontal gradients that was of the scale of the chosen transects. This was observed via satellite as well; it is evident that each data set will aid in interpretation of the other.

During the November albacore-oceanography survey, "ground truth" data were collected for studies using remotely-sensed observations from satellites. In cooperation with the Center, Roswell Austin of the Scripps Institution of Oceanography Visibility Laboratory, sent G. Edwards, a senior staff engineer, to oversee the collection of observation of atmospheric attenuation, cloud patterns, ocean water optical characteristics and ocean color (chlorophyll) aboard the Jordan. Arrangements were made through the National Environmental Satellite Service (NESS) for the NIMBUS-7 coastal zone color scanner to collect data in a large region in the vicinity of the <u>Jordan's</u> area of operation during the November cruise. In addition, infra-red temperature data from the NOAA-6 satellite were collected by the Scripps Remote Sensing Facility. While the cruise was in progress radio facsimile transmissions of satellite-observed ocean fronts were made to the <u>Jordan</u> where Lynn used these observations to adjust the ship's track to obtain the best "ground truth" data.

Although processing of the data is still underway, it is evident that remote-sensing and "ground truth" data sets will reveal the in-depth significance of the surface thermal gradients observed via satellite, and the satellite findings will provide spatial continuity to the widelyspaced oceanographic observation of fronts.

The study and monitoring of ocean fronts via satellites is proving to be an increasingly effective approach as advances are made in technology and processing techniques. The consensus is that the advent of the Scripps Remote Sensing Facility is opening new vistas in the application of satellites to fishery problems.

To obtain information on ocean frontal structure associated with the North Pacific Transition Zone at a time when the nearshore albacore fishery is in progress and for use in planning the November albacoreoceanography cruise, Ken Bliss, Oceanographer at the La Jolla Laboratory, conducted oceanograhic sampling and limited albacore trolling on a cruise aboard the NOAA R/V <u>Surveyor</u> in September 1979. The cruise departed Kodiak, Alaska and a series of 1000 m conductivity-temperature-depth (CTD) observations were conducted at 30 mile spacings between 40° N and 29° N latitude along meridians 144° W and 137°30' W. Trolling operations were conducted where sea surface temperatures were favorable (14° C to 22° C). Albacore were caught to the north and northeast of the CTD area. The temperature-salinity data collected by Bliss were valuable in planning the November cruise and provided new information on the structure and development of the subarctic and subtropic fronts.

Albacore Physiology Studies

With a scientific team of marine biologists, oceanographers and medical scientists, led by Dr. R. Michael Laurs of the Southwest Fisheries Center in La Jolla, a 14-day albacore physiology cruise was conducted aboard the NOAA research vessel, <u>David Starr Jordan</u>, off the coast of southern California in late July. It was the third in a series of annual albacore "environment/physiology" cruises. Cruise participants included scientists from the Southwest Fisheries Center, the University of California at San Diego (UCSD) School of Medicine, Scripps Institution of Oceanography, the Scripps Clinic and Research Foundation, and Oregon State University.

The overall purpose of the environmental physiology research on albacore tuna is to provide a basic knowledge of the physiology of the fish and its ocean environment with the objective of understanding causal factors underlying albacore-oceanography relationships important in determining their migration, distribution and availability.

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Researchers participating on the cruise made a number of significant findings, including (1) the first simultaneous measurements that have been made in a fish of cardiac output, heart rate, blood pressure and regional blood flow; (2) successful culturing of whole blood for chromosome isolation and isolation of chromosomes for karyotyping studies; (3) measurements of thermoregulation and the effects of various drugs on the thermoregulation process; (4) blood volume measurements; (5) blood chemistry and hematology studies; (6) iron transferrin studies; (7) investigation of prostaglandins and their potential role in thermoregulation; (8) vascular anatomy studies; and (9) further developments and improvements in a lifesupport system for holding and transporting live albacore.

In addition to the physiology and biochemistry studies conducted on live albacore aboard the Jordan, oceanographic measurements were also made during part of the cruise in support of albacore acoustic tracking studies carried from the F/V, Linda, on charter to AFRF. Dr. Andrew Dizon and Lt. Al Jemison of the Honolulu Laboratory and Ron Dotson and Stephanie Revesz from the La Jolla Laboratory participated in the acoustic tracking operations. Two albacore equipped with acoustic transmitters that telemetered depth of swimming were tracked from 30 hours each and one fish equipped with an acoustic transmitter that telemetered ocean temperature at depth of swimming was tracked for 8 hours. The experiments yielded some unexpected results including the findings that the albacore tracked (1) spent most of the time in water temperatures considerably below what has been believed to be within the optimal temperature preference for albacore, (2) spent most of the time in or below the thermocline, and (3) virtually no time in the upper mixed layer. In addition, (4) one fish that appeared to be migrating continuously during the tracking showed little difference between day and night depth distribution and (5) showed less variation and less extensive vertical excursions in swimming depth than did one fish that appeared not to be migrating.

1979 U.S. Albacore Landings Low

The 1979 U.S. albacore fishery was one of the poorest on record. Landings totaled about 5,500 tons. This compares to a seasonal total for the U.S. fishery in 1978 of 18,500 tons and to the seasonal 10-year average of about 23,000 tons. There appear to be a number of factors contributing to the low landings of albacore in 1979 including (1) the late arrival of both the "northern" and "southern" substocks of fish into North American coastal waters; (2) generally weak or non-existent temperature fronts along much of the U.S. West Coast, especially off the Pacific Northwest, as the result of low coastal upwelling, causing fishing in many areas to be spotty, scattered and lasting only a few days in given locations because fish were on the move; (3) high winds and rough seas hampered fishing effort notably off central and northern California; (4) fish not biting, in particular in the Cortez Bank area and off central California; (5) low availability of 12-15 pound (5.5-6.8 kg) fish off California which normally make up a significant portion of the U.S. catch; and (6) closure of waters within 200 miles of the coast of Canada to U.S. albacore fishermen.

Extension of U.S. Albacore Jigfishing to Western North Pacific Waters

Twenty-six U.S. jigboats operated in the western North Pacific, between about 160° E and 160° W during the spring-summer months in 1979. Most vessels enjoyed very good fishing success with an average catch per vessel of 77 tons and a total production slightly over 2,000 tons.

NORTH PACIFIC BLUEFIN TUNA

Bluefin Tuna Study

Landings of North Pacific bluefin tuna have declined since the peak of 1966. To understand better this highly valued fishery, California Department of Fish and Game (CF&G) has received a contract to compile and organize existing bluefin tuna data. California Fish and Game Marine Biologist Doyle A. Hanan, has been assigned to the Southwest Fisheries Center at La Jolla and has begun to collect the data for entry into computer data bases.

Utilizing California Fish and Game and published information on tagging, tag recoveries, catch and effort, landings, number and size of boats, size and age of fish caught and fishing areas, an overview document describing and evaluating the fishery will be produced by the end of the contract.

