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U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
SOUTHWEST FISHERIES CENTER
P.O. Box 271
La Jolla, California 92038

DIRECTOR'S REPORT

TO THE

TWENTY-SIXTH TUNA CONFERENCE

ON

TUNA AND TUNA-RELATED ACTIVITIES

AT THE

SOUTHWEST FISHERIES CENTER

LA JOLLA, CALIFORNIA 92038

FOR THE PERIOD

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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 development, 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, a major emphasis is applied to studying the sensory and physiological reactions of tunas to their environment. Other tuna-related programs underway include assessment of the South Pacific and North Pacific albacore populations and recreational fisheries research, principally the sport fishery for billfishes.

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 California Current Fisheries Resources Division 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 the Atlantic bluefin tuna (Thunnus thynnus thynnus), 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. The following is a current summary of Center activities in tuna population dynamics:

NORTH PACIFIC

Albacore

In late 1974, the Center arranged with the Far Seas Fisheries Laboratory in Shimizu, Japan, to undertake a cooperative study of the population dynamics of the North Pacific albacore stock. Both Japanese and U.S. albacore fishery data are being analyzed to obtain a preliminary assessment of the albacore resource. Plans are underway to hold a workshop meeting in early December 1975 in Honolulu, Hawaii. Other studies related to the North Pacific albacore include 1) analysis of tagged albacore data, 2) merging and standardization of catch-effort data of albacore data collected by fishery agencies of the states of California, Oregon, and Washington, and 3) distribution and partial processing of uniform albacore logbooks.

SOUTH PACIFIC

Albacore

An assessment of the South Pacific albacore tuna stock was recently published in the Marine Fisheries Review (vol. 37, no. 3, March 1975). The results indicate that the South Pacific albacore fishery has reached or nearly reached the MSAY.

Yellowfin Tuna

There are no current active studies undertaken by the Center which are directed to the assessment of the yellowfin stocks in the Pacific Ocean. Center staff are keeping abreast of the studies presently undertaken by the Inter-American Tropical Tuna Commission.

Bigeye Tuna

The Center is currently not engaged in any assessment studies of the bigeye tuna in the Pacific Ocean.

Bluefin Tuna

No research on the population dynamics of Pacific bluefin tuna is being undertaken by the U.S. at this time.

Skipjack Tuna

The SWFC's Honolulu Laboratory is presently working closely with the South Pacific Commission in developing an extensive system to collect catch-effort and size data of skipjack tuna from the several fisheries which have recently developed in the central and western Pacific, e.g. British Solomon Islands, Tahiti, and Papua, New Guinea.

Other Tunas

The Honolulu Laboratory is presently putting together status reports of the several species of small tunas and related species. This work is being done as part of the background work needed for the FAO-sponsored Working Party on Small Tunas and Related Species. Tentative plans are being developed to discuss the status of several of the smaller tunas at a meeting of the Working Party scheduled to be held in Honolulu in December 1975.

ATLANTIC OCEAN

Albacore

A provisional assessment of the North Atlantic albacore stock has been made by the La Jolla Laboratory of the Southwest Fisheries Center. This includes a production model analysis and a cohort analysis.

Yellowfin Tuna

Currently the La Jolla Laboratory is conducting several specific studies directed toward assessment of the yellowfin tuna in the Atlantic. These include 1) age composition covering the period 1967-1973, 2) status of yellowfin tuna stocks, and 3) cohort analysis of this species.

Bigeye Tuna

The La Jolla Laboratory is currently engaged in status of stock study of the bigeye tuna in the Atlantic Ocean.

Bluefin Tuna

The NMFS Southeast Fisheries Center in Miami, Florida, is currently working on several aspects of the Atlantic bluefin tuna.

Skipjack Tuna

The La Jolla Laboratory has currently several studies underway relating to stock assessment of the skipjack tuna in the Atlantic Ocean. These include 1) age composition covering the period 1967-1973, and 2) a status of stocks study.

In addition to the specific research listed above, the La Jolla Laboratory is engaged in several general studies relating to stock assessment of tunas. These include 1) a review and evaluation of estimates of natural mortality for tunas, 2) creation of computer data base for Atlantic tuna fisheries statistics, and 3) review of 1973 and 1974 eastern tropical Atlantic tuna fishery.

Following is an account of research highlights on tuna and tuna-related activities at the NMFS Southwest Fisheries Center, La Jolla, California.

NORTH PACIFIC - ALBACORE

The La Jolla Laboratory and the American Fishermen's Research Foundation (AFRF) have cooperated in albacore research studies during the 1971 through 1975 fishing seasons. An important element of the cooperative studies carried on during these years has been research carried out during the early albacore season in offshore waters. The purposes of the early season surveys were to investigate the shoreward migration of albacore tuna into the U.S. west coast fishery, and the associated marine environmental factors that could influence the migration, and to examine the early-season distribution and the availability of albacore in the offshore area. The surveys were designed to improve understanding of the underlying factors affecting the prediction of the onset and subsequent development of the fishery, and to examine the possibilities for fishermen to extend the albacore fishery farther offshore and to start the fishery earlier than the season usually begins.

In June 1975, three jigboats and one baitboat on charter to AFRF departed San Diego to conduct exploratory fishing and to tag albacore in the early-season offshore fishery. Although the boats took some fish on most days, their catches did not exceed 17 fish per day until they reached 38° N in the offshore area during the last week of June. The albacore were found scattered over a very broad region; some had moved close to southern California at an early date and a modest number were found much further north than in previous surveys. The ocean characteristics that likely influenced this distribution were the warmer-than-average temperatures in the offshore region, the broad spread of Transition Zone waters, and the modest development of the subarctic front. The concentrating effect of the Transition Zone and the boundary fronts upon the albacore was more effective in 1972 and 1973 when the Zone was more narrow and the fronts were stronger.

Of particular interest in the cooperative NMFS-AFRF albacore research is the tagging study whose objectives are to examine the movements of albacore within North American coastal waters during the U.S. fishing season, to obtain information on fish that may re-enter the U.S. fishery in subsequent years, and to obtain information on growth for use in population studies.

Dr. Michael Laurs, in charge of the study at the La Jolla Laboratory, reports that in 1975, 37 recoveries were made by Japanese albacore tuna fishermen in the western North Pacific of albacore tagged and released in the eastern North Pacific during the joint NMFS-AFRF albacore tagging program . Of these recoveries, 36 were taken on live bait fishing vessels and one on a longline vessel. A total of 64 albacore tagged during the joint NMFS-AFRF tagging program have been recovered by Japanese and Korean fishermen; 58 caught on Japanese live bait vessels and 5 on Japanese longline vessels, and one on a Korean longline vessel.

The results from the tag recoveries provide new information on 1) the seasonal development and distribution of the Japanese live bait fishery, 2) location and character of the migration of fish out of the live bait

fishery, and 3) movements of albacore among the North American, Japanese livebait, and Japanese longline fisheries.

The tag returns indicate that during the early portion of the Japanese live bait fishery in March-April, the fish are distributed generally over a broad latitudinal range, roughly 28° to 40° N, within a few hundred miles of the Japanese islands. As the season advances the fish move eastward in a progressively contracting latitudinal band. Near the end of the live bait fishery in June, the fish appear to follow a narrow, well-defined emigration route extending over only a couple degrees of latitude and centered in the Emperer Seamount area at about 35° N, 171° E. The latter conclusion is based on the recovery of 29 tagged fish within very close proximity of each other in the vicinity of the Emperor Seamount within a 3-week period in June 1975 and the recovery of 14 tagged fish in the same area during a 12-day period in mid-June, 1974. One of the tagged fish which was captured in June 1975 near the Emperor Seamount, was tagged 21 days earlier by a U.S. jig vessel conducting exploratory fishing in the western North Pacific in cooperation with the La Jolla Laboratory. The fish was tagged 400 plus miles south-southwest from where it was recovered. Assuming a straight line movement and that the fish was caught immediately upon entering the location where it was recovered, the fish moved eastward at slightly over 20 miles per day.

It is well established that the North Pacific population of albacore tuna supports three main fisheries--the North American surface fishery, Japanese live bait surface fishery, and Japanese longline subsurface fishery--and that there are movements of fish among these fisheries. There is disagreement in the literature, however, concerning the pattern of movement among the fisheries. According to some investigators the albacore move from the U.S. fishery mainly to the Japanese longline fishery and then to the Japanese live bait fishery with some exchange from both of the Japanese fisheries back to the U.S. fishery. Another hypothesis is that fish, upon leaving the U.S. fishery, mainly enter the Japanese live bait fishery and then the Japanese longline fishery. Results from the joint NMFS-AFRF tagging program conclusively demonstrate that the latter hypothesis is correct.

Ninety-two percent of the tagged albacore recovered by the Japanese have been from live bait fishing vessels and the majority of these recoveries were made during the first Japanese live bait fishing season following release of the fish.

Cooperative State-Federal Effort to Standardize Data for West Coast Albacore Fishery

Dr. Michael Laurs, Leader of the Albacore Fishery program at the La Jolla Laboratory, completed a manuscript which is being written collaboratively with fishery scientists from State agencies dealing with catch-per-effort data by time-area strata for the albacore tuna fishery off the west coast of North America. The paper is based on data collected by individual States which has been merged and standardized. The results are unique in that they make available for the first time estimates of a standardized catch per unit of effort

for the entire range of the fishery. This has been made possible by a cooperative program worked out by Dr. Laurs several years ago involving albacore fishery scientists from the NMFS La Jolla Laboratory, California Department of Fish and Game, Fish Commission of Oregon, and later the Washington Department of Fisheries and the Pacific Marine Fisheries Commission.

Many of the statistics for the North Pacific albacore fishery have been published separately by individual states. However, in this paper some of the more recent data from the States have been combined and uniformly standardized to provide additional information about the entire range of the fishery and to take into account any coastwide variation in the characteristics of fishing vessels, in geographic or seasonal characteristics of the fishery, or in other factors which may influence the estimates of fishing effort.

The information about catch localities and fishing effort was obtained by the States from logbooks and from interviewing fishermen on the waterfront. Great care was taken by the individual States to insure confidentiality of the records of individual fishing vessels. This was done by removing the name of the vessel and any identification number which could be traced to the vessel from the records, and by assigning a special code number which was kept constant each year for a given boat.

Assessment of the North Pacific Albacore

Dr. Jerry Wetherall, Fishery Biologist at the Honolulu Laboratory, heads the SWFC study of North Pacific albacore population dynamics. This study is a joint undertaking between the NMFS Southwest Fisheries Center and the Far Seas Fisheries Research Laboratory in Shimizu, Japan. In its first phase, which began last fall, available statistics on nominal effort, size composition, and catch from major North Pacific albacore fisheries were compiled and indices of abundance and standardized effective effort statistics were constructed. Detailed tables of summary catch and effort statistics for the Japanese longline fishery in the North Pacific were computer-produced for 11 years of available data (1962-1972). One set of tables gives adjusted effort and catch per unit effort statistics, and reported figures for a grid of 88 areas in the North Pacific monthly and for three species categories; a second set presents summary statistics for various combinations of space-time groupings along with the time series plots. Computed monthly, they show a concentration of the longline fleet on albacore from October through March or April in most years.

