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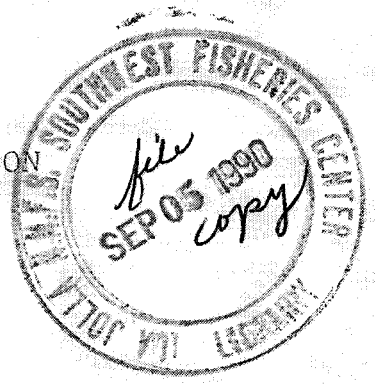

DIRECTOR'S REPORT

TO THE

THIRTIETH TUNA CONFERENCE

ON

TUNA AND TUNA-RELATED ACTIVITIES

AT THE

SOUTHWEST FISHERIES CENTER
LA JOLLA, CALIFORNIA

FOR THE PERIOD
APRIL 1, 1978 TO MAY 1, 1979

MAY 13 - 16, 1979

SWFC ADMINISTRATIVE REPORT NO. LJ-79-12

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INTRODUCTION

Tuna research in the National Marine Fisheries Service, with the notable exception of work on the Atlantic bluefin which is carried on in the Southeast Fisheries Center in Miami, Florida, has been the responsibility of the Southwest Fisheries Center since 1971.

At its laboratory in Honolulu, Hawaii, scientists led by Director Richard Shomura are seeking to determine the variables that influence the ecology of tropical tunas through their behavioral and physiological responses to environmental alterations under controlled experiments; investigating thermoregulation in tunas through use of telemetry techniques; calculating the caloric cost of swimming tuna at various velocities to construct a balanced energy budget; studying the etiology of "burnt" tuna; studying biological communities and deploying anchored floating objects to aggregate skipjack and yellowfin schools; analyzing basic fishery statistics on tunas, billfishes and other important pelagic species of interest to U.S. commercial and recreational fishermen to elucidate the biological factors affecting fish population dynamics, biomass production and yield potential; monitoring tuna fishing activity; and preparing catch and effort statistics and economic data on market transactions.

Some of the scientific achievements of the SWFC's Honolulu laboratory in tuna research in past years include the following:

•Locating a concentration of large, deep-swimming tunas in an equatorial band and determining their relationship to the oceanographic and meteorological features of the Pacific Ocean.

•Maintaining tunas in captivity for extended period. The Honolulu Laboratory was the first research laboratory to do so and even today, no other facility in the world captures and holds skipjack. This development has opened the way for the Honolulu Laboratory and visiting scientists to conduct significant experiments on the behavior and physiology of tunas including describing the visual acuity of skipjack tuna and kawakawa; determining the hydrodynamics of kawakawa and its effect on behavior; and obtaining conclusive evidence that yellowfin tuna can physiologically thermoregulate.

•Elucidating the migration of the albacore and skipjack tuna in the Pacific.

•Identifying the larvae and juveniles of yellowfin and skipjack tunas and determining their distribution.

•Providing an estimate of the potential yield of the skipjack tuna resources in the Pacific Ocean. The Honolulu Laboratory studies have contributed to the dramatic development of skipjack tuna fishing activities in the western tropical Pacific.

•Developing anchored fish aggregating systems in Hawaii waters to enhance commercial and recreational fishing success for pelagic fishes; e.g., tunas, billfishes, etc.

•Determining the cause of "honeycombing" in skipjack tuna and developing procedures to prevent this condition. The recommendations resulting from this study were instrumental in reducing considerable losses to the Hawaii skipjack tuna industry.

•Determining the spawning habits of albacore in the South Pacific including a description of the spawning season and major spawning grounds.

Tuna research at the La Jolla Laboratory is centered within the Oceanic Fisheries Resources Division, led by Dr. Gary Sakagawa. Work in progress emphasizes population dynamics of tunas to determine the effects of fishing and to provide management advice on tunas and billfishes to U.S. delegations to international tuna management commissions; development and refinement of methods and technology to reduce further porpoise mortality incidental to yellowfin tuna purse seine fishing; determination of the status of dolphin stocks involved in the tuna fishery in the eastern tropical Pacific. This Division also operates a fishing information system for the eastern tropical Pacific and west coast albacore tuna fisheries and conducts research on the economics of tuna fisheries.