SOUTH PACIFIC FISHERIES AGENCY

In early 1979 the South Pacific Forum appointed William Razzell as the Director of the newly created South Pacific Fisheries Agency. The Agency was organized to handle fisheries matters, especially those relating to tunas, for the Forum countries. The Southwest Fisheries Center has not had much direct contact with the Agency; to date the primary activity of the Center has been to monitor the activities of the Agency. Presently the Agency is still in the early stages of being organized. Recent reports indicate that Mr. Razzell has resigned from his post and Mr. Richard James of the Solomon Islands fisheries department has been appointed as interim Director.

CENTRAL PACIFIC -- YELLOWFIN TUNA

The yellowfin tuna, <u>Thunnus albacares</u>, resource in the Pacific Ocean was also considered at the "Workshop on the Assessment of Selected Tuna and Billfish Stocks in the Pacific and Indian Oceans," held in Shimizu, Japan, June 13-22.

The Pacific yellowfin tuna resource is assumed to be composed of east and west stocks with the possibility of a third stock in the central Pacific. Total Pacific catches of yellowfin tuna were less than 146,000 metric tons (MT) annually during 1952 to 1959. From 1970 to 1977 they ranged between 200,082 and 416,976 MT. The catch per unit effort (CPUE) in most areas fell sharply following the initial few years of fishing and then gradually declined further as effort continued to increase.

A production model analysis of eastern tropical Pacific (ETP) yellowfin tuna estimated maximum sustainable yield (MSY) to be about 160,000 MT within the Commission's Yellowfin Regulatory Area (CYRA) of the Inter-American Tropical Tuna Commission (IATTC). In the ETP yellowfin tuna fishery, recent catch levels have exceeded the estimated MSY. A continuation of the IATTC's experimental overfishing program is required to determine whether the estimate of MSY is accurate, or whether further increases in catch can be sustained.

Production model analyses have not been done for the surface and longline fisheries in the western and central Pacific. However, an analysis of the Pacific-wide longline fishery provided an MSY estimate of around 80,000 to 90,000 MT and suggested that increases in longline effort above present levels would not increase the catch appreciably. While there is a possibility that the overall yield of central and western Pacific yellowfin tuna could be increased by expanded surface fisheries, no analyses of this prospect have been done.

CENTRAL PACIFIC -- SKIPJACK TUNA

Owing to other more pressing needs, research on skipjack tuna at the Honolulu Laboratory during the past year was at a very low level of activity. Routine sampling of skipjack tuna otoliths for age and growth studies is continuing. Samples have been collected from various areas in the central and western Pacific, including samples collected through the cooperation of Dr. Robert Kearney of the South Pacific Commission, for possible comparisons of skipjack tuna growth rates in yarious areas of the Pacific.

James H. Uchiyama, Fishery Biologist, completed the revision of a manuscript which includes a description of the age and growth of skipjack tuna in the central Pacific (Uchiyama, James H., and Paul Struhsaker. Age and growth of skipjack tuna, <u>Katsuwonus pelamis</u>, and yellowfin tuna, <u>Thunnus albacares</u>, as indicated by daily growth increments of sagittae). Counts of the daily growth increments of sagittae provided the means of determining growth curves for central Pacific skipjack tuna up to 3 yr. old. The study was based on a sample of 51 skipjack tuna ranging in size from 3 to 80 cm fork length (FL). The data indicated stanzas of linear growth for skipjack tuna. Estimated daily growth rates was 1.6 mm/day for fish up to a length of about 27.0 cm, 0.8 mm/day for fish between 27.0 and 71.4 cm, and 0.3 mm/day for fish between 71.4 and 80.3 cm.

Sagittae samples were also available from 20 skipjack tuna from the eastern Pacific ranging in size from 38.0 to 65.0 cm FL. The data indicated that the eastern Pacific skipjack tuna grew at a slower rate than those in the central Pacific.

IN SUPPORT OF DOMESTIC REQUIREMENTS

WESTERN PACIFIC COUNCIL BILLFISH AND OCEANIC SHARK MANAGEMENT PLANS

Progress in developing a Billfish and Oceanic Shark Fishery Management Plan (FMP) by the Western Pacific Regional Fishery Management Council was slowed down considerably in 1979 by a pronouncement issued by Washington, D.C. of a major policy change. The Council was informed that area closures and season or gear restrictions are now legitimate options for the management of billfishes in the FCZ; however, to be acceptable such options must meet certain criteria. These criteria are that the options must have an effect of a net benefit to the Nation, provide for a reasonable opportunity for foreign vessels to fish for tuna in the FCZ, and impose the least burden on tuna fishing that will achieve the conservation and management objectives of the plan. Prior to this change in policy the Council's Billfish Planning Team had worked on the assumption that none of the tuna fishries could be controlled even if a major by-catch involved a species that was not highly migratory.

The Billfish FMP is currently being revised by the Planning Team and a new draft is scheduled to be completed by July 1980.

PACIFIC COUNCIL BILLFISH AND OCEANIC SHARK PLAN DEVELOPMENT

In May 1979 the first draft of the Fishery Management Plan for Billfish and Oceanic Shark prepared by the Fishery Management Plan (FMP) Development Team was submitted to the Pacific Fishery Management Council for their review.

The FMP development process began in early 1978 when approval for a joint development of an FMP between the Western Pacific Fishery Council and the Pacific Fishery Council was made by the Secretary of Commerce, the two fishery councils and their respective scientific and statistical committees.

In the course of the Plan development process, the FMP Development Team recently revised the management objectives and list of options for consideration by the Pacific Council for the west coast fisheries for striped marlin, swordfish, thresher, mako and blueshark. The second draft of the FMP is well underway. However, its future status is yet to be determined. In August 1979 the Pacific Council directed the FMP Development Team to delay the plan development process pending the results of a hearing scheduled before the Supreme Court of the State of California to determine California's authority to control its citizens beyond the 3 nautical mile territorial sea.

Work on the second draft of the FMP has continued. However, the final decision and further development of the FMP for Billfish and Oceanic Shark is expected to e made by the Pacific Fishery Management Council at their meeting on May 15, 1980.

Pacific - International Billfish Angler Survey

The Pacific International Billfish Angler Survey is conducted throughout the Pacific Ocean area in cooperation with the International Game Fish Association.

The 1978 survey was the 10th annual survey conducted in the Pacific area to determine the trend in billfishing in terms of catch per angler day for billfish fishing locations. The information derived from this survey is summarized by geographical areas and species caught and is "public information" available to anyone interested in the trend of billfish fishing. These data have been used by government and other organizations in the development of fishery management plans for billfish common to their countries' waters.

James Squire, Fishery Bioloigist at the La Jolla Laboratory reported that the 1978 billfish angler survey data show 14,681 angler days. The number of billfish reported captured in 1978 was 4,142, up only slightly from 4,040 fish in 1977. The overall billfish catch rate (fish per angler day) for 1978 was 0.28 or 3.54 days fishing per fish. This is slightly less than that observed in 1977 (0.36 fish per day, 2.7 days fishing per fish) and continues to be well below the 1969-1972 average of 0.55 fish per day and of 1.80 days fishing per fish.

Sailfish

The trend of CPUE for the major sailfishing area in the eastern Pacific (Acapulco) shows a slight increase in recent years. The catch trend in Mazatlan is slightly downward when compared to that observed for Acapulco. Recent correspondence with Sr. Hector Zurita, Instituto Nacional de Pesca Billfish Biologist at Acapulco, indicated that a CPUE of 1.0 fish/day was recorded in 1979.