Dr. Wetherall next completed a draft inventory of albacore fishery data from the states of California, Oregon, and Washington in collaboration with Dr. Laurs at the La Jolla Laboratory, and reviewed present procedures employed at the La Jolla Laboratory to merge and standardize the data on a coastwide basis. He also completed the compilation of length-frequency data from the U.S. west coast albacore fisheries for a 20-year period. The length-frequency statistics are presently being used in cohort analyses of the albacore stock and an assessment of the yield-per-recruit in the multigear, multinational fishery.

A workshop on the population dynamics of North Pacific albacore has been scheduled for December 1975 at the Honolulu Laboratory. Participants from FSFRL and SWFC, and the fishery departments of the Pacific coast states will discuss results of preliminary analyses being undertaken in Shimizu and at the Honolulu Laboratory.

Albacore Advisory Work

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

1975 Albacore Fishery

The 1975 albacore fishing season began with a June to early July cooperative research, tagging and scouting cruise carried out cooperatively by the National Marine Fisheries Service, La Jolla Laboratory, and the American Fishermen's Research Foundation (AFRF). The AFRF chartered three jigboats and a baitboat to scout and tag albacore in the offshore waters off California while the NMFS research vessel Townsend Cromwell with Mr. Ronald Lynn, Oceanographer at the La Jolla Laboratory as chief scientist, conducted oceanographic work as well as trolling in late June along 135° W longitude from 41° to 30° N latitude. The chartered vessels caught albacore as soon as they left San Diego, but commercial quantities were caught only in the area 600 miles offshore between San Francisco and Cape Mendocino. In the previous 2 years other commercial boats were also in the offshore waters, but in 1975 little effort was expended because of the lack of a price settlement .

The traditional commercial albacore season in the near shore waters began in early July after a price of $675/ton, delivered to the cannery, was negotiated with one cannery and subsequently reached by most of the canneries on the west coast. Sport boats out of San Diego, however, had already been fishing off Baja California for 2 to 3 weeks.

Although albacore had been caught off Baja California by sport boats since mid-June, many of the commercial boats did not fish this area after the price settlement. Instead, most of them headed north and began catching albacore in quantity north of Point Arena. As the season progressed boats moved northward and spent most of July and August in the Pacific Northwest south of Cape Cook, Vancouver Island. By mid-September many of the jigboats were fishing off central California. Baitboats, however,

remained off Washington and northern Oregon and began making better catches in September.

Unlike 1973 and 1974, boats did not fish north of Cape Cook with much success in 1975. Weather conditions were poor and rough seas were a major problem during much of the season.

In order to assist the commercial fleet of jigboats and baitboats, the AFRF also chartered three jigboats to scout and tag albacore in areas removed from the center of the on-going fishery.

CENTRAL PACIFIC - SKIPJACK, BAITFISH, YELLOWFIN, BIGEYE

Tagging Data Examined in the Study of Skipjack Tuna Growth

As part of an ongoing assessment of the skipjack tuna resource in the Pacific Ocean, Fishery Biologist Dr. Robert Skillman assisted by Mathematician Ms. Marian Yong completed computations necessary for their study of skipjack tuna growth utilizing tagging data. The following estimates of von Bertalanffy growth parameters were obtained using measurement data from fish measured by personnel of the Honolulu Laboratory.

	L_∞	K	n (grouped)
Male	101.1	0.3850	80
Female	86.8	0.5587	96
Combined	92.4	0.4741	176

Many of the recaptures reported to the Honolulu Laboratory by fishermen showed "no growth" despite a range in days from release to recapture from 1 to 420 days; these data were omitted from the calculations.

Field Trials, Shoreside Experiments, and a Detailed Feasibility Study Mark the Progress of the Baitfish Transport Project

The full development of any pole-and-line fishery for skipjack tuna depends on an adequate supply of live bait. In Hawaii the traditional baitfish, the Hawaiian anchovy or nehu, is utilized at considerable cost, since the skipjack fishermen must sacrifice valuable tuna fishing time to go baiting. So valuable is this extra fishing time that during years of high skipjack abundance the fishermen could afford to buy bait at $6 or $7 per pound with no decrease in their profits.

Among the bait supplies that have been considered as supplements to the natural nehu stocks is a scheme in which northern anchovy from California are loaded into specially modified 5,100-gallon aircraft fuel tankers and transported to Hawaii aboard roll-on/roll-off freighters. During the past year, Honolulu Laboratory staff led by Fishery Biologist Roger Green engaged in field trials of this anchovy transport tank system and conducted experiments to determine optimum loading densities. They encountered many difficulties in obtaining healthy bait and in holding enough of it alive in aging tanks for shipment. In the six trial shipments undertaken, often less than half the shipment of live bait survived the 4-day trip.

In February a detailed study of the economic feasibility of the transport scheme was conducted at the Honolulu Laboratory. The study was headed by Dr. Jerry Wetherall with the assistance of Roger Green and Ms. Marian Young. Seasonal patterns of variation in the value (opportunity cost) of nehu and usage rate were established, and the mathematical foundation for an analysis of various anchovy transport schemes involving the use of "preseason" deliveries was developed. Dr. Wetherall determined that "preseason" schemes, while feasible, are always inferior to systems involving "season" shipments only, the monetary benefits to the industry being greater if direct shipments with immediate usage are considered. Also used in the feasibility study was a simulation model of the anchovy transport system to examine the stochastic behavior of various decision rules governing investment in (hypothetical) small-scale transport systems.

This economic study as well as bait transport alternatives were reviewed by the ad hoc bait transport committee and in program review sessions held in April. Recommendations emerging from these discussions included 1) continuing work with roll-on/roll-off transportation of baitfish but moving operations to the Tiburon Laboratory, and preceding the next trial shipment with 3 months of experiments to determine causes of mortality during aging and shipment, and 2) supplying threadfin shad from Wahiawa Reservoir for fishing tests during the 1975 skipjack tuna season.

The baitfish transport project is gearing up in Tiburon, where Roger Green is preparing for further holding experiments using northern anchovy.

Tests Using Threadfin Shad as Skipjack Tuna Bait Hampered by Shortage of "Season" Fish

Several projects suffered as a result of the shortage of large skipjack tuna in the Hawaiian fishery this summer. One was a renewed effort by the Honolulu Laboratory to test the efficacy of threadfin shad as bait for pole-and-line fishing of skipjack. The Honolulu Laboratory and the Vocational Technology Department of Oahu's Leeward Community College cooperated to take approximately 150 buckets (1,500 pounds) of shad from Wahiawa Reservoir weekly beginning in June. These baitfish were made available to local fishing vessels after acclimatization to salt water at the Honolulu Laboratory's Kewalo Basin Research Facility. The object of this was to give the threadfin shad a thorough test as skipjack tuna bait during the summer months, since shad should be tested during peak fishing when fish are running larger. They were successful in attracting the available small fish (the biting of small skipjack fished with shad was termed "rough"), although none of the skipjack tuna fishing boats were returning with good catches, regardless of the bait they were carrying.

"Roback" Automatic Fishing Machines Given Initial Test on Local Skipjack Tuna Fishing Vessel Anela

In October a meeting was held at the Honolulu Laboratory to discuss plans for testing the "Roback" automatic fishing machines in Hawaiian waters. In response to interest expressed by the local fishing industry, the Honolulu Laboratory purchased four units. Installation of the four automatic fishing poles on the fishing vessel Anela was completed in January, and Anela left Honolulu soon thereafter to test the machines, accompanied by two HL staff members and the manufacturer's representative. She fished one school of skipjack tuna off Kahoolawe (Hawaii) and landed 951 fish ranging in size from 10 to 20 pounds and averaging 14 pounds in 39 minutes of fishing. Fishing was carried out by eight fishermen and two Roback poles, one on each side. The two Robacks accounted for 125 skipjack tuna. The machines functioned very well and were well-received by captain and crew, but further testing was precluded for the entire summer by the extremely poor skipjack tuna season in Hawaii.

Otolith Reading Demonstrated as Valuable Tool in Aging Tropical Fishes

Techniques of otolith reading as a means of aging tropical fishes were developed at the Honolulu Laboratory and reported in last year's report to the Tuna Conference. In the continued use of this unique tool, skilled reader James Uchiyama recently completed reading otoliths from the three largest skipjack examined to date (76.1 to 80.3 cm). These data were incorporated with earlier readings and resulted in L_∞ and K values of 87.4 and 1.02 for Central Pacific fishes. Previous values were 99.1 and 0.99.

He also read daily growth increments of four albacore otoliths taken in the eastern Pacific Ocean. Two specimens about 51 and 52 cm FL from near the San Juan Seamount indicated ages of 18.2 and 19.4 months, respectively. Two specimens about 63 and 66 cm FL from near the Columbia River indicated ages of 24.2 and 25.0 months, respectively. Great difficulty was encountered in aging the albacore because daily growth increments of albacore otoliths are much thinner than those of skipjack and yellowfin tunas.

Instrument to Facilitate Heat Transfer May Lessen "Burn" in Bigeye and Yellowfin Tunas

Honolulu Laboratory Fishery Biologist Heeny Yuen is chief investigator into a phenomenon described as fish "burn", a discoloration of the flesh occurring in yellowfin and bigeye tunas taken by trolling and handline off the island of Hawaii. Hypothesizing that the condition is caused by heat denaturation of body protein as a fish struggles on the hook, Mr. Yuen has designed a "heat transfer facilitator", a device to speed the cooling of

just-captured tunas on the assumption that the "burn" condition is the result of not chilling the fish rapidly enough. Each device is made of five commercial "baking nails" held together by a 5-inch aluminum bar in a comb-like configuration. Sea Grant extension personnel are handling the distribution to fishermen for field testing.

Work Accomplished by the Experimental Ecology of Tunas Group of the Honolulu Laboratory During the Reporting Period

The objective of the Honolulu Laboratory's Experimental Ecology of Tunas group under Dr. Andrew Dizon is to measure directly the responses of tropical tunas to environmental factors. This information is used to formulate a predictive model of habitat, distribution, and energy flow for skipjack tuna. Experimental work is done at the Honolulu Laboratory's Kewalo Basin Research Facility, the only such laboratory where live tunas are routinely kept. During the past year emphasis has been on the study of responses to gradients and discontinuities in simulated environments, on bioenergetics, and on feeding studies. Besides numerous reports and papers, various models have been formulated from information collected.