The staff of the La Jolla Laboratory's Coastal Fisheries Resources Division, in cooperation with the fisheries departments of the states of California, Oregon and Washington (coordinated in part by the Pacific Marine Fisheries Commission), with the industry-funded American Fishermen's Research Foundation, and with scientists from Japan, Korea, Taiwan, and Canada, carries out research on oceanographic interactions and the availability and vulnerability of albacore to the U.S. fishery.

Recent achievements in tuna research at La Jolla include:

•An order of magnitude decrease in incidental marine mammal mortality as a result of the NMFS program of innovative purse seine gear modifications and marine mammal releasing techniques developed with the cooperation of the U.S. tuna purse seine fleet. Incorporation of these mortality-reducing techniques and technology into purse seining operations is an important milestone toward the eventual goal mandated by the Marine Mammal Protection Act of 1972 to reduce marine mammal mortalities incidental to commerical fishing to insignificant levels.

•Determination of the impact of incidental marine mammal mortality on the populations in the eastern tropical Pacific Ocean. This is a critical requirement of the Marine Mammal Protection Act in order to issue a permit to the U.S. tuna purse seine fishery for fishing for tuna associated with marine mammals.

•Development of a system for monitoring the incidental mortality of 21 stocks of marine mammals on a weekly basis.

- Determination of the status of albacore, yellowfin, skipjack and bigeye tuna stocks of the Atlantic Ocean as required by the Standing Committee on Research and Statistics of the International Commission for the Conservation of Atlantic Tunas to which the U.S. is signatory.

- With scientists of the Far Seas Fisheries Research Laboratory of Japan determination of the condition of the North Pacific albacore stock and evaluation of the impact of the fisheries.

- Provision of technical expertise for development of a Fisheries Management Plan for Pacific billfishes.

- Continuation of cooperative field studies with the American Fishermen's Research Foundation which have yielded new knowledge about the North Pacific albacore resource. The albacore tuna off North America apparently represent two independent and geographically separate groups with apparent different migration patterns.

Izadore Barrett, Director
Southwest Fisheries Center

May 1979

IN SUPPORT OF EXISTING INTERNATIONAL AGREEMENTS

STATUS OF NEGOTIATIONS CONCERNING A REPLACEMENT ORGANIZATION FOR THE INTER-AMERICAN TROPICAL TUNA COMMISSION (IATTC)

Efforts to renegotiate the Inter-American Tropical Tuna Convention (in force since 1949) to allow for historical demands of the coastal State members of the IATTC for coastal state preferences in the form of increased guaranteed allocations of the resource continued in 1978. Until recently, these demands were successfully met through a series of compromise arrangements which allowed for closed season resource allocations for developing countries based on hardship criteria. Dissatisfaction with these arrangements and changes brought about by adoption of extended fishery legislations culminated in 1977 with Mexico and Costa Rica announcing their withdrawal from the IATTC. In September of that year a meeting of Plenipotentiaries to develop new conservation and management arrangements for tuna in the eastern tropical Pacific was held.

During the last two years the U.S. Government has responded to these developments by producing a series of options and working papers. These papers have attempted to develop a U.S. position which would minimize the impact of any new arrangements on the U.S. tuna fleet but which would be responsive to the issues raised by the coastal states.

Efforts to resolve the issues within the context of the present IATTC (a strategy preferred by the United States) continue to be unsuccessful and it is now apparent that continuation of a management and conservation regime for tuna in the eastern tropical Pacific will depend on the negotiation of a new treaty which includes as a minimum provisions for an international licensing scheme, a system for allocation of the resource to the coastal states on the basis of some form of coastal state preference and an international surveillance and inspection system.

With input from scientists at the Southwest Fisheries Center, the U.S. has now drafted its own proposal for addressing the issues. These papers include the tuna and marine mammal conservation and management principles and annexes on allocation of the tuna resources, an international surveillance and inspection system, tuna/porpoise research and a licensing scheme.

While U.S. industry representatives have agreed that an international licensing scheme which guarantees access to the resource throughout its migratory range in exchange for payment of uniform and reasonable fees to the international organization is a practical provision in any new arrangement, their reaction to the development of an allocation scheme has been mixed. A number of models for devising the allocation of the eastern Pacific regulated tuna resource have been developed and discussed within the U.S. delegation with inconclusive results. Regardless of the criteria employed to develop an allocation system, the amount of regulated tuna available to the U.S. fleet for capture during the open season will be reduced from the amount available under current arrangements. The negotiation of an allocation scheme acceptable to all participants is likely to be the most difficult of the issues to resolve.