Striped marlin

The CPUE for striped marlin in the major fishing area (tip of Baja California) is down from the levels observed in the early 1970s. This decline parallels the decline in CPUE observed for the longline fleet operating off Baja Califoria. It appears that the southern Califoria fishery, being a "fringe distribution" fishery which operates upon the North Pacific stock, appears not to be affected by the reduction in CPUE observed off the lower tip of Baja California, Mexico.

Blue marlin

Graphic data for blue marlin catches off Hawaii are included for the first time and indicate current catch rate of about 0.2 fish per day.

Black marlin

Black marlin CPUE data indicates a peak in the period of 1970-1973, with an overall average of about 0.65 days per fish 1974-1978.

Eastern Pacific - Southern California Commercial Swordfish Fishery Recreational Striped Marlin Fishery

Swordfish

Swordfish landings in California were down from the record catch of 14,000-15,000 fish in 1978. Preliminary estimates indicate about 2,800 swordfish were landed in 1979 - only 19% of the number caught in 1978. The long-term average catch is about 4,500 fish per year so the 1979 catch was only 62% of average.

The at-sea sampling program was continued in 1979. During the early part of the season (July-August), samplers were placed aboard harpoon boats. However, few fish were observed and sampled. Samplers were shifted to shark gillnet boats and swordfish were taken and sampled as incidental catches to thresher, mako and blue sharks. The harpoon fishery made catches starting late in the season.

A substantial but unknown amount of swordfish was landed by shark gillnet boats in 1979. Shark drift gillnetters recorded swordfish catches as early as May 1979 and catches increased in August and September. Indications are that 1979 may have been a year of low surface availability and the catches of gillnets would indicate that swordfish are available subsurface when not available to the harpoon fleet which relies on the observation of surface swimming fish.

Striped marlin

Striped marlin landings by the recreational fleet off southern California totaled 1,017. The long-term average is about 800 fish; the 1979 catch, therefore, was about 217 fish above average.

Pacific - Cooperative Marine Game Fish Tagging

Since 1954, billfish have been tagged by cooperative marine game fish tagging programs in many of the major sportfishing areas of the Pacific. The marine game fish tagging program is currently supported by the National Marine Fisheries Service in cooperation with the International Game Fish Association.

James Squire, Fishery Biologist at the La Jolla Laboratory, coordinates the tagging program and reported that in calendar 1979, 989 tag report cards were received. This was 65 fewer tag cards than received in 1978. One of the reasons for this reduction is that in 1979 most of the black marlin tagged off North Queensland, Australia are being tagged with equipment supplied by New South Wales Fisheries, Sydney, New South Wales, Australia. In 1979 only 55 tag cards for black marlin were received at La Jolla, a marked reduction from the 248 received in 1978 and 339 in 1977.

The total number of tag cards received at the Center in 1979 was 989. Additional black marlin were tagged off North Queensland, Australia; Mexico's Instituto Nacional de Pesca has also been cooperating and a number of sailfish have been tagged under the direction of Sr. Hector Zurita B. off Acapulco, although the precise number is not known at this time.

Cooperating anglers tagged and released 563 striped marlin (<u>Tetrapturus</u> <u>audax</u>) comprising 72% of the total billfish tagged. Tag totals and percentages for the other billfish species are: black marlin (<u>Makaira indica</u>) 57 tagged (7%); sailfish (<u>Istiophorus platypterus</u>), 145 tagged (19%); blue marlin (<u>Makaira nigricans</u>), 12 tagged (2%); swordfish (<u>Xiphias gladius</u>), 1 tagged (0.1%); and shortbill spearfish (<u>Tetrapturus augustirostris</u>), 1 tagged (0.4%).

Anglers will note the increased tagging of fish in New Zealand. The big game species of mako shark are being tagged in increasing numbers. The New Zealand Ministry of Agriculture and Fisheries through their representative Peter Saul who is stationed in Whangarei, New Zealand, has increased cooperative tagging activity for several of the game fish species. The oceanic shark species, such as the mako have shown that a substantial recovery rate can be expected from the domestic and foreign distant water longline fishery. Preliminary indications are that the total return rate for 213 mako sharks reported tagged is 4.2%. With a large number (127) reported tagged in 1979 the recoveries are expected to increase.

According to Squire, increased tagging throughout the major distributional range of each billfish species would provide better information on the seasonal migrations and the level of interchange between geographical areas and stock boundaries hypothesized for the six different species common to the Pacific (striped, blue and black marlin, sailfish, shortbilled spearfish and swordfish). To date much of the billfish tagging has been centralized in two areas of the Pacific, about the tip of Baja California, Mexico and Off the great Barrier Reef, North Queensland, Australia for two species, striped and black marlin. Increased tagging effort is needed in other areas of the Pacific to assist in filling in gaps of knowledge concerning the migration of marlin and swordfish.

A total of 9 billfish was reported recovered in 1979, down 17 from the number recovered in 1978. Recoveries by species totaled 4 striped marlin, 3 blue marlin and 2 black marlin. In 1979 fewer black marlin tags were recovered than in 1978 (2 vs 9) and no swordfish were tagged or recovered off southern California in 1979. In 1978, 6 swordfish were recovered off this area.

The first recovery of a blue marlin tagged off Hawaii was recorded in 1979. On August 22, 1977, angler Linda Audionel of Laguna Niguel, California and charter boat Captain Bobby Brown, Kailua-Kona, Hawaii, tagged a blue marlin off Keahole Point, Hawaii. This marlin was recovered almost 2 years later 1-1/2 miles off Keahou Point, near the point of tagging, by angler Mike Holtz of Kailua-Kona, Hawaii. Fifty-two blue marlin were tagged off Hawaii in 1977 and about 1/2 of these wre tagged from the boat of Captain Bobby Brown.

Two additional blue marlin were recovered from tagging off Rancho Buena Vista, Baja California Sur, Mexico and recovered a short time later by a Japanese longline vessel. These three recoveries are the first recoveries for blue marlin tagged in the Pacific. IN SUPPORT OF OTHER DOMESTIC REQUIREMENTS

TUNA/PORPOISE PROBLEM - MARINE MAMMAL PROTECTION ACT OF 1972

Purse seine fishing for yellowfin tuna in the eastern tropical Pacific often involves porpoise found in association with yellowfin tuna. This association is used by tuna fishermen, who pursue and capture the porpoiseyellowfin tuna complex, and then release the porpoise from the net while retaining the yellowfin tuna. During this fishing process, incidental mortality of porpoise occurs.

Available information indicates that purse-seine fishermen used this technique as early as 1959, and that prior to that the baitboat fleet also utilized this association although without incidental mortality of porpoise. In the mid-1960's the Bureau of Commercial Fisheries, predecessor of the National Marine Fisheries Service, conducted limited research to document the situation and to collect data on the mortality and stocks involved. After the passage of the Marine Mammal Protection Act (MMPA) in 1972 substantial research efforts were mounted at the Southwest Fisheries Center in La Jolla, California to assess the status of the stocks and to develop procedures for reducing the incidental mortality and serious injury of porpoise.