Responses of tunas to gradients and discontinuities in simulated environments.--Temperature has long been considered a major factor in the determination of tuna distribution, and high priority is placed on determining the temperature preference of free-swimming tunas. Honolulu Laboratory has constructed an anular-shaped tuna behavioral thermoregulation system in which spatial temperature gradients can be simulated temporally and temperature preference and behavioral thermoregulation studied in gradient levels comparable to those encountered in the tuna's environment. Data collection in this "doughnut" tank is scheduled to start soon.

However, this past year the effects of temperature, salinity, and oxygen gradients upon swim speed were studied in the partially operational tank. Results of temperature gradient studies are as follows: 1) swimming speed in skipjack tuna and kawakawa was virtually independent of temperature in the range of 19° to above 30° C, 2) yellowfin tuna swam slower as the water temperature decreased, with swim speed changes lagging behind the water temperature changes. This effect was most certainly due to the large thermal inertia which is a property of tuna red muscle. A linear relationship was found when log swim speed was plotted against red muscle temperature. Temperature coefficients (Q_{10}'s) ranged from 2.58 to 1.44 (median 2.05), and 3) no evidence of thermoregulation (reflected in changes of swim speed) was observed in yellowfin tuna during a 24-hour period at 19° C.

No responses were noted to salinity gradients of 0.075 ppt/min to about 25 ppt. Skipjack and yellowfin tunas and kawakawa were tested.

As observed with temperature gradients, skipjack and yellowfin tunas demonstrated dramatically different responses to oxygen gradients. Yellowfin tuna demonstrated no change in behavior during periods (300 min) of decreasing

(to 1.5 ppm) and then increasing (to saturated) oxygen levels; skipjack tuna in contrast increased swim speed as oxygen dropped to 4 ppm and never survived the entire test period. Yellowfin showed no visible signs of stress or alterations in basal swim speeds when subjected to 200 min at 1.4 ppm and 200 min at 1.6 ppm. Skipjack did not survive these levels very long. Death occurred in 20 min at 1.4 ppm, 42 min at 1.7 ppm, and 47 min at 2.6 ppm. Swim speeds increased up to about 3.5 lengths/sec at 4 ppm.

Rates of success of purse seining have been related to characteristics of the thermocline. Low temperatures and oxygen levels and high turbidity associated with the thermocline have been suggested as effective barriers to escape through the unpursed net. Research Assistant Randolph Chang recently completed a study to determine how objectionable water conditions must be before tuna will not voluntarily enter a small oval tank attached to the wall of a large diameter holding tank. Passage between the tanks was through a 2-foot-square hatch. In brief, low temperature did not prove to be a very effective barrier. Presumably, the large thermal inertia of tuna muscle prevents very rapid temperature change in vital tissues. Oxygen levels of below 2 ppm also did not prevent entry although there were obvious signs of stress during periods in the low oxygen water. The fish voluntarily remained in the low oxygen or low temperature water for periods that were long enough to escape from the deepest hanging net. There was some indication that turbid water was the most effective barrier, but more work must be done.

Knowledge of rates of heating and cooling and excess tissue temperatures are necessary parameters for estimating body temperatures given time-series of environmental temperatures. Knowledge of body temperatures are critical for determining suitable habitat and allowable levels of activities. These parameters have been previously determined for skipjack tuna by Dr. William Neill, formerly of the Honolulu Laboratory and now with Texas A & M, and others in the experimental group. During the past year, graduate student Minato Yasui, from Tokai University in Japan, has tested seven yellowfin tuna to determine rates of temperature change and excess body temperature. The preliminary results were as follows: 1) rates of temperature change were not markedly different from skipjack tuna of a similar size, but 2) yellowfin tuna warmed more rapidly than they cooled by a factor of two. Skipjack have resistances to heating and cooling that are about the same. The difference between the two species may result from different temperature coefficients for metabolic rate. 3) However, no evidence of a relationship between excess body temperature of the red muscle and water temperature was discovered. 4) Excess body temperatures were smaller than those of comparable sizes of skipjack. Work is continuing.

Bioenergetics of tunas.--Experiments to determine routine metabolic rates and low oxygen resistance times were conducted by Fishery Biologist Reginald Gooding. Over the range of oxygen tensions tested there was no correlation between oxygen concentration and swim speed. Swim speed averaged 1.4 lengths/sec for all tests. There was a slight but significant decrease in respiration rate as oxygen levels in the respirometer decreased. Even at upper levels of saturation the fish may have been oxygen dependent at minimum swim speeds and the so-called incipient limiting level is very

close to normal saturation for 24° C. When the log of absolute oxygen consumption is plotted against log body weight, the regression line is nearly 1, indicating that oxygen consumption is very nearly weight proportional. Other species have slopes ranging from 1.0 to 0.8. There was a very significant correlation between swim speed and metabolic rate; this is typical for all animals. However, respiration rates are high when compared with other fish: 0.5 mgO_2 g^{-1} hr^{-1} versus 0.04 - 0.2 mgO_2 g^{-1} hr^{-1}.

Respiration rate of skipjack tuna was also measured over the range of thermal tolerance--18°, 24°, and 29° C--by Messrs. Randolph Chang and Bernard Ito. A multiple linear regression was used to compare mean metabolic rate and mean experimental variables of 1) sequential replication number, 2) test temperature, 3) weight, 4) elapsed time fish were in respirometer, and 5) swimming speed. Swim speed was the only significant covariate. Temperature had no effect on routine metabolic rate. This observation supports previous data indicating that the temperature coefficient of swim speed was 1.

Attempts at determining active respiration rate will be made during the coming year.

Feeding studies.--University of Wisconsin graduate student Ms. Sherry Steffel, under the direction of Drs. John Magnuson and Andrew Dizon, is determining input parameters for a bioenergetics model developed by Dr. James Kitchell, also of the University of Wisconsin. The first phase of the study involves determination of maximum daily ration, diel feeding periodicity, and routine metabolic rates. Eventually measurements of active metabolic rates will be attempted.

Small, mixed species schools are being used to determine maximum daily consumptions. Thawed smelt were cut in about 4-gram pieces and presented individually to the fish for either one feeding to satiation at a specific time of day or continuous feeding at 15-min intervals. It has previously been determined that fish in our tanks do not feed at night. The values for percent body weight consumed per day during continuous feeding ranged from 12% to a high of 41%. One feeding to satiation per day indicated maximum stomach capacity of 6 to 10% of body weight. Work is continuing.

After use in the feeding experiment, the yellowfin tuna and the kawakawa are tested for routine respiration rates by Mr. Thomas Byles. Fish were starved for 24 hours and then placed in the respirometer. Values obtained for the one yellowfin tested to date were 0.584, 0.474, and 0.500 mgO_2 g^{-1} hr^{-1} (2.701 kg, 52.2 cm). Two kawakawa were tested: 0.865 and 1.078 mgO_2 g^{-1} hr^{-1} (1.892 kg, 45.9 cm), and 0.539, 0.572, and 0.571 mgO_2 g^{-1} hr^{-1} (2.472 kg, 47.0 cm). All fish were swimming at or near their minimum swim speeds. Elevation of respiration rate of the first kawakawa was caused by allowing O_2 levels to fall too low during the test.

Modeling efforts.--Oceanographer Dr. Richard Barkley has hypothesized habitats based on temperature and oxygen requirements of skipjack tuna. Assuming that these laboratory requirements apply to skipjack in nature, many of the peculiar features of oceanic skipjack distribution can be explained.

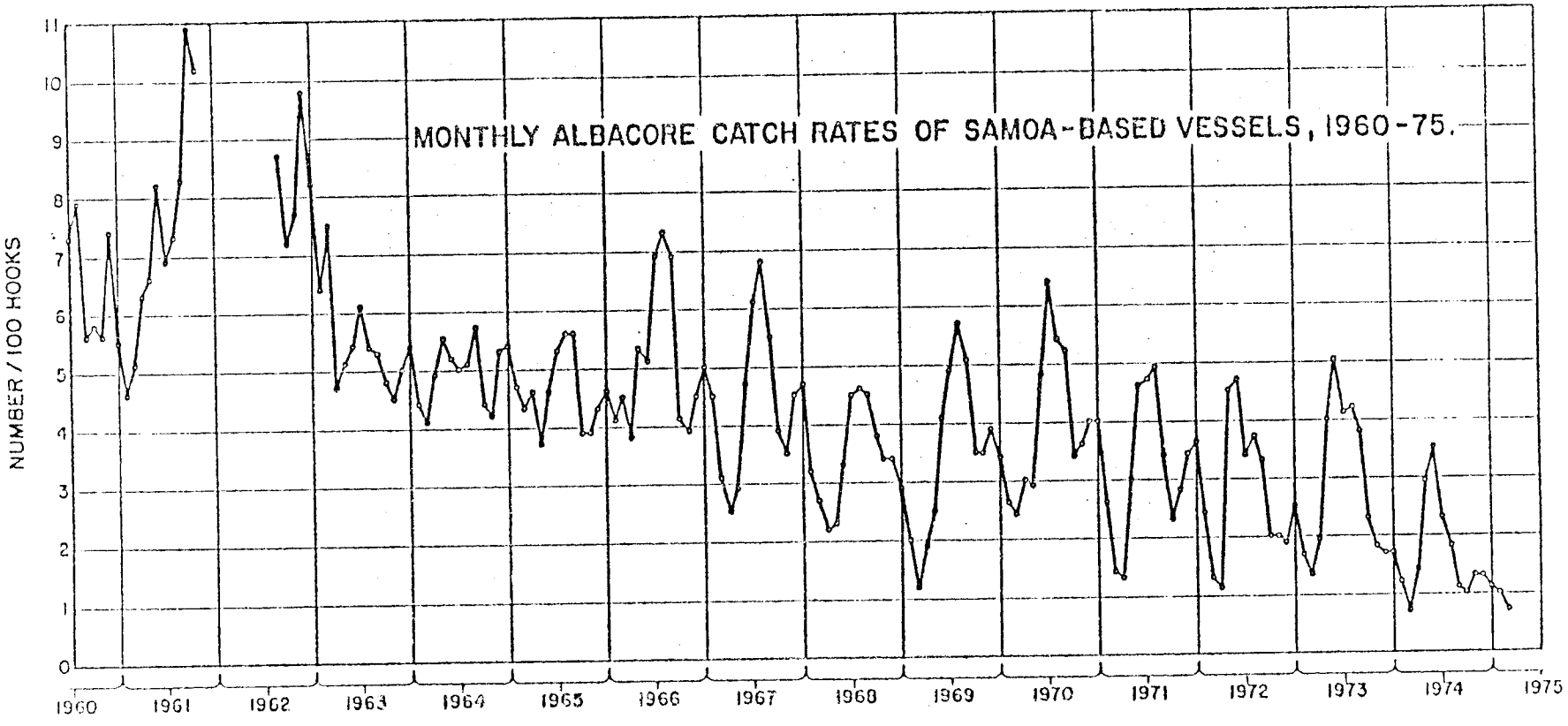
Dr. James Kitchell, University of Wisconsin, has developed energy budgets for skipjack as a function of body size using parameters determined in studies with captive animals. Among others, these results suggest why discontinuous growth curves are observed (growth determined by otolith studies(, and predict maximum skipjack size.