Delegations from Mexico, Costa Rica, and the United States met March 7-8, 1979 in Washington, D.C. to discuss positions on the remaining issues in the eastern Pacific tuna negotiations. The impasse in the negotiations remains despite efforts to resolve the differences. Substantive proposals introduced by the Mexican delegation on the questions of guaranteed allocations of yellowfin tuna to coastal states, the last trip, and special allocations to disadvantaged vessels were judged inadequate by the U.S. delegation in meeting the needs of the U.S. tuna fleet.

As of this writing (May 3-4, 1979), U.S.-Mexico bilateral/fisheries consultations are underway in Mexico City where several options regarding the U.S. position on the subject of the guaranteed annual allocations of yellowfin tuna to the coastal states under a new eastern Pacific tuna treaty will most probably be presented by the U.S. delegation. Izadore Barrett, Center Director, is serving as a scientific advisor to the U.S. delegation at these talks.

THE FIRST SPECIAL MEETING OF THE INTERNATIONAL COMMISSION FOR THE CONSERVATION OF ATLANTIC TUNAS

As a member of the International Commission for the Conservation of Atlantic Tunas, the U.S. has direct responsibility for Atlantic tuna stock assessment work and for tuna management recommendations. The Commission has been in existence only since 1969 and during the initial years many of its activities centered around administrative and organizational arrangements. With time the issues facing the Commission have become increasingly complex and an effort to resolve some of these problems was the principal reason for the first special meeting of ICCAT held in Madrid, Spain, November 6-21, 1978.

The special meeting was preceded by a meeting of the Standing Committee on Research and Statistics (SCRS) which met from November 6-15. SWFC scientists attending that meeting were I. Barrett, Center Director; Dr. Gary Sakagawa, leader of the Tuna Resources program; Dr. N. Bartoo, fishery biologist; R. Rinaldo, Fishery Biologist; and heading the U.S. scientific delegation, Dr. W. Fox, now Director of the Southeast Fisheries Center in Miami.

Scientists from 12 of the 18 member countries attended the SCRS meeting, reviewed 106 documents, and used the information to determine the current status of tuna and billfish stocks in the Atlantic.

The SCRS found that yellowfin tuna stocks were heavily fished, particularly in the eastern Atlantic Ocean where recent catch increases resulted from offshore expansion of the fishing area. The result of further geographic expansion is uncertain, but future catch levels will be influenced by mortality of small yellowfin tuna, which currently appears to be high. The SCRS recommended firm application of the 3.2 kg minimum size regulation.

The SCRS judged that skipjack tuna stocks had a larger potential catch than the record high of 118,000 metric tons obtained in 1977, although the status of the stocks is not clear.

Bluefin tuna stocks were found to be at low abundance levels. Stock abundance had been decreasing and now appears to be stabilized with a low recruitment. The SCRS expects an increase in the mortality of medium to large fish, if the catch remains at levels of recent years. The scientists recommended that current regulations establishing at 6.4 kg minimum size and restricting fishing mortality no more than that to recent levels be maintained.

The SCRS found that the south Atlantic albacore stock was harvested at about maximum sustainable yield, but that the north Atlantic albacore stock was overfished. Recruitment to the north Atlantic fishery is quite variable and is presently at about 20 to 25% of the 1957 level. The SCRS recommended that the Commission prepare to adopt strong management measures if analyses in 1979 should indicate a need to increase the north Atlantic albacore spawning stock.

Bigeye tuna stocks were found to be in good condition. The SCRS noted a large number of small bigeye tuna were being caught and recommended that a 3.2 kg minimum size regulation be adopted. The scientists considered that such a regulation would also solve the problem of undersized yellowfin tuna being landed and reported as bigeye tuna.

The SCRS found that white marlin stocks were harvested near maximum sustainable yield levels, while the blue marlin stocks were being overfished. The SCRS recommended that the Commission prepare to adopt management measures if continued analysis showed that either species was overfished.

The scientists also approved a detailed proposal for an ICCAT International Skipjack Year Program. The Program is a coordinated, Atlantic-wide research effort investigating the population biology of skipjack tuna. The objective of the program is to obtain information on the population biology of the stocks in order to develop more precise management advice for the Commission. A bluefin tuna workshop for 1979 was also approved by the SCRS.