The following is an account of the highlights of research conducted at the Southwest Fisheries Center during the past year in support of the MMPA.

Status of Porpoise Stocks Workshop

The first workshop on stock assessment of porpoise (interchangeable, dolphins) involved in the eastern tropical Pacific (ETP) yellowfin tuna fishery was held by the National Marine Fisheries Service (NMFS), Southwest Fisheries Center (SWFC), in July 1976. Management actions have been promulgated based on the results of that workshop, and the incidental mortality of porpoise involved in the fishery has been reduced as improvements in gear and fishing techniques have been introduced. The NMFS management procedures have consisted of gear regulations, reduction of an annual basis of the quotas on the allowable kill of each stock, and an increased number of "porpoise observers" who accompany tuna purse seine fishing vessels. Research studies recommended by the participants in the 1976 workshop on the population biology of the porpoise stocks have been undertaken, and since 1978 the Inter-American Tropical Tuna Commission (IATTC) has initiated a research program, including placing observers on the international fleet of purse seiners in 1979.

With expiration in 1980 of the current 3-year management regime, NMFS must propose a set of regulations to govern the U.S. tuna purse fishery in 1981 and possibly beyond. The NMFS-SWFC, therefore, organized a workshop of experts in population dynamics, with special emphasis on large mammals, to reassess the condition of the porpoise stocks involved in the eastern tropical Pacific yellowfin tuna fishery. The workshop was held August 27-31, 1979, at the SWFC, La Jolla, California, and was chaired by Dr. Tim Smith, Fishery Biologist at the La Jolla Laboratory. A number of documents were prepared by staff members of the Oceanic Fisheries Resources Division for the Status of Porpoise Stocks Workshop.

Drs. R. Holt, Operations Research Analyst, and J. Powers, former Leader of the Marine Mammal Assessment and Monitoring Program, completed a working document detailing the estimation of current abundance of porpoise populations. The estimates are based primarily on aerial and research vessel surveys conducted in 1977 and 1979, and secondarily on information from tuna vessel observations. The abundance estimates are generally lower than those used previously (which were based on 1974 field work), and represent a substantial improvement in methodology and sample size. Principal areas of improvement in methodology include photographic validation of visual school size estimates, and direct estimation of perpendicular distances of schools from the flight path.

Drs. N. Lo, Statician, and T. Smith, Fishery Biologist, completed a working document, "Estimation of incidental mortality of porpoise associated with the yellowfin tuna purse seine fishery, 1959-1972." The paper reestimates incidental mortality of offshore spotted and eastern spinner dolphin from 1959-1972. Lo and Smith drew information from several previously unused porpoise kill observations made in the 1960s. The new incidental kill estimates are generally lower than similar ones made during the 1976 workshop. The paper describes the statistical properties of the new estimates, and includes an estimation of the variances and covariances of all of the 14 annual estimates for each porpoise population.

Fishery Biologist Eric Barham completed a working document, "<u>Grampus</u> <u>griseus</u>: A possible index form for aerial surveys of dolphin populations," which analyzes aerial and shipboard sighting data for <u>Grampus</u> <u>griseus</u> as a possible useful reference-species for strengthening the estimates of other species. Barham's paper provides a description of the data and procedures, and reviews some density estimates.

Operations Research Analyst David Au, Supervisory Fishery Biologist William Perrin, and NOAA Officer Lt. Wayne Perryman completed a working document, "Dolphin distribution and the relationship to environmental features in the eastern tropical Pacific," which describes the historical ranges of the several porpoise populations, based on past sighting records and oceanographic features of the eastern tropical Pacific. The paper states that the boundaries for many of the stocks have changed, and describes centers for new stocks.

Dr. William F. Perrin, Supervisory Fishery Biologist, and John R. Henderson, Fishery Biologist, completed three reports for the workshop on the life history and gross annual production of various porpoise stocks. One of them, "Growth and reproductive rates in two populations of spinner dolphins, <u>Stenella longirostris</u>, with different histories of exploitation," is particularly relevant, as porpoise stock assessment in the past has been based upon a model of density-dependent change in net reproductive rate. The eastern spinner dolphin population is estimated to be at a lower fraction of original size than is the population of whitebelly spinner dolphins. Higher reproductive rates would be expected in the former than in the latter on the basis of the density-dependence model. The manuscript reports that, based on analyses of over 4,000 specimens collected through 1978, 1) there is a relative paucity of fully adult males in the eastern population (possibly indicating lower average fertility), 2) the eastern spinner female attains sexual maturity about one tooth-layer unit (probably one year) earlier than does the whitebelly spinner, 3) ovulation rate and pregnancy rate in young females are lower in the eastern population (possibly because of the low number of fully-adult males), and 4) the proportion of all females which are sexually mature is lower in the eastern population (possibly indicating a shift in age structure toward younger animals). Gross annual reproductive rates are not different in the two populations (about 8-10% in both cases), and the results of the comparison do not confirm the assumption of densitydependent increase in gross reproduction.

Manuscripts were also prepared for the workshop by Fishery Biologist Warren Stuntz on unobservable stress-related mortality of dolphins in the tuna fishery, and by Fishery Biologist Jacqueline Jennings, who reported on preliminary results of tag returns from a tagging experiment in the eastern tropical Pacific in October 1978.

Based on better and more abundant data than in 1976, the workshop participants concluded that the stocks of eastern spinner dolphin, <u>Stenella</u> <u>longirostris</u>, and the northern offshore spotted dolphin, <u>S. attenuata</u>, were below the optimum sustainable population levels as stipulated by the Marine Mammal Protection Act. The final workshop report, edited by Dr. T. Smith, made it clear that this conclusion should not be interpreted as meaning that the stocks are continuing to decrease because of fishing mortality, but that the result is based on new data and improved methods of estimating the abundance of dolphins. According to the analyses done during the workshop, most of the reduction in the porpoise population occurred prior to 1975.

The new assessment is being used in formulating new regulations for the tuna purse-seine fishery. These regulations are expected to go into effect sometime during 1980 following a series of public hearings and other decision-making steps which are presently underway.

Marine Mammal Research at the La Jolla Laboratory

Research at the La Jolla Laboratory devoted to the problems of conflicts between fisheries and marine mammals is supervised by Dr. William Perrin, Leader of the Marine Mammal Biology and Technology Program and by Dr. Tim Smith, Leader of the Marine Mammal Monitoring and Assessment Program. Ongoing research by staff members include estimating growth and reproductive parameters, research to develop improved porpoise rescue gear and methods, development of better research tools, monitoring of the incidental kill and assessment of the condition of the stocks involved in the fisheries. Some highlights of research during the past year are as follows:

Development of a computer-based simulation model model of the purse seining operation

Experimental gear research is very expensive because of the high cost of vessel charter. An innovation that can lead to reducing the cost is being pursued in development of a computer-based simulation model of the seining operation. The purpose of the simulation model is to permit screening and

development of ideas for gear modification before they are taken to sea. The model is being developed under contract by Scientific Applications, Incorporated and will be completed during 1980.