Dr. William Neill, Texas A & M University, has been developing a conceptual model for behavioral thermoregulation by tunas. Using physiological parameters both known and approximated, Dr. Neill is able to show why thermal fronts tend to concentrate tunas.

Currently, Dr. Tim Smith, University of Hawaii, and a Research Assistant, are investigating the possibility of formulating a deterministic growth model taking as inputs temperature, oxygen, and depth. Growth will be simulated for various forage densities and distributions; assumptions will be made regarding prey-predator strategy.

South Pacific Albacore Fishery Exceeds Maximum Sustainable Average Yield in 1973

Dr. Robert Skillman, assisted by Ms. Marina Yong, updated the 1974 and 1975 summaries of catch and catch per unit effort statistics for the South Pacific albacore fishery based in American Samoa. They also determined that the longline fleet based there landed approximately 30,000 MT (metric tons) in 1973, and from this it was estimated that the total catch in the South Pacific was near 50,000 MT. This figure is considerably over the maximum sustainable yield of 33,000 to 35,000 MT predicted by Dr. Skillman. Catch rates have continued to decline in the fishery, as shown in the accompanying figure.


MONTHLY ALBACORE CATCH RATES OF SAMOA-BASED VESSELS, 1960-75.
NUMBER / 100 HOOKS
0
1
2
3
4
5
6
7
8
9
10
11
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975

Following are accounts of the SWFC's involvement in research on yellowfin and skipjack tuna of the eastern Pacific.

Geographical Distribution of Skipjack Tuna Explained Using Physiological Parameters

Recent physiological studies at the Honolulu Laboratory using captive skipjack tuna have shown these fish to be limited by both water temperature and dissolved oxygen concentrations. Skipjack of all sizes appear to need water warmer than about 18° C with more than 3.5 ml/liter (5 ppm) dissolved oxygen and, although they may be able to adjust to slightly colder water on conditioning, these two factors seem to define the lower limit of their normal habitat.

Tunas are equipped with well-developed heat exchangers in their blood circulatory systems that conserve body heat and presumably make them more efficient high-speed swimmers. Freshly caught skipjack may have muscle temperatures as high as 11° C above the surrounding water. However, this unusually high internal temperature may limit their ability to tolerate warm water, since their muscle protein may be damaged by internal temperatures much above 35° C. Juvenile and adolescent skipjack can tolerate water temperatures of 26° C or more and thus can inhabit the entire tropical Pacific Ocean, but larger skipjack may be limited to water that is cooler than normally found at the sea surface in the tropics. Adult skipjack are seldom seen in mid-ocean; they probably come to the surface only for special reasons such as feeding, and then only for short periods of time unless they deliberately reduce their activity to avoid overheating. If they cannot find water cool enough and with enough oxygen in large areas of the eastern Pacific Ocean, this would explain why only small skipjack tuna are found there.

Pending field studies will check on the validity of the above laboratory findings in nature. Results will be used in developing more sophisticated models of energetics, life history, and behavior in relation to oceanographic features and events.

The Real-Time Fishery Systems

The Real-Time Fishery Systems task at the La Jolla Laboratory consists of three major activities: 1) the tropical tuna radio facsimile program (FAX), 2) the Fishing Information publication, and 3) the development of concepts and data necessary for implementing a real-time fishery system. In addition to these primary tasks the Real-Time Fishery Systems staff cooperates with, and provides moderate support to the XBT ship-of-opportunity program.

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

Facsimile recorders, procured from government surplus and adapted for use with shipboard communications equipment, are presently installed on about 58

participating vessels under a reciprocal agreement providing for daily data transmission from the fishing grounds. In addition, the SWFC has adapted and installed independently procured units on 11 other ships. All participating vessels take and transmit surface weather observations, including wind speed and direction, weather, cloud cover, barometric pressure, air temperature, sea surface temperature, swell direction, and wave height. Some 26 vessels in the tropical tuna fleet are also equipped with XBT systems and report subsurface temperatures in standard BATHY message format. BATHY messages include temperatures and depths at significant points down to 500 m, extracted from XBT analog traces. Maintenance of the NMFS-owned XBT equipment is performed by the La Jolla Laboratory.

During the period September 1974 to August 1975, an estimated 721 XBT observations and 3,686 surface weather observations have been received from participating tuna boats in the eastern tropical Pacific. Since the beginning of the program in 1971 to the present time, about 17,400 observations have been received from facsimile-equipped tuna vessels.

In return for their participation in the weather and XBT reporting program the FAX-equipped tropical tuna vessels receive daily weather advisory charts. The National Weather Service produces an analysis of wind and weather twice and a sea state analysis once daily. The resulting charts are transmitted to the SWFC and then broadcast from radio station WWD in La Jolla. Until June 1975, the wind and weather analysis was provided only at the afternoon (2300 GMT or 1600 PDT) broadcast time. Beginning on June 9, a second wind and weather chart has been broadcast in the morning at 1400 GMT (0800 PDT). The sea state analysis continues to be broadcast daily at 2300 GMT. The charts are now being broadcast on two frequencies in the 8 and 16 MHz bands to provide complete coverage of the fishing grounds.

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

Fishing Information Publication

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

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

1) sea surface temperature for the eastern North Pacific;

2) sea surface temperature for the western North Pacific;

3) sea surface temperature for the eastern tropical Pacific;

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

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

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

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

Fishery Systems Analysis

A major objective of the Real-Time Fishery Systems is to develop models relating environmental factors to availability of tuna and to fluctuations in tuna populations of the eastern tropical Pacific. The successful development of these models will enable us to provide continuous, real-time analyses useful to both tactical fishing operations and tuna management decisions.

Conceptually, a better predictive knowledge of fish availability and location will be directly useful to fishermen at sea. Fishermen generally have a very thorough knowledge of conditions within their general vicinity. When fishing conditions are poor, however, additional information indicating where conditions are likely to be better will contribute significantly to the efficiency of research procedures. The ultimate pay off from the fishery advisory program should, from the fishermen's viewpoint, be increased catch rates.

From a fishery management viewpoint, the environmental research will contribute to the definition and measurement of catchability, and thus to the assessment of population abundance. Standard stock assessment techniques have, hitherto, ignored the potentially significant influence of weather, sea state, and ocean thermal characteristics upon the catch rates of tuna vessels.

Statistical research supported by the weather data, XBT observations, and summary catch data from the Inter-American Tropical Tuna Commission was begun last year. Significant relationships between tuna catch and sea state, weather, and ocean thermal structure are being found. These relationships will be a key ingredient to both the fishing tactics models and the management models.

Ocean Environment Related to Fishing Success in Eastern Tropical Pacific Tuna Fishery

During the past year, scientists from NMFS, La Jolla Laboratory, and the Inter-American Tropical Tuna Commission, completed the first phase

of a joint project to study possible relationships between success in purse seining for tropical tunas and the ocean properties monitored aboard tuna boats. A detailed statistical analysis has now been completed by Mr. Forrest Miller, IATTC, Mr. Dick Evans, Mr. K. Bliss, La Jolla Laboratory and Mr. C. Orange, IATTC, using approximately 2,000 surface and sub-surface (expendable bathythermograph) observations matched in time and location to purse seine sets. The environmental data included sea surface temperature (SST), mixed layer depth (MLD), temperature gradient in the thermocline (TGRAD), and windspeed (WSPD). These parameters were paired with catch data which included the catch-per-set, the type of set (porpoise set, school set, log set, night set), the species of tuna captured, and the type of set attempted when no fish were captured. For each vessel all the variables were averaged over 5° squares per month. After eliminating "skunk sets" 127 data points remained for use in the statistical analyses.

The statistical results re-confirmed earlier studies which note the importance of the thermocline depth (MLD) and temperature gradient in explaining catch success. Surface temperature (SST) alone did not provide a satisfactory explanation of catch per set. However, an examination of the data revealed that 86% of the successful sets on yellowfin were made in waters where SSTs were between 79° and 83.5° F. From season-to-season the area of the eastern tropical Pacific bounded by the 79° and 84° F isotherms fluctuates markedly. The annual distribution of yellowfin catch confirms that the areas most heavily fished correspond to the surface temperature regime between 79° and 84° F.

Some of the more revealing statistical results were multiple regression equations which used average catch-per-set as the dependent variable and SST, TGRAD, WSPD and MLD as independent variables. Initial analysis indicated that MLD might have a non-linear effect. Dummy variables were fitted to the equation until it was determined that the MLD had a critical value of 100 feet. Using this critical value on porpoise sets, the environmental parameters combined to explain 22% of the variation in the catch.

Analogous results for the non-porpoise set were insignificant, probably due to the small number of observations. Although the proportion of variance explained by the linear regression equation was small, the highly significant F-statistics lend support to the hypothesis that environmental conditions which were monitored are important factors in the success of tuna seining. A more comprehensive study of these relationships is underway based on the insights gained in this initial analysis.

Porpoise-Tuna Interaction

As a direct result of the passage of the Marine Mammal Protection Act of 1972, an expanded program of research was undertaken at the La Jolla Laboratory in late 1972 to develop fishing methods and gear technology which would reduce the incidental mortality of porpoises in the yellowfin

tuna purse seine fishery and to determine the status of the porpoise stocks associated with the incidental mortality. The present program to accomplish this consists of three somewhat related components: 1) mortality reduction technology, 2) general biology, ecology, and population dynamics, and 3) data management and quantitative analysis.

Based on the resources available and the probability of success in the short term, mortality reduction research concentrated on mechanisms for reducing mortality if and when porpoise contact the net and reducing the probability of contact through minor changes in gear and procedures. These measures include 1) the use of speedboats to prevent net collapse, 2) a "porpoise apron" to improve the net backing down procedure, 3) use of fine mesh webbing to prevent mortality due to entanglement, 4) design of a new large-volume purse seine which can safely contain large catches of tuna and porpoise, 5) anti-torque purse line to prevent roll-ups of the net, 6) the use of ribbons as current indicators to position the net, and finally, 7) a "porpoise grabber" to assist rescuers in removal of all live porpoise from the net.

During the year, two gear research cruises were conducted to test these gear and methods under charter to the NMFS; in addition, the large volume purse seine, apron, anti-torque cable, lengthened current ribbons, and grabber received additional testing in the U.S. purse seine fleet with the cooperation, participation, and investment of members of the fleet.

The resulting evaluation of the data indicates that technological developments certain to reduce further incidental porpoise mortality are the use of speedboats, when needed, to hold the net open prior to the execution of backing down and the use of rescuers at the corkline. Technological developments that will require further testing and analysis but that are promising to further reduce incidental porpoise mortality are certain design features of the large volume purse seine, finer mesh Medina panels and use of fine mesh in other areas of the nets, the porpoise apron, and the grabber.