Barrett and Sakagawa attended the Commission meeting, November 15-21, serving as scientific advisors to United States ICCAT Commissioners C. Blondin, H. Cary, and F. Carlton. Representatives of 16 of the 18 ICCAT member countries attended the Commission meeting. The representatives endorsed the International Skipjack Year Program and adopted the first year's budget. A 3.2 kg minimum size regulation on bigeye tuna was adopted to complement the current 3.2 kg minimum size regulation on yellowfin tuna. This regulation has subsequently been suspended until clarification of the voting procedure used to adopt the regulation. No new bluefin tuna regulations were adopted, but a proposal to establish separate east and west management units was discussed. The special meeting closed with an agreement that the Sixth Regular Meeting of the Commission would be held in Madrid, Spain during November 14-21, 1979.

INTERNATIONAL SKIPJACK YEAR PROGRAM

Center scientists were involved during the past year in the development of an intensified Atlantic-wide skipjack tuna research program sponsored by the International Commission for the Conservation of Atlantic Tunas (ICCAT). Dr. Gary Sakagawa, Chief of the Oceanic Resources Division at the La Jolla Laboratory, who is the Convenor of the Subcommittee on Skipjack for ICCAT's Standing Committee on Research and Statistics (SCRS), reported that the Commission officially adopted the "International Skipjack Year Program" at the First Special Session of the Commission in Madrid, Spain in November 1978. Acceptance of the program followed two years of planning by scientists of member countries.

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

The program is designed as an ICCAT-coordinated activity specifically to obtain information on the skipjack tuna stocks through an intensive research effort that addresses four basic questions on skipjack tuna:

1. Can catches of skipjack tuna be increased by fishing new areas (and presumably new stocks), especially in the western Atlantic?

2. Can catches of skipjack tuna be increased by fishing other elements of the currently exploited stock, especially fish over 5 kg?

3. What could be the effects of the above two actions, if successful, on the existing fisheries?

4. How can better assessments be obtained of the existing fisheries? In particular, will increasing effort in these fisheries significantly increase the total catch?

Fundamental to answering these questions adequately is knowledge on the distribution of skipjack tuna stocks; the relation of skipjack tuna to the environment; estimates of abundance of skipjack tuna; the relation among abundance, catch-per-unit-of-effort, fishing effort and fishing mortality; stock structure of the population; and estimates of basic population dynamics parameters. A set of 13 research activities specified in the plan would provide the required basic information and knowledge for answering the questions.

As the proposed program is currently designed, it is to extend for 4 years: starting with a preparatory-planning phase in the first year (1979), continuing into a limited execution phase in the second year (1980), rising to a peak "International Skipjack Year" phase in the third year (1981), and winding down with an analytical-evaluation phase in the fourth year (1982).

The proposed program is designed as one in which ICCAT would coordinate the collective inputs of ICCAT member countries and other interested parties rather than as a fully ICCAT-funded and controlled program.

Nine activity teams have been organized to direct the 13 research activities and a Skipjack Coordinator has been employed by ICCAT to integrate the research efforts of the member countries. Dr. P.E. Symonds, a Canadian fishery biologist, was selected as ICCAT Skipjack Coordinator and assumed the post in April 1979.

U.S. scientists cooperating on activity teams are as follows:

Tagging:	Dr. W.H. Bayliff, IATTC
Fishery Oceanography:	Dr. M. Laurs, SWFC Mr. Richard Evans, SWFC Dr. F. Williams, University of Miami
Genetics:	Dr. G. Sharp, FAO
Aging:	Dr. G. Sakagawa, SWFC Dr. A. Wild, IATTC
Exploratory Fishing:	Mr. J. Squire, SWFC

The U.S matching contributions will consist of a three-month research cruise and a four-month tagging project. Planning for a skipjack tuna tagging project in the western Atlantic in 1980 and a project to place fishery observers on commercial tuna vessels fishing in the Atlantic in 1981 has started, according to R. Rinaldo, Fishery Biologist. A contract to prepare planning documents for these projects was awarded to Living Marine Resources, Inc., San Diego in February 1979.

The primary purpose of the western Atlantic tagging project is to gain a better understanding of the distribution, migration and stock structure of skipjack tuna in the western Atlantic. Fishing and biological information collected by the fishery observers will be used in the analysis of fishing effort and catch in the multispecies Atlantic tuna fishery.

RESULTS OF TUNA RESEARCH AT SOUTHWEST FISHERIES CENTER PRESENTED AT ICCAT

Research for ICCAT - 1978

The U.S. commitment to the International Commission for the Conservation of Atlantic Tunas (ICCAT) resides primarily in the Southwest Fisheries Center and specifically with the staff of the Tuna Resources Program at La Jolla, California led during this past year by fishery biologist Dr. Gary Sakagawa.