Documentation of marine mammal/fisheries conflicts

The California Department of Fish and Game is under contract to the Southwest Fisheries Center to gather data on direct conflicts between marine mammals and California fisheries. The types of conflicts include damage to the catch, damage to gear and incidental kill of marine mammals. Emphasis during the first year of the proposed 3-year project has been on understanding the conflict within the salmon fisheries of northern California. Data are being collected both directly and indirectly by interviewing fishermen. Emphasis in the second year will be on gillnet and purse seine fisheries of southern California.

Development of a satellite-based tracking system for porpoise

Because of the large area involved in the purse seine fishery for yellowfin tuna associated with porpoise in the eastern tropical Pacific and because of the seasonal shifts of fishing effort between areas, several important questions concerning the home ranges and seasonal movements of porpoise populations remain unanswered. To allow observation of movements over long periods of time, a satellite-based tracking system is being developed in collaboration with the National Fisheries Engineering Laboratory in Bay St. Louis, Mississippi. The problem of attachment of the radio transmitter to the porpise has been solved, and a prototype transmitter has been designed. Field tests of the system, using NIMBUS 7, will begin in about a month. If the tests are successful, it is planned to place about 30 transmitters on animals in the eastern tropical Pacific, mainly to examine the question of the stock affinities of spotted dolphins fished seasonally south of the equator.

Marine mammal salvage

As part of the effort to assess interactions between marine mammals and fisheries, information is being collected that will allow assessment of the stocks of marine mammals in California waters. Stranded marine mammals are valuable sources of data on growth, reproduction, feeding habits, sources of natural mortality, seasonal movements, and mortality in fishing operations. The program staff has organized a marine mammal salvage program in cooperation with the Scripps Institution of Oceanography, the San Diego Zoo, Hubbs/Sea World Research Institute, Naval Ocean Sciences Center, and the Autonomous University of Baja California in Ensenada. A contract is also being negotiated for necropsies to determine causes of death of retrieved beached animals.

Porpoise age determination

A continuing problem in studies of porpoise growth and reproduction has been the uncertainty associated with estimating age from layers in the teeth. Considerable resources have been focused on this problem with the objective of developing a satisfactory method of age determination. At this time, the group has arrived at a much-improved method of preparing and reading teeth has been developed. The problem of calibrating the readings is now being tackled. Dr. A. Myrick, in charge of the project, has attacked this problem by <u>in vivo</u> studies of tooth growth. Tetracycline compound has been injected into several hundred tagged animals and released on the fishing grounds. Several captive animals at Sea World in San Diego and Sea Life Park in Hawaii have also been injected with the compound. Teeth are being extracted from the captive animals at regular intervals to monitor formation of layers, and notices have been released to obtain teeth from tagged animals that are killed by the fishery.

Workshop on capture stress

Of major concern to managers of large terrestrial mammals is a syndrome called, "capture myopathy," in which animals develop severe symptoms and often die several days after being chased and captured. Because of concern that this might be happening in porpoise chased and captured in the tuna fishery, a workshop was held on this subject at the Southwest Fisheries Center in La Jolla in May 1979. The invited participants included veterinarians, pathologists, game managers and zoologists. The workshop participants concluded that not enough is known about the physiology and pathology of porpoise to permit evaluation of physiological stress or pathology imposed by the fishing operation. They also concluded that the stress-related incidental mortality rate, if it exists, is probably very small. It should be pointed out, however, that even a very low rate (1%, for example) would be highly significant because of the very large numbers of porpoise chased and captured in the fishery. Further research is planned on this problem.

Porpoise Life History Data Base Augmented

Specimens and data for an additional 2,159 porpoise were processed and the data integrated into an automated data base. Data are now on hand for approximately 24,000 porpoise from the tuna fishery, collected during 404* cruises.

Progress has also been made in developing computer programs for editing the data and for generating summary tables and reports and plots. The data base is utilized in studies of growth and reproduction, in systematics studies of geographical variation and differentiation of potential management units, and in studies of age structure and mortality rates.

Studies of Growth and Reproduction

In preparation for the Status of Porpoise Stocks Workshop held at the Southwest Fisheries Center in August 27-31, updated estimates of reproductive parameters were prepared for several species and stocks, including the northern and southern stocks of the offshore spotted dolphin (<u>Stenella</u> <u>attenuata</u>), the eastern, northern and southern whitebelly stocks of the spinner dolphin (<u>S. longirostris</u>), and several stocks of the common dolphin (<u>Delphinus delphis</u>) and the striped dolphn (<u>S. coeruleoalba</u>). The reports containing these analyses are being prepared for publication.

*Includes only cruises on which porpoise were processed.

Studies of Stock Identification

Several projects are underway to examine the questions of stock differentiation and boundaries. The University of Oklahoma is under contract to re-examine geographical variation in the large amount of morphological specimens and data now available. Utah State University is assessing the potential of using chromosomal morphology in defining populations. Long Beach State University has a contract to evaluate the use of parasite faunas as population markers. These contracts will all be completed and the results evaluated in 1980. The results may lead to new or different specimencollecting efforts in the observer program.

Porpoise Population Abundance Estimation

Between January and April 1979, the NMFS conducted an extensive aerial and ship survey of marine mammal populations in the eastern tropical Pacific (ETP) Ocean. Over 32,000 miles were flown while completing 20 survey flights. A total of 387 marine mammal sightings were recorded which included 288 dolphin, 98 whale and 1 unidentified marine mammal schools. Two research vessels, the R/V David Starr Jordan and R/V Townsend Cromwell searched approximately 60 days each in the eastern tropical Pacific. Together they searched 591 dolpin and 175 whale sightings. An ad hoc workshop consisting of recognized experts in survey analysis methods was convened by Drs. R. Holt and J. Powers of the SWFC in June 1979 to make recommendations for the analysis of the data. The resultant population abundance estimates formed an integral part for the assessment of the status of porpoise stocks which are incidentally taken by the tuna purse seine fishery. A committee of internationally recognized experts, convened by Dr. T. Smith of SWFC, concluded that two stocks - the eastern tropical whitebelly spinner and the northern offshore spotted dolphin - were below the range of their optimum sustainable population size.

Analysis is proceeding with results from the 1st coastal marine mammal cruise of the R/V <u>David Starr Jordan</u> (September 27-October 24, 1979). It is apparent that temperature, salinity, and chlorophyll can be used to delineate and describe the complex spatial distribution of the coastal water mass overlying the continental slope, and that certain cetaceans are influenced by the distribution of this surface water mass. For example the common dolphin (<u>Delphinus delphis</u>) tended to be seen in warmer oceanic waters north of Cape Conception while occurring throughout the complex coastal water streams in the Southern California Bight. Most cetaceans were seen in coastal water which often extended in complex swirls seaward of the continental slope. These results indicate that mesoscale features may delineate the habitats of coastal marine mammals, and that coastal disturbances may affect mammals to the degree that they co-occur in the same water mass.