A major paper on the general biology of the offshore spotted dolphin (Stenella attenuata), historically the species with the highest mortality in the eastern Pacific tropical tuna fishery, was completed. The study was based on data from several thousand specimens of these porpoises and treated such matters as gestation period and fetal growth, age determination, length-weight relationships, geographical variation, etc. Biological research has since concentrated on the biology of the eastern spinner dolphin (Stenella longirostris subspecies) the species with the second highest total incidental mortality. Work on the biology of the common dolphin (Delphinus species), the species with the third highest mortality, and the striped dolphin (Stenella coeruleoalba), a more rarely encountered species, is continuing. One of the more difficult problems in porpoise biology, direct calibration of age, received special attention when a contract was granted to Dr. Jeffrey Bada of the University of California at San Diego to apply his new technique of aging mammals through biochemical analysis of dental protein.

Under the provisions of the Marine Mammal Act of 1972, and with the cooperation of the U.S. tuna fleet, NMFS field technicians go to sea aboard

U.S. tuna purse seiners, where they count porpoises killed incidentally in the fishing operations, record statistics on size and makeup of the catch, collect specimens to be used in studies of porpoise life histories and stock assessments, make detailed observations of the rescue operations during each tuna set, and make other observations on cetaceans and birds.

In 1975, the field technician program, working cooperatively with the tuna industry completed 31 trips, which adequately covered the entire U.S. unregulated, yellowfin tuna fishing season within the Commission Yellowfin Regulatory Area (CYRA). Temporal coverage of the U.S. fishing operations was better than expected owing to the unusual economic problems in the U.S. tuna industry and unresolved issues regarding the Inter-American Tropical Tuna Commission yellowfin tuna regulations, and resulted in many trips which were considerably longer than in previous years.

Information derived from the field technician program is integrated with data from an aerial survey and further treated statistically to derive an estimation of porpoise stocks, Tentative conclusions of the staff are that the stock of offshore spotted dolphins in the eastern Pacific may be estimated at 3.1 to 3.5 million animals. Using data obtained from the field technician program and data collected by the IATTC, the staff estimated that 72,000 offshore spotted dolphins were killed in 1974. The estimated incidental fishing mortality rate for 1974 is 2.1 to 2.3%. The best estimate at present is that, biologically, the population could sustain an annual fishing mortality rate of 1.4 to 4.4%. There is no striking evidence that the stock is either increasing or decreasing.

Similar estimates place the stock of eastern spinner dolphins in the eastern Pacific at 1.1 to 1.2 million animals and the 1974 annual rate of mortality caused by fishing at 1.8 to 1.9%. The best estimate at present is that, biologically, the population could sustain an annual incidental fishing mortality of 2.8%. As with the spotted dolphin, there is no striking evidence that the stock is either increasing or decreasing.

Using data from 1973, 1974, and 1975, an evaluation of the U.S tuna fleet's kill rate performance for 1975 under conditions comparable to previous years was made. Tentative conclusions which were made from the analysis of these data indicated that total porpoise mortality from fishing in 1975 will probably be greater than in 1974. The revised preliminary kill estimate for 1974 was 113,000 animals (98,000 by U.S. vessels). The preliminary kill estimate for 1975 is 93,000 to 214,000 animals. Using the same percentage as in 1974, the U.S. kill for 1975 will probably be 81,000 to 186,000 animals. While it appears that the kill rate will be higher in 1975 than in 1974, analysis of the data revealed that fishing conditions changed between 1974 and 1975 and that under similar conditions the kill rate in 1975 would have been 22% lower than in 1974.

The above information was summarized from a comprehensive report (SWFC Administrative Report No. LJ-75-68), "Progress of research on porpoise mortality incidental to tuna purse-seine fishing for fiscal year 1975", compiled by Dr. William Fox, Acting Chief of the Oceanic Fisheries Resources Division, and the staff of the Porpoise/Tuna Interaction program at the

La Jolla Laboratory, headed by Dr. William Lenarz. This report, which was released to the public by NMFS, Washington, D. C., on August 18, 1975, will also serve as background information on hearings in early October 1975, on consideration of the issuance of a general permit allowing the tuna industry a continued incidental take of marine mammals.

Billfishes and Other Marine Gamefish - Eastern Tropical Pacific

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

Mr. James Squire, Fishery Biologist at the La Jolla Laboratory, coordinates the tag returns and complies statistics on fish tagged by sport fishermen participating in the Cooperative Marine Gamefish Tagging Program.

In a tagging report prepared on the results of the 1974 cooperative marine gamefish tagging program for the Pacific area, Mr. Squire noted that during calendar year 1974 the number of fish reported tagged was more than double the 1973 amount for a total of 1,697 fish tagged and released. Billfish accounted for a high percentage of the fish tagged, totaling 1,616 or 95.2% of the total number. The 1974 billfish tagging record was much improved over the 1973 record when only 747 billfish were tagged out of a total of 858 fish tagged. Of the total number of billfish tagged, striped marlin accounted for 818, black marlin 577, sailfish 194, and blue marlin 27. One billfish angler in Australia reported accidentally tagging himself.

The tagging results are again approaching the all-time record high of 2,040 fish tagged in 1972. Mr. Squire has requested assistance in tagging two species, common to the Gulf of California and about the lower tip of Baja California, Mexico--the roosterfish and yellowtail. In 1974, a total of 13 roosterfish and 14 yellowtail were tagged. Higher tagging rates for yellowtail were obtained in previous years. The tag now in use ("H" type) appears to be suitable for use on both of these species and provides a high rate of return for both.

Subsequent to the preparation of the above report, additional black marlin tag returns in the southwest Pacific were obtained from points distant from the center of tagging which is located off the Great Barrier Reef near Cairns Australia. Two tagged black marlin were recovered off the north tip of New Zealand about 2,000 nautical miles from Australia. Two fish were recovered 1,000 miles or more southeast of Cairns, off and north of Sidney, Australia.

An increased number of tags were returned in the past year, with a number of black marlin being recovered in the same area (Cairns Australia/Coral Sea) as tagged, and 2 years after being tagged.

During the 1974 striped marlin season off southern California this year, more fish were tagged by sportsmen than in any previous year. The count showed 75 striped marlin tagged, over three times the number of fish previously tagged. The total catch of striped marlin off southern California was about 900 fish. Although this number did not equal the 1,200 caught in 1963, it was a significant improvement over the total catch made during the past few seasons. Using the 900 figure, approximately 8.3% of all fish caught off southern California during 1975 were tagged and released by sport fishermen.

Catch/Effort Data of Big Game Fish

An analysis of 1973 catch/effort data has been made from 4,801 days of fishing recorded in the annual postcard survey of big game fish anglers fishing in the Pacific. The analysis indicated the following trends. The total number of billfish caught during the 4,801 angler days was 2,011, equalling 0.42 fish per day or 2.38 days fishing per fish. This is a decline from the 4-year average through 1972, of 0.55 fish per day and 1.80 days of fishing per billfish.

In 1972, the striped marlin catch rate off southern California was 18.6 days fishing per fish; in 1973, the rate declined to 41.3 days fishing per fish. The other major striped marlin fishery in the eastern Pacific at Baja California, showed a decline from 1.56 days per fish in 1972 to 2.93 days fishing per fish in 1973.

Sailfish catch rates rose from 1.56 days per fish off Acapulco in 1972 to 1.20 days fishing per fish in 1973. However, catch rates for 1973 declined off Mazatlan and Baja California. In 1972 rates were 2.36 and 14.00 off Mazatlan and Baja California, respectively, and in 1973 they were calculated to be 2.43 and 25.4, respectively.

For 357 days of fishing reported in 1973 off Australia, the catch of black marlin was considerably better than the previous 4-year average of 0.40 fish per day or 1.65 days fishing per fish. In 1973 these rates were 1.5 fish per day and 0.66 days per fish.

The downward catch trends for sailfish and striped marlin fishing matches the downward trend of total worldwide billfish catches, from about 80,000 metric tons in 1965 to 57,000 metric tons in 1971. An expanded billfish angler catch/effort survey for the Pacific was conducted during the spring of 1975, in cooperation with the International Gamefish Association and resulted in an expanded sample base. Formerly, only those individuals participating (about 2,000) in the tagging program were requested to complete the angling survey. Data obtained in the 1974 survey are now being analyzed to determine the trend in billfish catch rates for the more important billfishing areas throughout the Pacific.

Honolulu Laboratory Fishery Scientists Gather Data and Disseminate Information at 17th Hawaiian International Billfish Tournament

The 17th Hawaiian International Billfish Tournament was held in Kailua-Kona, Hawaii, August 2 through 10, during which time a tournament record of 114 billfishes and 79 yellowfin tuna were caught. Honolulu Laboratory Fishery Biologist Heeny Yuen and Research Assistant Ray Sumida were in attendance. They collected data on catch and effort in tournament areas, and on length, weight, and stomach contents. The Honolulu Laboratory put up a display on our national fishery resources. The display was in a prominent location at tournament headquarters. In a seminar at the end of the tournament, Mr. Yuen summarized existing knowledge on the biology of blue marlins.

Honolulu Laboratory Fishery Scientist Travels to Southwest Pacific to Stimulate Billfish Research There

During the period March 3-19, Fishery Biologist Heeny S. H. Yuen attended marlin fishing tournaments at Russell, New Zealand and Papeete, Tahiti. The trip was sponsored by the Hawaiian International Billfish Association for the purpose of stimulating the participation of appropriate officials of the respective countries in research on game fishes and marlin in particular. In both countries the responses to discussions with Mr. Yuen and to demonstrations of the Honolulu Laboratory's activities at the annual billfish tournament in Kailua-Kona were enthusiastic.

ATLANTIC - YELLOWFIN, SKIPJACK

The focus of efforts of the staff of the Tuna Stock Assessment program at the La Jolla Laboratory is on providing the basic fishery analysis and management information on tunas in support of U.S. commitments to the International Commission for the Conservation of Atlantic Tunas (ICCAT), and to provide technical advice to U. S. Commissioners on the Inter-American Tropical Tuna Commission (IATTC) and U.S. delegates to various international tuna fisheries bodies. The staff of this program, headed by Dr. Gary Sakagawa, performs the stock assessments and fishery evaluations and develops the framework and analysis for quantitative assessments of the impact or potential impact of management decisions on the world tuna populations and the tuna fisheries of the U.S.

Preliminary 1974 Fisheries Statistics on Atlantic Tunas

Dr. Sakagawa, assisted by Mr. A. Coan, completed tabulation and compilation of the final 1974 statistics on U.S. catches from the Atlantic tuna fisheries. These statistics are distributed to scientists for use in determining the status of the stocks and in evaluating management decisions.

A total of 26 American tuna seiners fished in the eastern tropical Atlantic in 1974 and caught 5,600 MT (metric tons) of yellowfin, 20,000 MT of skipjack, 900 MT of bigeye, and 40 MT of black skipjack tuna. The bulk of the yellowfin tuna catch (75%) was caught in the Gulf of Guinea, and the bulk of the skipjack tuna catch (84%) was caught off Angola. The average length of yellowfin tuna was 81 cm and skipjack, 46 cm. The average catch rate was 11.5 MT/day's fishing (2.8 MT of yellowfin/day's fishing and 8.7 MT of skipjack/day's fishing).