Biologists and mathematicians of the Tuna Resources Program completed an array of documents on stock assessment analyses for Atlantic yellowfin, skipjack, bigeye tuna, and albacore which were presented at the meeting of the Standing Committee on Research and Statistics (SCRS) of the ICCAT. Briefly, these papers may be summarised as follows:

Yellowfin-skipjack

The Atlantic yellowfin-skipjack tuna fishery was examined, with particular emphasis on the American fishery, by Dr. G. Sakagawa, leader of the Tuna Resources Program in La Jolla, A.L. Coan, mathematician, and T.C. Murphy, fishery biologist. In the paper, "A review of the yellowfin-skipjack tuna fishery of the Atlantic Ocean and American participation, 1965-75," they describe the tropical tuna fishery as the largest tuna fishery in that Atlantic, with approximately 174,000 metric tons of yellowfin and skipjack landed in 1975. The eastern tropical surface fishery for yellowfin tuna has grown since 1969, while longline catch has stabilized at about 30,000 metric tons. The skipjack tuna fishery, also primarily in the eastern tropical Atlantic, produced a record high catch of 114,700 metric tons in 1974, but declined sharply to 59,500 metric tons in 1975.

American participation in the Atlantic fishery began in 1967, grew rapidly in 1969 to 27 vessels, and peaked in 1972 with 36 vessels participating in the tuna fishery off Africa. In 1975, 32 American tuna seiners participated in the eastern Atlantic fishery and their total catch was 13,960 metric tons of yellowfin tuna and 7,370 metric tons of skipjack tuna. The authors conclude that both stocks appear to be in good condition. The yellowfin tuna stocks are capable of yielding larger catches, but probably at reduced catch-per-unit of effort. Future catches of skipjack tuna are expected to vary markedly, because the skipjack tuna fishery is dependent on one or two year classes and the amount of fishing effort is dependent on the availability and abundance of the co-target species, yellowfin tuna.

The status of the yellowfin tuna stocks was investigated by Coan and Dr. W. Fox, now Director of the Southeast Fisheries Center in Miami. In their paper, "A production model analysis of yellowfin tuna, (Thunnus albacares) stocks in the Atlantic Ocean, 1964-1977," production model analyses were performed to determine how the status of stocks were affected

by the expansion of the fishery into a new offshore area in the eastern Atlantic Ocean. Large purse seiners, of carrying capacity greater than 450 metric tons, are the primary vessels involved in fishing this new offshore area. The authors approached the assessment for the eastern Atlantic surface fishery with two standardization of effort procedures. The result of production model analysis on data standardized without using the high catch rates of the large purse seiners gave an estimated maximum sustainable average yield (MSAY) of 116,000 metric tons. Their analysis with large purse seine data included in the standardization procedures resulted in a MSAY estimate of 143,000 metric tons. The authors concluded that the status of the Atlantic yellowfin tuna stocks, as judged only by production model analysis, appears to be more optimistic than in previous analyses owing to recent increases in yield from offshore expansion of the surface fishery. The authors note that any sustainable increases in catch are very uncertain and the fishery should continue to receive careful scrutiny.

Dr. N.W. Bartoo, fishery biologist, and Coan completed an analysis on "Changes in yield per recruit of yellowfin tuna (Thunnus albacares) under ICCAT minimum size regulation," (3.2 kg). The authors performed a cohort analysis on aged catch data to estimate the entire fishery equilibrium yield per recruit (Y/R) for the pre-regulation period, 1966-1972, and the post-regulation year, 1975. Recruitment to age I was estimated for birth years 1965-1975. Y/R isopleths calculated with this analysis indicated that longline fishery experienced a drop in equilibrium Y/R of 57% between the pre- and post-regulation period. The purse seine fishery experienced an increase of 55% in equilibrium Y/R, due to increased catches of older fish. The baitboat fishery experienced a decline in equilibrium Y/R of 45%, due to decreased catches of older fish and increased catches of age I fish. The authors conclude that increasing fishing effort without changing size at recruitment or age structure of the catch will result in slight losses in Y/R to the purse seine and longline fishery. The baitboat fishery will realize slight Y/R gains by increasing fishing effort without changing size at recruitment. A generalization of the results of the recruitment estimates indicated that either recruitment has been increasing or that the 1965, 1967, and 1968 year classes were weaker than average. Current evidence suggests that the latter case is more likely.