The NOAA research vessel, <u>David Starr Jordan</u> and the <u>Townsend Cromwell</u>, were involved in a survey to measure porpoise density gradients within the eastern tropical Pacific. The vessels which departed their respective home ports, San Diego and Honolulu on January 3, 1980, surveyed areas of the habitat of tropical porpoise north of the equator and to about 150° W for 63 days. The distribution of sightings indicated that west of 110° W, spotted and spinner porpoise were narrowly concentrated along the thermal ridge at latitude 10° N.

Other projects underway or recently completed under contract include:

- 1. A study of porpoise behavior in the tuna seine (Karen Pryor).
- 2. A study of behavior and social structure in wild spinner porpoise schools (University of California, Santa Cruz).
- 3. Summary and analysis of available data and specimens of bottlenose dolphin (<u>Tursiops truncatus</u>) in the eastern Pacific (Los Angeles County Museum).
- 4. A study of the population biology and growth and reproduction of the Pacific white-sided dolphin (<u>Lagenorhynchus obliquidens</u>) in the North Pacific (Hubbs/Sea World Research Institute).
- 5. A review of information available on strandings of marine mammals along the U.S. west coast prior to 1966 (Los Angeles County Museum).
- 6. Pathology of porpoise killed in the fishery (University of Texax Medical School).
- 7. Investigation fo the potential of amino-acid racemization analysis for age determination (Scripps Institution of Oceanography).
- 8. Testing of various tags and tag materials on captive porpoise (Hubbs/Sea World Research Institute).

SOUTHWEST FISHERIES CENTER WORKSHOP ON TUNA RESEARCH PLANNING

The Southwest Fisheries Center's Workshop on Tuna Research Planning was held at the San Clemente Inn, San Clemente, California on September 11-13, 1979. The purpose of the Workshop was to review the situation regarding a number of tuna and billfish stocks of importance to the U.S. and to improve the Center's near-term and long-range tuna research plans.

Participating in the Workshop were 22 persons, including 19 from the Center, 2 from NMFS, Southwest Regional Office, and 1 from the NMFS Office of Science and Environment, Washington, D.C.

The staff of the Southwest Fisheries Center presented 13 Situation Reports which evaluated the status of stocks of the world tuna fisheries, and outlined the research efforts and needs for 23 of the world's tuna stocks.

Pacific, Atlantic and Indian Ocean tuna stocks of major significance and future potential to the United States were all reviewed.

A summary of the Situation Reports presented to the Workshop is as follows:

Pacific Tunas

Recent analysis of status in relation to ongoing fishing effort shows that the status of stocks of central and western Pacific yellowfin are still unknown. It appears that exploitation of skipjack tuna can be safely expanded but that catches of yellowfin in the eastern tropical Pacific and albacore in the South Pacific are already at or near maximum sustainable yields.

North Pacific Albacore

The Pacific albacore population is assumed to be composed of two major stocks, one north and another south of the equator. In the North Pacific fishery, the general trend in atch from 1961-1977 was upward. The North American fishery catches from 1961-1977 average slightly more than 20,000 MT and were fairly stable until 1977 when a low catch of 12,000 MT was recorded. The ex-vessel value of the albacore catch averages \$126 million per year from 1973-1977 with the U.S. fishery receiving \$25 million per year over the same period. Currently, there are no fishries management regulations in force for North Pacific albacore.

The U.S. has a domestic fishery operating on the North Pacific albacore stock. Imports of albacore far exceed the domestic caught supply and some of these imports come from the North Pacific albacore stock.

Currently, most of the research on the North Pacific albacore stock is conducted by NMFS, La Jolla and the Tohoku and Far Seas Fisheries Research Laboratories, Japan. The data quality is generally good with longline catch and effort data very good, especially for later years.

Using conventional techniques, the production model analyses indicte that a conservative estimate of MSY is 125,000 MT.

Among data and research needs, the recent Fourth North Pacific Albacore Workshop (see page 8) pointed out that those recommendations leading to stock assessment research which should receive emphasis are age structure based models. Concurrent environmental research should emphasize investigations into quantifying key oceanographic processes and parameters affecting vulnerability and availability and their effects on catch per unit of effort measures.

Because of the importance of the North Pacific albacore stock to U.S. fishermen and the current low level of reliability of estimates, the need is evident for increased management-related research.

Atlantic Tunas

Recent catches (circa-1977) compared to estimated maximum sustainable average yield (MSAY) for seven stocks of Atlantic tunas indicates that opportunities for significant increases in catch may be possible only for the western stock of Atlantic skipjack (figure on following page).



SUMMARY OF SITUATION REPORTS ATLANTIC TUNAS

Indian Ocean Tunas

None of the tunas in the Indian Ocean is under management and at this time no management plans are contemplated for any of the Indian Ocean tunas.

Research on Indian Ocean tunas, caught by longline, has been conducted mainly by the Far Seas Fisheries Research Laboratory; production model analyses on Indian Ocean albacore, bigeye tuna and yellowfin tuna have been completed at the Southwest Fisheries Center's Honolulu Laboratory; systematics, biology and fishery biology are conducted at the Central Marine Fisheries Research Institute, Mandapam Camp, India, and at the Fishery Research Station, Sri Lanka.

American interests are not currently directly involved in fishing in the Indian Ocean; the importance of the area is as a potential source of supply of tuna for such U.S. competitors as Japan.

Although the U.S. has no present direct stake in the Indian Ocean tuna fisheries, the Southwest Fisheries Center will continue to monitor the Indian . Ocean tuna situation for potential U.S. involvement

Pacific Billfish

Centers of fishery activity for the various species are: Mexico, New Zealand, and California for striped marlin; Hawaii, Tahiti, and Guam for blue marlin; and Australia and Chile for black marlin. The major commercial fisheries for the three species are conducted by the longline and harpoon fishermen of Japan, Taiwan, and Korea. American participants are the commercial longline fishermen of Hawaii and recreational fishermen primarily .from California, Hawaii, and Guam.

The 1976 catches of these three species in the Pacific were: 17,032 MT of striped marlin; 14,813 MT of blue marlin, and 3,182 MT of black marlin. The Japanese longliners have by far the largest catch of marlins of the countries fishing for them. The prices from January 1978 to May 1979 show striped marlin to be the most valuable of the three species.

The marlins are under no management scheme at present. U.S. interest is primarily recreational, although the commercial aspects are not ignored.

Based on steadily decreasing CPUE with increasing fishing effort, the blue marlin stock is judged to be overfished. If the striped marlin is assumed to be two stocks, the picture for the North Pacific stock is unclear while the South Pacific stock is being fished at about optimum level. A meaningful evaluation of the stocks of black marlin is not feasible.

The current population assessments were based on incomplete catch and effort data for three species; all assessments need improvement, particularly those for black marlin.

Data, research and management needs are more urgent for the blue marlin because of its apparent overfished condition. Restrictive regulations may be needed to manage the blue marln properly. Presently no management measures appear to be necessary for striped marlin. There is uncertainty about the need for management of the black marlin.