Four American seiners fished in the western tropical Atlantic and the Caribbean Sea. They made no catch in 20 days of fishing.

In the bluefin tuna fishery of the northwestern Atlantic, American fishermen caught 1,500 MT of bluefin tuna in 1974; 850 MT with purse seines, and 680 metric tons with handlines, harpoons, and traps. The dominant age group in the purse seine catch was age I. Most of this catch was landed by five purse seiners that fished in that region during the summer months.

Annual Meeting of the International Commission for the Conservation of Atlantic Tunas (ICCAT) - November, 1974, Madrid, Spain

The annual meeting of the International Commission for the Conservation of Atlantic Tunas (ICCAT) was held in Madrid, Spain, November 13-26, 1974.

The contigent from the La Jolla Laboratory was led by Dr. Brian Rothschild, Center Director, who presently also heads up ICCAT's Standing Committee on Research and Statistics, Dr. William Fox, Acting Chief of the Oceanic Fisheries Resources Division at the La Jolla Laboratory, and Dr. William Lenarz, presently Acting Head of the Porpoise/Tuna Interaction Program. Drs. Fox and Lenarz represented the U.S. on the Standing Committee for Research and Statistics as did two scientists from the Southeast Fisheries Center in Miami.

The U. S. presented status of the stocks analyses for yellowfin, albacore, and bluefin tunas and a paper on billfishes. Concern for the fisheries centered around two major issues: 1) large catches of yellowfin tuna smaller than the present minimum size regulation by bait boats based in Tema, Ghana (mostly Japanese flag), and 2) the status of bluefin tuna. Calculations of yield per recruit showed that significant decreases in yield per recruit would occur if the catching of undersized yellowfin persisted. Japan agreed to take the necessary steps to reduce the catch of undersized yellowfin. The U.S. proposed regulations on Atlantic bluefin tuna consisting of a 6.4 kg minimum size limit and a limit on the amount of fishing mortality in each fishery. The general feeling of some of the scientists was that a reduction in fishing mortality is needed, however; many of the countries expressed their concern that severe problems would develop in their fisheries if their catches were to be reduced. The U.S., therefore, proposed the limitation of fishing mortality for a period of 1 year only so that, in the interim, more recent data can be employed in analyses to define better the direction in which the regulatory program should proceed.

Preparation for 1975 Annual Meeting of the International Commission for the Conservation of Atlantic Tunas (ICCAT)

The 1975 annual meeting of ICCAT is scheduled for November 12-25, in Madrid, Spain. Presently, the staff of the Tuna Stock Assessment program is preparing about 10 documents for submission to the Standing Committee on Research and Statistics of ICCAT. The documents will be concerned with the current status of the yellowfin, skipjack, and bigeye tuna stocks of the Atlantic Ocean. Tentative titles of the documents are:

Yellowfin Tuna - Atlantic

W. Fox and A. Coan. The status of the yellowfin tuna stocks of the Atlantic Ocean from a production model analysis.

G. Sakagawa, W. Murphy and A. Coan. Yield per recruit of yellowfin tuna from cohort analysis.

A. Coan and G. Sakagawa. Age structure of the yellowfin tuna catch from the Atlantic Ocean, 1967-73.

Skipjack Tuna - Atlantic

W. Murphy, A. Coan and G. Sakagawa. The status of the skipjack tuna stocks of the Atlantic Ocean from production model analysis.

A. Coan and G. Sakagawa. Age structure of the skipjack tuna catch from the Atlantic Ocean, 1967-73.

Bigeye Tuna - Atlantic

A. Coan and G. Sakagawa. The status of the bigeye tuna stocks of the Atlantic Ocean from production model analysis.

Recently completed papers by the staff include the following:

G. Sakagawa. The purse seine fishery for bluefin tuna in the northwest Atlantic Ocean.

G. Sakagawa, A. Coan and G. Holzapfel. Length composition of yellowfin, skipjack, and bigeye tunas caught in the eastern tropical Atlantic by American purse seiners.

A. Coan. Length, weight, and age conversion tables for Atlantic tunas.

U.S. Caught Atlantic Tuna Length Composition Analysis

An annual assessment of the status of Atlantic tuna stocks is made by the La Jolla Laboratory. Among the various information that contributes to the assessment is length composition of the catch, and a manuscript that describes the procedures used to estimate length composition of tunas has now been completed. Included in the manuscript is an analysis of the length composition of tunas caught by American seiners in the eastern tropical Atlantic in 1968-1973. In those years, the catch of yellowfin tuna ranged from 0.2 to 1.1 million fish with 1-year olds dominating the 1968 and 1970-1972, and 3-year olds dominating in 1969 and 1973. The annual catch of skipjack tuna was estimated to be 1.2 to 12.8 million fish. One-year olds dominated in virtually all years. Only a few bigeye tuna (530 to 29,400 fish annually) were caught by the American fleet. Four age groups of bigeye tuna were represented but none was dominant.

Sampling Tuna Landings in Puerto Rico

Virtually all Atlantic-caught tuna that are marketed in the United States are landed and packed in Puerto Rico. The landings of U.S. vessels are monitored by the Inter-American Tropical Tuna Commission for the Southwest Fisheries Center under contract. Landings of foreign vessels are monitored by Biological Technician Eugene Holzapfel of the La Jolla Laboratory who is stationed in Mayaguez. One of the primary objectives of this monitoring

program is to collect data on catch, catch-effort, and length frequencies of Atlantic-caught fish landed in Puerto Rico. The data are used to support research on stock assessment of Atlantic tunas which is conducted by the U.S. and other member countries of ICCAT. As of this writing, Mr. Holzapfel collected 33 yellowfin, 14 skipjack, 10 albacore, and 1 bigeye length-frequency samples of 50 fish each from foreign landings.

Data Base System for Tuna Data

At the La Jolla Laboratory, work began in January 1975, to create tuna data bases on the INFONET COM1 system. This system was selected for use because of its capabilities for archiving and managing dissimilar types of data files. Initial phases involved the creation of two data bases for Atlantic tunas, one for length frequencies and total landings by country and gear and one for catch and effort statistics by country and gear. Eventually, tuna statistics from other oceans will be placed on the data bases.

As of this writing flow diagrams for processing, editing and entering data have been completed and total catches by year, area and country have been placed on cards. The data base for length frequencies and total landing by country and gear for Atlantic tunas has been created and are being used in analyses.

SWFC PUBLICATIONS ON TUNA AND TUNA-RELATED ACTIVITIES

OCTOBER 1974 TO SEPTEMBER 1975

PUBLISHED

Clark, N. E., T. J. Blasing and H. C. Fritts. 1975. Influence of interannual climatic fluctuations on biological systems. Nature 266: 302-305.

Growth patterns of conifers in western North America and the population distribution of albacore tuna (Thunnus alalunga) along the west coast of North America respond, not only to variations in their respective environments but also to interannual changes in large-scale atmospheric flow patterns which are modified by air-sea interaction processes over the eastern North Pacific. Although the systems respond during different times of the year, there is strong evidence that they are actually reacting to the same climatic fluctuations.

Dizon, Andrew E., E. Don Stevens, William H. Neill and John J. Magnuson. 1974. Sensitivity of restrained skipjack tuna (Katsuwonus pelamis) to abrupt increases in temperature. Comp. Biochem. Physiol. 49A: 291-299.

1. Restrained skipjack tuna (Katsuwonus pelamis) signaled by deceleration of heart rate that they could perceive abrupt temperature increases (1° C/sec) as small as 1° C).

2. A thermal stimulus directed into the oral-branchial cavity was more effective in eliciting responses than stimuli delivered to the nasal cavity or the dorsal, anterior quandrant of the body surface.

This finding is discussed in relation to the current belief that thermal sensors in fish are generously scattered over the skin surface.

Eldridge, Maxwell B. and Paul G. Wares. 1974. Some biological observations of billfishes taken in the eastern Pacific Ocean, 1967-1970. NOAA Tech. Rep. NMFS SSRF-675: 89-101.

This report provides data gathered from examination of sport-caught billfish landed at sites in southern California (San Diego) and Mexico (Buena Vista, Baja California, and Mazatlan, Sinaloa) from 1967 through 1970. A total of 2, 056 striped marlin, 821 sailfish, 61 blue marlin, and one black marlin was examined. Information is given on reproduction, average length and condition factor, food habits (1970 only), and parasites of fish examined.

Laurs, R. Michael and Ronald J. Lynn. 1975. The association of oceanic boundary features and albacore tuna in the northeast Pacific. STD Conference and Workship Proceedings, February 12-14, 1975, San Diego, California, pp. 23-30.

The distribution and apparent abundance of albacore tuna during the early-season migration toward the U.S. west coast fishery are related to the oceanographic conditions of the Transition Zone and associated oceanic frontal structure. Cooperative surveys involving a National Marine Fisheries Service research vessel and chartered fishing fessels were conducted during 1972, 1973, and 1974, in a region centered 500 to 1,000 nautical miles offshore California. The findings show that albacore are more readily available within the Transition Zone than outside it and that year-to-year variations in ocean structure are reflected in variations in albacore distribution.

Lenarz, William H. and Eugene L. Nakamura. 1974. Analysis of length and weight data on three species of billfish from the western Atlantic Ocean. Proc. Int. Billfish Symp., Part 2. Rev. Cont. Pap., NOAA Tech. Rep. NMFS SSRF-675: 121-125.

Estimates of parameters of relations among weight, girth, total length, body length, trunk length, and caudal spread were made for blue marlin, and sailfish captured in the western Atlantic. Some sexual differences were found.

Mather, F. J., III, B. J. Rothschild, G. J. Paulik and W. H. Lenarz. 1974. Analysis of migrations and mortality of bluefin tuna, Thunnus thynnus, tagged in the northwestern Atlantic Ocean. Fish. Bull., U.S. 72(4): 900-914.

An analysis is presented on the release and return data from bluefin tuna, Thunnus thynnus, tagged in the northwest Atlantic Ocean from 1954 to 1970. There was an apparent northward movement of fish from the New Jersey area as the fishing seasons progressed. Tag returns from bluefin released in the Long Island and southern New England areas tended to be to the north at first and then to the south. Mean distances between release and return tended to be greater for fish released in the New Jersey area than for the other two areas. Estimates of mortality rates for tagged bluefin were made using the Chapman-Robson method and then adjusted for Type-I and Type-II tag shedding and Type-I tagging mortality. The average estimate of instantaneous fishing mortality is 0.57 and other losses (nature, tagging, and emigration) is 0.68 on an annual basis. The estimate of other losses is considerably higher than the natural mortality that would be expected for bluefin. Evidence is presented suggesting that the rate of emigration may be quite high. The average single season exploitation rate of tagged bluefin was estimated to be 0.33. It was noted that since bluefin may be both immigrating to and emigrating from the fishery the estimate of exploitation may not be

representative of the entire population. Even though validity of available effort data is questionable, regression estimates of mortality and survival rates were amde using catch per effort data. These estimates of survival are lower than those obtained using the Chapman-Robson method.