Yellowfin-Bigeye

Sakagawa and Coan examined the problem of misidentification of young yellowfin tuna and young bigeye tuna and produced a document entitled, "Adjusted catches of yellowfin and bigeye tunas for the 1976 Atlantic fishery." Young yellowfin tuna and bigeye tuna are very difficult to tell apart. The authors note that there is no economic incentive for fishermen or fishbrokers to separate the catches of these fish and to accurately record the catch statistics. This leads to inaccuracy in the catch statistics reported by the ICCAT. Sakagawa and Coan reviewed the misidentification problem and provided estimates of adjusted bigeye and yellowfin tuna catches for 1976, using species composition and/or

length frequency data. In the authors' opinion, the best estimates are 12,100 metric tons for bigeye tuna and 93,300 metric tons for yellowfin tuna for the surface fishery. In contrast, the reported surface fishery catch, according to official ICCAT statistics, is 12,800 metric tons for bigeye tuna and 92,800 metric tons for yellowfin tuna.

The "Effects of Atlantic yellowfin (Thunnus albacares) stock structure hypotheses on production model analysis" were examined by R.G. Rinaldo, fishery biologist, and Coan. They investigated six hypothetical stock structures: an eastern Atlantic stock, an inshore eastern Atlantic stock, a surface eastern Atlantic stock, a deep eastern Atlantic stock, and offshore eastern Atlantic stock, and a total Atlantic stock, using production model analysis for the yellowfin tuna fishery, 1964-76. In addition, they examined the effect of misidentified young yellowfin tuna-bigeye tuna in the catch statistics on production model analysis. The resulting maximum sustainable average yields for the best fitted production model ranged from 13,000 metric tons for the eastern Atlantic longline fishery to 142,300 metric tons for the total Atlantic fishery. Their results indicate that the effects of stock structure uncertainty appear to be minimal in most cases. Maximum sustainable average yield values were approximately 10% higher when yellowfin tuna landing data for 1964-1976 are adjusted for inaccurate reporting of bigeye tuna and yellowfin tuna.

Albacore

The status of the south Atlantic albacore was examined by Bartoo. In his paper, "An examination of the harvest status of south Atlantic albacore," two production model analyses were performed to estimate maximum sustainable yield (MSY) of the stock using two treatments of the basic data: nominal annual effort with total catch. Although all data sets used with the production model indicated substantial increases in yield are available, the MSY indicated by the two analyses did not agree. This lack of agreement suggests that additional research on standardization should be done if catches begin to increase. The author also performed a cohort analysis on age composition data from the south Atlantic stock to produce an age-specific fishing mortality vector for use in estimating equilibrium yield per recruit (Y/R) to the fishery. The fishery is currently realizing a Y/R of about 7.65 kg. The analysis indicated that increases in effort, or size, at recruitment will produce only slight changes in the Y/R.

Bartoo also investigated the status of the north Atlantic albacore stock. In his paper, "The status of the north Atlantic albacore (Thunnus alalunga) stock," he used a cohort analysis to estimate recruitment to age 1 for the 1963 to 1971 cohorts. Recruitment estimates were quite insensitive to changes in fishing mortalities at older ages. Catch per effort of longline-caught albacore was used as a parent stock index to develop a spawner-recruit relation. The results show the current adult albacore population to be about 1/3 to 1/4 or less of its original size. A period of increased variation in recruitment from 1968 to 1974 corresponds to low parent stock abundances. The Y/R of the entire north Atlantic

albacore fishery was estimated to be between 3.83 and 4.03 kg., depending on the assumed natural mortality rates. At the current size of recruitment, a reduction in fishing effort of between 20% and 50% is required to maximize Y/R to the fishery. The actual realized gain in Y/R would be between 1% and 12% depending on natural mortality rates chosen.

Dr. Andrew Bakun of the Pacific Environmental Group at Monterey, California, has analyzed available data and presented a description of "Guinea Current upwelling" for submission to the ICCAT. He presents a comparison of summer-fall upwelling to July-October rainfall in Ghana and to the catch of the Ghanaian herring fishery. The author concludes coastal rainfall are associated with strong upwelling.