The total annual value in the form of canned products to the U.S. of catches and imports from these stocks of tuna is \$1,288,000,000. To help put this value into perspective, it should be realized that the \$1.3 billion figure represents about 35% of the annual total revenue and expenditures of the states of Maryland or Massachusetts and nearly 100% of the annual revenue and expenditures of the states of Hawaii or Arkansas. Annual values (1978) of tuna catches and tuna imports included in the above figures are:

	canned imports	\$65	million
•	fresh frozen imports	\$327	million.
•	domestic landings	\$240	million

Authors presented highlights of these reports to the Workshop and solicited questions and comments from the group. The Workshop concentrated on the stock assessment and fishery evaluation aspects of the Center's tuna research program, but some time also was devoted to a discussion of the tuna environment interaction.

On the basis of these reports and discussions, the Center Director, Director of the Honolulu Laboratory, and the Chief of the Oceanic Fisheries Resources Division, constituting the Tuna Program Board, made a number of important decisions regarding future program emphasis and direction of tuna research at the Southwest Fisheries Center.

Behavioral Thermoregulation Studies on Yellowfin Tuna Continue

Dr. Andrew E. Dizon, Leader, experimental Ecology of Tunas Task, and Research Assistant Martina K. K. Queenth continued to collect temperature preference data from small yellowfin tuna, <u>Thunnus albacares</u>. To date, four yellowfin tuna, approximately 40 cm FL have been tested in the thermoregulation tank complex which is designed to measure the temperature preference of test animals. This system allows the test subject, after a minimum training period, to control its environmental temperature by swimming between two adjacent tanks connected by a 30- x 30-cm hatch. If the fish is in the fish stations itself in the cooler of the two, the temperature drops at -1° C/hour. By movement between tanks, the test subject can drive its environmental temperature either up or down.

The initial fish (A) adapted quickly to the tank system, fed well, and learned to swim through the small hatch. After the initial familiarization period of 1 week, the fish was allowed to "take control" of its environmental temperature. It demonstrated a surprisingly accurate but high tank temperature preference centered around 27° C. The next two fish would not adapt to the tank complex; one would not feed and the other refused to pass through the hatch. The fourth fish (D) adapted satisfactorily and then controlled its tank temperature at around 27° C, but without the precision of fish A. To statistically test the mechanism of thermoregulation, the tank situation was modeled to simulate a fish which was moving randomly between the tanks in the system without regard to temperature. Temperatures in the model would still rise and fall at 1° C/hour depending on the tank the hypothetical fish was in, but the timing of the movement would be independent of the temperature. This is a typical "gambler's ruin" situation where ruin would occur when the upper or lower lethal temperature was reached. The rationale was that a fish in the test system would quickly cause the temperature to drift to one of these limits and would die.

However, in the computer simulation, fish were still able to keep the temperature of the tank complex between the "ruin" points even though they were moving from side to side without any temperature bias. All this required was a certain level of activity - about 5 minutes between passes. In fact, the simulation showed that 10 out of 1,000 fish moving at about 5 minutes between passes maintained modeled tank temperatures with equal or greater precision as the first fish. Dr. Dizon and Ms. Queenth have not had a chance to examine the data from the fourth fish (D) as yet. Tests of several fish should reveal whether, in the real situation, fish are timing their passes from one tank to the other on the basis of temperature cues or are just moving randomly.

Captive Tunas Induced to Spawn in Experimental Tanks

Dr. Calvin M. Kaya, a visiting scientist from Montana State University, successfully induced two kawakawa, <u>Euthynnus affinis</u>, to spawn during June-July 1979 in experimental tanks at the Honolulu Laboratory's Kewalo Research Facility. The experimental procedure to induce spawning involved periodic biopsies on the fish to monitor the development of eggs in the ovaries of the females. Because the kawakawa, like other tunas, is highly active, special handling procedures had to be developed in immobilizing the fish to conduct the biopsies. Once these techniques were perfected and the biopsies showed that the fish were ready for hormone treatments, Kaya and his assistants began injecting various hormones into the muscles of male and female fish. Following two separate injections of hormones a day apart in mid-June, a female kawakawa spawned in the holding tank. The second female receiving a similar treatment in early July spawned on July 4. Eggs stripped from the second kawakawa were successfully fertilized by mixing them with milt from a ripe male.

The first cleavage divisions in the fertilized eggs were observed about an hour later, and first hatching of larvae were observed about 31 h after fertilization (water temperature 21.1°-26.3° C). With the limited facilities for maintaining the developing embryos, it was possible to sustain only a small fraction of the fertilized ova. About 300 larvae hatched out in glass containers and these continued developing and absorbing their yolk sacs over the next 2 days. No attempt was made to feed the larvae and all were dead by the third day following hatching. Although quantitative estimates have not yet been made, it appears that the number of ova stripped from the female exceeded 50,000 and the number collected in the strainers, which sample about half of the outflow water from the spawning tank, may have exceeded 200,000. With this second successful induced spawning in as many attempts, it appears that the technique can be developed into a routine procedure.

• PUBLICATIONS

SWFC PUBLICATIONS ON TUNA AND TUNA-RELATED SUBJECTS

APRIL 1, 1979 to MAY 1, 1980

PUBLISHED

Barham, Eric G., Jay C. Sweeney, Stephen Leatherwood, Robert K. Begg and Cecilia L. Barham. 1980. Aerial census of the bottlenose dolphin, <u>Tursiops truncatus</u>, in a region of the Texas coast. Fish. Bull. U.S., 77(3):585-595.

On five replicate aerial surveys in late March 1978, the bottlenose dolphin, Tursiops truncatus, herds were sighted and their numbers estimated in 21 strip transects flown across bays and channels between barrier islands and the coast from Port Aransas northeast to Matagorda, Texas. The transects were spaced at 4.63 km intervals and herds were scouted in about 800 m wide strips totaling 436 km in length, providing approximately 17% coverage of the area. On surveys 1-4 (survey 5 was excluded from population calculations because it was conducted in adverse weather) 133 bottlenose dolphin herds were sighted, containing an estimated 916 animals. Within these strips the mean herd size was 6.95 animals and mean herd density was 0.0947/km², extrapolating to a population estimate of 1,319 dolphins and a density estimate of 0.752/km² for the entire area. These figures are relatively high in contrast to recent studies in other environments. About half the herds were feeding and approximately one-third were traveling. Sightings were most frequent in ship channels, shallow areas inside barrier islands, and near shore. There were several sources of bias in our measurements, and we consider the results to be conservative.

- Brill, Richard W. 1979. The effect of body size on the standard metabolic rate of skipjack tuna, <u>Katsuwonus pelamis</u>. Fish. Bull., U.S. 77(2):494-498.
- Brill, Richard W. and Andrew E. Dizon. 1979. Effect of temperature on isotonic twitch of white muscle and predicted maximum swimming speeds of skipjack tuna, <u>Katsuwonus pelamis</u>. Environ. Biol. Fish. 4:199-205.

Latent period, rise time, contraction time, and half relaxation time from isotonic contractions of isolated white muscle samples from skipjack tuna, <u>Katsuwonus pelamis</u>, were determined at 20°, 27° and 34° C. These parameters were found to be inversely proportional to temperature ($Q_{10} = 1.47$, 1.67, 1.62 and 1.72, respectively). The data show that contraction time and the effect of temperature on contraction time of skipjack tuna white muscle are not unique when compared to other equal-sized teleosts. Based on contraction time, maximum swimming speeds at each muscle temperature were calculated and found not significantly to exceed the maximum speeds of other equal-sized teleosts, when comparisons are made at the same white muscle temperatures. . 1979. Red and white muscle fibre activity in swimming skipjack tuna, <u>Katsuwonus pelamis</u> (L.). J. Fish. Biol. 15(6): 679-686.