Matsumoto, Walter M. and Thomas K. Kazama. 1974. Occurrence of young billfishes in the central Pacific Ocean. NOAA Tech. Rep. NMFS SSRF-675: 238-251.

Plankton and other net-caught samples collected on cruises of NMFS Honolulu Laboratory vessels in Hawaiian and central Pacific equatorial waters were examined for billfish larvae and juveniles. In 4,379 net tows, 342 billfish young were found. Larvae of only three of the six billfish species nominally found in the Pacific were taken in the equatorial central and North Pacific: blue marlin, Makaira nigricans, shortbill spearfish, Tetrapturus angustirostris, and swordfish, Xiphias gladius. Two sailfish, Istiophorus platypterus, larvae were taken in New Hebrides waters. The absence of striped marlin, Tetraptures audax, larvae in Hawaiian waters suggests that this species migrates elsewhere to spawn.

Otsu, Tamio. 1974. A report from the National Marine Fisheries Service, Southwest Fisheries Center, Honolulu Laboratory (Honolulu Suisan Kenkyusho no kenkyu katsudo--toku ni katsuo gyogyō kaihatsu shiken--ni tsuite). [In Japanese.] Proceedings 1973 Tuna Research Conference, Shimizu, Japan, February 7-9, 1974. Fisheries Agency, Far Seas Fisheries Research Laboratory, pp. 277-280.

As a means of alleviating the bait problem in the Hawaiian skipjack tuna fishery and to enable this fishery to expand, it was decided that the Honolulu Laboratory would carry out experiments to transport California anchovy to Hawaii to augment the bait supply. The various steps involved in this experiment, and the problems are described. The baitfish problem is also a serious deterrent to Japan's skipjack tuna fishery development program.

Sakagawa, Gary T. 1975. The purse seine fishery for bluefin tuna in the northwest Atlantic Ocean. Mar. Fish. Rev. 37(3): 1-8. (MFR Paper 1126.)

The history of the purse-seine fishery for bluefin tuna in the northwestern Atlantic Ocean is reviewed, and events that contributed to fluctuation of the catch are discussed. The fishery began in 1958 and produced 5,770 MT (metric tons) at its peak in 1963. The catch declined from 4,290 MT in 1970 to about 1,780 MT in 1973. The 1973 catch was landed by a fleet with

about 4,900 MT carrying capacity, which was in excess of the catch. Average length of bluefin tuna in the purse-seine catch decreased from about 140 cm in 1960 to about 89 cm in 1973, owing in part to a southward expansion of the fishing grounds into areas where small bluefin tuna are more available. Prior to 1962, the fishing grounds were centered in Cape Cod Bay. Currently it is centered off New Jersey-New York. The nominal catch rate of Class 3 seiners has fluctuated, but it appears that the prevailing trend in the 1970's is downward with the current rate at a low level.

Shomura, Richard S. and William L. Craig. 1974. Mercury in several species of billfishes taken off Hawaii and southern California. NOAA Tech. Rep. NMFS SSRF-675: 160-163.

The results of analyses of the mercury content of 37 blue marlin, Makaira nigricans, 56 striped marlin, Tetrapturus audax, and three swordfish, Xiphias gladius, are presented. The levels of total mercury found in white muscle of blue marlin caught in Hawaiian waters ranged from 0.19 ppm to 7.86 ppm; the mercury content of the livers of 26 blue marlin ranged from 0.13 to 29.55 ppm. Striped marlin from Hawaii showed a range of mercury levels in white muscle of 0.09 to 1.09 ppm; those from California 0.03 to 2.1 ppm. Livers of nine specimens from the Hawaii catch had mercury levels ranging from 0.05 to 1.53 ppm. Mercury levels ranging from 0.05 to 1.53 ppm. Mercury levels in white muscle of three swordfish were 0.04, 1.71, and 2.10 ppm.

Shomura, Richard S. and Francis William (editors). 1975. Proceedings of the International Billfish Symposium, Kailua-Kona, Hawaii, August 9-12, 1972, Part 1. Report of the Symposium. NOAA Tech. Rep. NMFS SSRF-675, 33 p.

_____. 1974. Proceedings of the International Billfish Symposium, Kailua-Kona, Hawaii, August 9-12, 1972, Part 2. Review and contributed papers. NOAA Tech. Rep. NMFS SSRF-675, 335 p.

Skillman, Robert A. and Marian Y. Y. Yong. 1974. Length-weight relationships for six species of billfishes in the central Pacific Ocean. NOAA Tech. Rep. NMFS SSRF-675: 126-137.

Weight-length relationships for six species of billfishes in the central Pacific were developed by analyzing 20 years of data. Log-linear and non-linear statistical models were fitted to the data by regression analysis, and residuals from the models were tested. Blue marlin, Makaira nigricans (50 to 135 cm FL), male blue marlin ($\geq$135 cm FL), and sailfish, Istiophorus platypterus, apparently have coefficients of allometry less than 3.0. Black marlin, M. indica, and female blue marlin ($\geq$135 cm FL) apparently have coefficients equal to 3.0. Shortbill spearfish, Tetrapturus angustirostris, striped marlin, T. audax, and swordfish, Xiphias gladius, apparently have coefficients greater than 3.0.

Skillman, Robert A. 1975. An assessment of the South Pacific albacore, Thunnus alalunga, fishery, 1953-72. Mar. Fish. Rev. 37(3): 9-17. (MFR Paper 1127.)

From the mid-1960's through the early 1970's, markedly increased effort expended in the South Pacific albacore, Thunnus alalunga (Bonnaterre), fishery was met with a decline of more than 60% in apparent abundance. Further increases in harvesting pressure are proposed. These factors have prompted an assessment of the fishery. Based on the generalized production model of Pella and Tomlinson, a 25% increase in fishing effort over the 1971 level will result in either a small increase in catch or a substantial decline, depending on the measure of fishing effort used.

Squire, James L. 1974. Catch distribution and related sea surface temperature for striped marlin (Tetrapturus audax) caught off San Diego, California. Proc. Int. Billfish Symp., Part 2. Review and contributed papers. NOAA Tech. Rep. NMFS SSRF-675: 188-193.

Records for 4,535 marlin landed at San Diego, California, and related sea surface temperature data were examined for the period 1963 through 1970 to determine time-space distribution and the relationship of catch and sea surface temperatures. For the period 1963 through 1970 the catch of 4,535 marlin was compared to sea surface temperature conditions relative to increased catches.

Catch distribution based on 1963 to 1967 data showed that 76.4% were caught within a 35- by 40-nautical-mile area off San Diego, with the maximum catch being made from mid-August to mid-September. Catch temperatures off southern California calculated for this area from airborne infrared sea surface temperature survey data ranged from 61° F (16.1° C) to 73° F (22.8° C); the mean catch temperature was 67.8° F (19.9° C).

Sea surface temperature conditions based on 2-week average temperature charts issued by the National Marine Fisheries Service indicate that an initial warming of water to an average temperature of 68° F ((20.0° C) or above is related to an increase in catch. When average temperatures were below 68° F (20.0° C), 931 fish were caught; between 58° F (20.0° C), and 70° F (21.1° C) the catch was 1,886 fish; and a further increase to 70° F (21.1° C) or above resulted in a catch of 1,718 fish.

Catch data and isotherm charts, 1963 through 1970, indicate that the continuity of the 68° F (20.0° C) and 70° F (21.1° C) isotherms from off central Baja California to off southern California is associated with improved fishing. When these isotherms were discontinuous the average catch per biweekly period was 82.0 fish; when these isotherms were continuous the average catch was 146.1 fish. The highest average catch per biweekly period (205.3 fish) was recorded when the 70° F (21.1° C) isotherm was continuous.

Squire, James L. 1974. Migration patterns of Istiophoridae in the Pacific Ocean as determined by cooperative tagging programs. Proc. Int. Billfish Symp., Part 2. Review and contributed papers. NOAA Tech. Rep. NMFS SSRF-675: 226-237.

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

During 1954- 1971, 15,540 billfish were tagged. Records show 9,849 striped marlin (Tetrapturus audax), 4,821 sailfish (Istiophorus platypterus), 622 black marlin (Makaira indica), and 248 blue marlin (Makaira nigricans) were tagged during this period. Ninety-seven tag recoveries have been made; these include 85 striped marlin, 10 sailfish; and 2 black marlin. Eighty-one percent of these recoveries were by longline fishing vessels, the remainder by marine sport fishermen.

The tag recovery rates were 0.88% for striped marlin, 0.32% for black marlin, and 0.24% for sailfish. Recovery data for striped marlin tagged in the eastern Pacific show a movement away from the tip of Baja California in a south-to-southwest direction in late spring and early summer. Some recoveries were made of fish tagged near the tip of Baja California and recaptured northwest of the tip of Baja California, Mexico. The migration pattern to the south and southwest at this time of the year may be related to spawning. Striped marlin tagged off southern California show a migration to the south in late summer and early fall. Recoveries of striped marlin in the eastern Pacific were generally short-term (average of 89 days) and covered short distances, averaging 281 nautical miles. Only three of 85 tagged striped marlin, and one of two tagged black marlin, were recovered 1,000 nautical miles or more from the site of tagging. The few recoveries of tagged black marlin (2) and sailfish (10) did not provide sufficient data to determine migration patterns for these species.

_____. 1974. Angler catch rates of billfishes in the Pacific Ocean. Proc. Int. Billfish Symp., Part 2. Review and contributed papers. NOAA Tech. Rep. NMFS SSRF-675: 290-295.

In 1969, 1970, and 1971, marine game fish anglers participating in the Pacific phase of the National Marine Fisheries Service cooperative marine game fish tagging program were asked to complete a postcard form which requested information of the number of days billfishing the angler engaged in and the catches made. From the

17,876 angler days reported, the catch consisted of 10, 234 billfishes. The average for the 3-year period was 0.57 billfish per angler-day or 1.75 days of fishing per billfish. Analysis of data for the geographical areas in the eastern Pacific and Australia (Queensland) where billfishing is conducted resulted in a wide range of catch per effort for all billfish species combined. Off southern California, U.S.A., the catch was 0.10 fish per angler-day, equaling 10.3 days of fishing per fish. Off Baja California, Mexico, records show 0.82 fish per angler-day equaling 1.22 days fishing per fish, and fishing off Mazatlan yielded 1.2 fish per angler-day and 0.82 days fishing per fish. Off Acapulco, Mexico, the results were 0.95 fish per angler-day and 1.05 days per fish. Fishing off Australia the records show 0.55 fish per angler-day equaling 1.83 days per fish.