American Tuna Fisheries Statistics Reported to ICCAT

Preliminary 1978 statistics on the American fisheries for tropical and temperate tunas in the Atlantic Ocean have been reported to the International Commission for the Conservation of Atlantic Tunas (ICCAT) in Madrid, Spain. The U.S. is a founding member of ICCAT. Coan reports that these statistics, prepared with the assistance of Ronald G. Rinaldo, fishery biologist, and Robert Nydam, computer technician, include data on catch, catch and effort, and length frequencies of the catch for the American Atlantic tuna fleet. According to preliminary statistics, 27 American tuna vessels fished in the Atlantic in 1978, catching 21,225 metric tons (MT) of tuna and tuna-like species. The predominant species caught were yellowfin tuna, 9,902 MT, and skipjack tuna, 8,429 MT. Included in the report were tables for each of the major species showing catch and fishing effort by ICCAT area, by month, and by 1° to 5° squares for the eastern, midwestern, and northwestern Atlantic. Length-frequencies of the American catch were reported in tabular form as determined by area and month from 26 samples of yellowfin tuna, 29 samples of skipjack tuna, and 6 samples of bigeye tuna.

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Length-frequencies of Atlantic tunas from foreign transshipments of catches into Puero Rico were sampled during 1978 by Eugene Holzapfel, biological technician. Species composition of the catch was recorded and 192 samples (9,611 fish) were collected to determine the length-frequency of yellowfin tuna (72 samples), skipjack tuna (60 samples), bigeye tuna (53 samples) and albacore (7 samples). These data were reported in tabular form by year and quarter.

TUNA STOCK ASSESSMENT WORKSHOP SCHEDULED IN SHIMIZU, JAPAN

In the report to the Twenty-Ninth Tuna Conference, an announcement was made of a Tuna Stock Assessment Workshop to be held in Honolulu in May 1979. The workshop, now scheduled for June 1979 in Shimizu, Japan under the joint sponsorship of the Far Seas Fisheries Research Laboratory and the Southwest Fisheries Center, Honolulu Laboratory, will (1) review the status of tuna stocks (excluding skipjack tuna) in the central and western Pacific Ocean and (2) review the status of stocks of tunas (excluding skipjack tuna) and billfishes in the Indian Ocean. The need for this workshop became evident at the Indo-Pacific Fishery Commission/ Indian Ocean Fishery Commission (IPFC/IOFC) Tuna Management Committee Meeting held in Manila, March 8-17, 1978. The material available to the participants was inadequate for any indepth review of tuna management and resulted in very little substantive accomplishments during the meeting, as has also been true for all previous Tuna Management Committee meetings of IPFC/IOFC. Thus, the intent of the workshop is to bring together and review (1) comprehensive status-of-stocks papers on tunas (excluding skipjack tuna) and billfish covering large geographical areas in the central and western Pacific and the Indian Ocean; (2) papers providing detailed estimates of catch and effort data by suitable time and space strata; and (3) papers providing management options and analysis of their consequences, which should enable more meaningful discussions at the next IPFC/IOFC Tuna Management Committee meeting.

Richard S. Shomura, Honolulu Laboratory Director, has been working with Dr. Shoji Ueyanagi, Far Seas Fisheries Research Laboratory in making arrangements for the workshop. The tentative list of participants includes Dr. J. Gulland, Food and Agriculture Organization; Dr. J. Joseph, Inter-American Tropical Tuna Commission; Dr. R. Kearney, South Pacific Commission; B.Y. Kim, Republic of Korea; Dr. G. Murphy, Commonwealth Scientific and Industrial Research Organization; Dr. S. Ueyanagi, Japan; and Dr. R.T. Yang, Taiwan. Participants from the Southwest Fisheries Center will include Dr. G. Sakagawa and Dr. N. Bartoo, La Jolla Laboratory; R. Shomura, Dr. R. Skillman and Dr. J. Wetherall, Honolulu Laboratory.

IN SUPPORT OF POSSIBLE FUTURE INTERNATIONAL AGREEMENTS

NORTH PACIFIC ALBACORE

The albacore stock of the North Pacific Ocean supports major Japanese and U.S. fisheries and minor Canadian and Korean fisheries. In recent years the total annual catch has risen from about 70,000 MT to 122,000 MT primarily due to expansion of the Japanese pole-and-line fishery. Although the Japanese take about 2/3 of the catch, most of the remaining 1/3 is taken by the United States.