To test the hypothesis that white muscle fibre portions of the myotomes are used at sustainable swimming speeds, skipjack tuna, <u>Katsuwonus pelamis</u>, were forced to swim against various current velocities in a water tunnel while electrical activity of the red and white muscle fibres was simultaneously recorded. Eight fish were tested, five fish graded white muscle fibres into activity at swimming speeds above their minimum hydrostatic equilibrium speed, but well below the estimated maximum sustainable swimming speed of skipjack tuna. Three other fish showed white muscle fibre activity at minimum swimming speeds, a possibly abnormal condition.

Dizon, Andrew E. and Richard W. Brill. 1979. Thermoregulation in tunas. Am. Zool. 19;249-265.

Because tunas possess countercurrent vascular pathways serving the trunk musculature, metabolic heat is retained, and muscle temperatures can considerably exceed that of the surrounding water (+1° to +21° C). And because tunas have this excess, it is reasonable to suppose they have some means of controlling its magnitude. Tunas must contend with two exigencies which can perturb body temperature: changes in water temperature and, in contrast to nonthermoconserving fish, changes in activity. Both can be met by adaptive change in excess muscle temperature. If this could be accomplished in the absence of changes in environmental temperature or activity level, this would constitute physiological thermoregulation. If excess muscle temperature cannot be altered sufficiently to acceptable levels, more favorable environmental temperatures must be sought or activity levels changed. We would consider this behavioral thermoregulation. High sustained swim speeds, characteristic of the continuously swimming tunas, require special consideration. Heat production is proportional to approximately the cube of swim speed. In order to maintain a slight temperature excess at basal swim speeds (1-2 lengths/sec), and yet not overheat during sustained high speed swimming (>4 lengths/sec), mechanisms are required to conserve heat under the former conditions and to dissipate it effectively under the latter. In this report, we review published observations other investigators have interpreted as physiological thermoregulation in tunas, describe recent findings in our laboratory, and suggest some possible thermoregulatory mechanisms.

albacares. Physiol. Zool. 52:581-593.

To determine their capacity for thermoregulation, yellowfin tuna, <u>Thunnus albacares</u>, were subjected to a series of 12-h periods at T_a 's of 20, 25 and 30 C. Muscle temperature, measured with an ultrasonic transmitter attached to the fish, and swim speed were simultaneously monitored. No relationship was found between speed and muscle temperature, although metabolic heat production is exorably linked to the former. Because both direct and inverse muscle temperature/heat production relationships were observed, and because physical (as opposed to physiological) explanations for our data can be discounted, we hypothesize yellowfin tuna are capable of some type of central nervous system (CNS)mediated physiological thermoregulation.

Greenblatt, Paul R. 1979. Associations of tuna with flotsam in the eastern tropical Pacific. Fish. Bull, U.S. 77(1):147-155.

The fishing record for flotsam-associated tuna in the eastern tropical Pacific was examined. The rivers of Central America are probably the major source of flotsam. Correlation analysis of the number of sets occurring in an area indicates that unassociated tuna and flotsam-associated tuna are related. The number of sets made on floating objects has increased dramatically since 1971. The percentage of flotsam-associated sets has increased, indicating that flotsam-associated sets are more important to the tuna fishery than in 1963. The catch per set of tuna associated with flotsam has also increased markedly since 1967. Analysis of length-frequency data indicate that, on a single set basis, tuna fork length is more yariable in sets associated with flotsam than with unassociated schoolfish sets. Results of the length-frequency analysis support the idea that flotsam aggregates tuna.

Perrin, W.F., W.E. Evans and D.B. Holts. 1979. Movements of pelagic dolphins (<u>Stenella</u> spp.) in the eastern tropical Pacific as indicated by results of tagging, with summary of tagging operations, 1969-76. NOAA Technical Report NMFS SSRF-737, 14 p.

Through 1976, 3,712 small cetaceans were tagged in the course of research cruises operating out of the Southwest Fisheries Center. These included 2,996 spotted dolphins, <u>Stenella attenuata</u>; 324 spinner dolphins, <u>S. longirostris</u>; 193 common dolphins, <u>Delphinus</u> <u>delphis</u>; and 113 bottlenose dolphins, <u>Tursiops truncatus</u>. Others tagged in small numbers included Pacific whitesided dolphins, <u>Lagenorhynchus obliquidens</u>; striped dolphins, <u>Stenella coeruleoalba</u>; and a short-finned pilot whale, <u>Globicephala macrohynchus</u>. Several types of tags were used. Tags have been recovered from 97 spotted dolphins and 7 spinner dolphins. Time at liberty ranged from less than 2 h to more than 4 yr. Net distance traveled ranged from 7 to 582 n.mi. Average short-term movement in the spotted dolphin is 30-50 n.mi./day; range is 200-300 n.mi. in diameter, and seasonal onshore-offshore migrations may exist.

Perrin, W.F., P.A. Sloan and J.R. Henderson. 1979. Taxonomic status of the southwestern stocks of spinner dolphin, <u>Stenella longirostris</u>, and spotted dolphin, <u>S. attenuata</u>. 29th Report of the International Whaling Commission, pp. 175-184. Smith, T.D. and T. Polacheck. 1979. Analysis of a simple model for estimating historical population sizes. Fish. Bull., U.S. 76(4): 771-779.

Estimates of historical abundance of animal populations are important in many management decisions. Historical estimates based on a simple model of population growth have been made for several populations of dolphin involved with the yellowfin tuna purse seine fishery. We used the data for the bridled dolphin, <u>Stenella attenuata</u>, to investigate the behavior of the model by which these historical estimates were calculated. For populations with low net reproductive rates, the effect of bias in the estimates of the input parameters on the estimated historical abundances was approximately linear and additive. When all the input parameters were independently estimated, the variances of the historical abundance estimate and the coefficient of variation of the historical estimate was less than the largest coefficient of variation of any parameter.

Yoshida, Howard O. 1979. Synopsis of biological data on tunas of the genus <u>Euthynnus</u>. NOAA Tech. Rep. NMFS Circ. 420, 57 p.

Biological and fisheries data on <u>Euthynnus affinis</u>, <u>E</u>. <u>allettertus</u>, and <u>E</u>. <u>lineatus</u> from published and unpublished sources were compiled, synthesized, and summarized following the FAO species synopsis outline.

Yuen, Heeny, S.H. 1979. A night handline fishery for tunas in Hawaii. Mar. Fish. Rev. 41(8):7-14.

Night handline fishing effectively catches tunas in localized areas. The fishery for tunas by this method in Hilo, Hawaii, experienced a rapid growth when high prices on the fresh tuna market and fast air delivery to distant cities made new markets for the catch available. The simplicity of the method and low cost of equipment makes it a promising method for island cultures of low technology to use for developing a fishery. The paper describes the fishing method and gear in detail.

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