Struhsaker, Jeannette W., Wayne J. Baldwin and Garth I. Murphy. 1975. Environmental factors affecting stress and mortality of the Hawaiian anchovy in captivity. Univ. of Hawaii, UNIHI-SEA GRANT-TR-75-02.

Nehu (Stolephorus purpureus) is the primary baitfish in the Hawaiian skipjack tuna fishery. The purpose of this study was to increase fishing efficiency by reducing baitfish mortality and time spent baiting.

The following biological and technicological factors were examined for their effect on nehu mortality; salinity, aeration, oxygen, temperature, current, light, tank color, recirculated reduced salinity, buffers, protein skimmer, density, food, disease, and predation. Time of bait capture (night or day) was also examined. A study of these factors and their effect on survival was made during capture and transfer to bait wells, in experimental laboratory tanks, in bait wells on an experimental barge, and in baitwells of commercial vessels while at sea. Results of these studies were applied in designing and testing improved live bait holding facilities.

Uchiyama, James H. and Richard S. Shomura. 1974. Maturation and fecundity of swordfish, Xiphias gladius, from Hawaiian waters. NOAA Tech. Rep. NMFS SSRF-675: 142-148.

Sixteen swordfish, Xiphias gladius, with ovaries ranging in weight from 39 to 20,000 grams were examined. Based on the occurrence of ripe ovaries, time of spawning in Hawaiian waters was estimated. The developmental stages of ova were described. Fecundity was estimated for eight swordfish. Some variability was noted; a positive curvilinear relationship of increase in fecundity with increase in fish size was evident.

Wares, Paul G. and Gary T. Sakagawa. 1974. Some morphometrics of billfishes from the eastern Pacific Ocean. Proc. Int. Billfish Symp., Part 2. Review and contributed papers. NOAA Tech. Rep. NMFS SSRF-675: 107-120.

Length-weight and morphometric data collected over 4 years (1967-70) from sport fisheries at three eastern Pacific locations are presented for striped marlin (Tetrapturus audax), sailfish (Istiophorus platypterus), and blue marlin (Makaira nigricans). The data were gathered from San Diego, California (U.S.A.), Buena Vista, Baja California Sur (Mexico), and Mazatlan, Sinaloa (Mexico).

Regression of eye-fork length and covariance analysis were used to compare maximum body depth, depth at vent, pectoral fin length, dorsal fin height, mexillary length, snout to mandible and snout to posterior orbit lengths between sexes and areas for each species. Regression equations are given for coverting fork length and mandible-fork length to eye-fork length. Based on these conversions our Pacific Ocean data on sailfish are compared with data from the Atlantic Ocean.

Length-weight regressions using both eye-fork length and fork length are given for each species by sex.

Yoshida, Howard O. 1974. Landings of billfishes in the Hawaiian longline fishery. NOAA Tech. Rep. NMFS SSRF-675: 297-301.

Marlins and swordfish, Xiphias gladius, comprised about 34% of the Hawaiian longline catch from 1964-67. Blue marlin, Makaira nigricans, dominated the billfish catch from 1952-61; subsequent to 1963, dominant species was the striped marlin, Tetrapturus audax. Monthly landings and monthly catch rates of these two species showed similar trends.

Yuen, Heeny S. H., Andrew E. Dizon and James H. Uchiyama. 1974. Notes on the tracking of the Pacific blue marlin, Makaira nigricans. NOAA Tech. Rep. NMFS SSRF-675: 265-268.

In July of 1971 and 1972, five Pacific blue marlin, Makaira nigricans, were tagged with temperature-sending, ultrasonic transmitters off the west coast of Hawaii. These were tracked for durations up to 22-1/2 hours. The paths of three showed movement in a northerly direction. The other two showed no movement. Average swimming speed ranged from 2.2 to 3.4 km/h for the three fish tracked. Swimming depths differed considerably among the three.

TRANSLATIONS

Ikebe, Kenzo. 1939. Records of the introduction of top minnows into the South Sea Islands. Nanyo Suisan Joho (South Sea Fish. News) 3(9): 7-10. (Translated from Japanese by W. G. Van Campen for the Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812, 1975, 3 p., Translation No. 10.) [Limited distribution.]

Saito, Shoji and Seiji Sasaki. 1974. Swimming depth of large sized albacore in the South Pacific Ocean--II. Vertical distribution of albacore catch by an improved vertical longline. Bull. Jap. Soc. Sci. Fish. 40(7): 643-649. (Translated from Japanese by T. Otsu, 1974, 12 p., Translation No. 9; available at the Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Shiohama, Toshio. 1974. Yearly variations in catches and sizes of albacore in the Japanese pole-and-line fishery (Saozuri binnaga no gyokakuryo to taicho sosei no keinen henka). Background paper from Procceedings of the 1973 Japanese Tuna Fishery Research Conference, Shimizu, Japan, February 7-9, 1974, p. 273-276. (Translated from Japanese by T. Otsu, 1974, 5 p., Translation NO. 8; available at the Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.)

Suisan Shuho. 1975. The life blood of the skipjack tuna pole-and-line fishery - The problem of baitfish (anchovy) mortality (Katsuo ippon zuri no seimeisen - Katakuchi tairyo-shi no wadai wo otte). Suisan Shuho (The Fishing and Food Industry Weekly) 731: 16-17. January 25, 1975. (Translated from Japanese by Tamio Otsu, 1975, 4 p., Translation No. 11.) [Limited distribution.]

IN PRESS

Gwinn, Sharon and William F. Perrin. Distribution of skin pigment in features of the color pattern of Delphinus delphis (Cetacea: Delphinidae). Fish. Bull., U.S.

Laurs, R. Michael, Charles Hooker, Larry Hreha and Richard Lincoln. A uniform U.S. west coast logbook for albacore tuna, Thunnus alalunga, (Bonnaterre) and coastwide albacore fishery data system. Mar. Fish. Rev.

Laurs, R. Michael and Ronald J. Lynn. The association of oceanic boundary features and albacore tuna in the northeast Pacific. Ensenada Symp. Papers.

Matsumoto, W. M. Distribution, relative abundance and movement of skipjack tuna, Katsuwonus pelamis, in the Pacific Ocean based on Japanese tuna longline catches, 1964-67. Fish. Bull., U.S.

Otsu, T. A report from the National Marine Fisheries Service, Southwest Fisheries Center, Honolulu Laboratory. Proc. Tuna Conf. Japan, 1974 (in Japanese).

Perrin, William F. Distribution and differentiation of stocks of Stenella in the eastern tropical Pacific. J. Fish. Res. Bd. Canada.

Perrin, William F. and William W. Walker. The rough-toothed porpoise, Steno bredanensis, in the eastern tropical Pacific. J. Mammal.

Rothschild, Brian J. and Akira Suda. Population dynamics of tunas. FAO (Chapter in Book).

Uchida, R. N. Reevaluation of fishing effort and apparent abundance in the Hawaiian skipjack tuna, Katsuwonus pelamis, fishery, 1948-70. Fish. Bull., U.S.

Yoshida, H. O. The American Samoa longline fishery, 1966-71. Fish. Bull., U.S.

ADMINISTRATIVE REPORTS

Barham, E. 1974. The porpoise-tuna problem: Review of research progress. SWFC Admin. Rep. No. LJ-74-4, 164 p.

Coan, A. 1975. Length, weight and age conversion tables for Atlantic tunas. SWFC Admin. Rep. No. LJ-75-59, 4 p.

Huppert, Daniel D., William W. Fox, Jr. and David Mackett. 1974. Systems analysis of U.S. and world tuna management problems with recommendations for a NMFS program. SWFC Admin. Rep. No. LJ-74-23, 311 p.

Laurs, R. M. 1975. Oceanography and albacore tuna, Thunnus alalunga (Bonnaterre), in the northeast Pacific during 1974. SWFC Admin. Rep. No. LJ-75-65, 5 p.

Laurs, R. M. and Associates. 1974. Report of joint National Marine Fisheries Service-American Fishermen's Research Foundation albacore studies conducted during 1974. SWFC Admin. Rep. No. LJ-74-47.

Laurs, R. M. R. J. Lynn and N. E. Clark. 1974. Albacore tuna forecasting/monitoring at the La Jolla Laboratory. SWFC Admin. Rep. No. LJ-74-14, 36 p.

Lenarz, W. H. 1974. Cohort analysis of Atlantic yellowfin tuna fishery, 1971-1973. SWFC Admin. Rep. No. LJ-74-50, 7 p.

Lenarz, W. H. and A. Coan. 1974. Assessment of the condition of the North Atlantic albacore fishery. SWFC Admin. Rep. No. LJ-74-48, 11 p.

Lenarz, W. H. and W. W. Fox, Jr. 1974. Production model analysis of Atlantic yellowfin tuna fishery, 1964-1973. SWFC Admin. Rep. No. LJ-74-46, 8 p.

Lenarz, W. H. and J. R. Zweifel. 1974. A theoretical examination of some aspects of the interaction between longline and surface fisheries for tunas. SWFC Admin. Rep. No. LJ-74-45, 35 p.

Miller, F. and R. H. Evans. 1975. Analysis of the environment related to the tuna fishery in the eastern tropical Pacific. SWFC Admin. Rep. No. LJ-74-9.

NOAA, NMFS. 1974. United states report on fishes and research of Atlantic tuna and tuna-like fishes, 1973. SWFC Admin. Rep. No. LJ-74-51, 6 p.

Perrin, et al. 1975. Preliminary estimates of some parameters of growth and reproduction of the eastern spinner porpoise, Stenella longirostris subspecies. SWFC Admin. Rep. No. LJ-75-66.

Porpoise Program Staff. 1975. Progress of research on porpoise mortality incidental to tuna purse-seine fishing for fiscal year 1975. SWFC Admin. Rep. No. LJ-75-68, 73 p.

Rothschild, B. J. 1974. Director's Report to the 25th Tuna Conference on Tuna-Related Activities at the SWFC--Honolulu Laboratory and La Jolla Laboratory. SWFC Admin. Rep. No. LJ-74-8, 25 p.

_____. 1974. Issues in population dynamics of tunas--draft working paper prepared for ICCAT Workshop on the Population Dynamics of Tunas. SWFC Admin. Rep. No. LJ-74-19, 32 p.

Sakagawa, G. T. 1975. Preliminary 1974 U.S. fishery statistics on Atlantic tunas. SWFC Admin. Rep. No. LJ-74-53.

Smith, T. 1975. Current understanding of the status of the porpoise populations in the Black Sea. SWFC Admin. Rep. No. LJ-75-13.

_____. 1975. Estimates of sizes of two populations of porpoise (Stenella) in the eastern tropical Pacific Ocean. SWFC Admin. Rep. No. LJ-75-67, 82 p.

Squire, J. 1975. Cooperative marine game fish tagging program--Pacific area. SWFC Admin. Rep. No. LJ-74-55, 5 p.