Because of concerns about the status of the stock, the Third North Pacific Albacore Workshop was held at the National Marine Fisheries Service (NMFS) laboratory in Honolulu, Hawaii, on 13-14 September 1978. The event was part of a continuing informal arrangement established in 1974 between NMFS' Southwest Fisheries Center and the Far Seas Fisheries Research Laboratory, Shimizu, Japan, to promote and accelerate joint investigations into the biology, ecology, and population dynamics of North Pacific albacore, Thunnus alalunga. Two other workshops have been held; the first in Honolulu in December 1975 and the second at Shimizu in May 1977.

The third meeting was attended by scientists from the two principal agencies and by biologists representing the California Department of Fish and Game, the Oregon Department of Fisheries and Wildlife, the Washington Department of Fisheries and Fisheries and Environment Canada. Dr. Jerry Wetherall of the Honolulu Laboratory was Chairman and Dr. Norman Bartoo, La Jolla Laboratory and Mark Pederson, Washington Department of Fisheries, assisted by Dr. Gary Sakagawa of the La Jolla Laboratory, were rapporteurs. Other participants included Dr. Michael Laurs, La Jolla Laboratory; Richard Shomura and Marian Yong, Honolulu Laboratory; Fred Hagerman, CF&G; Dr. Sigeiti Hayasi, Tohoku Regional Fisheries Research Laboratory and Toshio Shiohama, Far Seas Fisheries Research Laboratory, Japan; Larry Hreha, Oregon Department of Fish and Wildlife; and Dr. Keith Ketchen, Fisheries and Environment, Canada.

The several purposes of the most recent workshop were: (1) to review the status of the various North Pacific albacore fisheries during 1978-79, to exchange fishery data, and to update basic statistical tables; (2) to exchange views, ideas, and research results on albacore stock assessment and ecology through the presentation and discussion of working papers; and (3) to produce a current assessment of the North Pacific albacore resource and prepare recommendations for continued cooperative research.

Following the Third North Pacific Albacore Workshop, a concentrated stock assessment research effort was begun at the La Jolla Laboratory to evaluate the stocks' status and address several of the workshop's recommendations. The assessment is being conducted by Bartoo and Earl Weber of the Tuna Resources Program, who are concentrating on updating the catch age structure, estimating fishing mortality rates and yield-per-recruit realized by the various fisheries and determining possible spawner and recruit relations.

COOPERATIVE NMFS-AFRF ALBACORE STUDIES

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

During the 1978 albacore season, joint NMFS-AFRF research activities included (1) an extensive tagging program off northern Baja California and central California of the "southern" group of albacore as part of a study of the migration patterns of this group of fish, (2) injection of fish tagged and released in (1) with tetracycline for a special growth study to evaluate the otolith daily-ring technique for aging albacore, and (3) a late season exploratory/research survey in waters several hundreds of miles off California. The NMFS La Jolla Laboratory also cooperated in an exploratory/research survey conducted during spring and summer 1978 and funded by the Pacific Tuna Development Foundation to evaluate the feasibility of jig fishing for albacore by U.S. vessels in the western Pacific. In addition, studies on albacore physiology were conducted in collaboration with medical scientists from the University of California at San Diego School of Medicine, Scripps Medical Clinic and Research Foundation, and Oregon State University. Work also continued in albacore oceanography studies in the California Current and North Pacific Transition Zone.

Tagging Studies

Nearly 2,700 albacore were tagged and released during 1978 bringing the total number of albacore tagged since the start of the cooperative NMFS-AFRF tagging program in 1971 to approximately 15,000. A summary by year of the number of albacore tagged, recovered and percent recovery is given in Table 1.

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

Year	Number of tagged fish released	Number of tagged fish recovered	Percent recovery
1971	887	34	3.83
1972	2082	180	8.65
1973	1805	111	6.15
1974	2486	175	7.04
1975	1349	115	8.52
1976	1581	79	5.00
1977	2061	91	4.42
1978	2688	52	1.93
Unknown	+	6	-
Total	14,939	843	5.64

Albacore Injected with Tetracycline in Age Determination Study

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

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

During the 1978 U.S. albacore season - the second season of the tagging study - tagging and tetracycline injection operations were conducted onboard the commercial albacore baitboat, Linda which was chartered by the American Fishermen's Research Foundation and worked cooperatively with the La Jolla Laboratory.

As of April 30, 1978, 83 injected fish had been recaptured. In 70 cases, the otoliths and information on recapture date were available. Inter-American Tropical Tuna Commission scientists have examined some of the otoliths and have trained NMFS scientists to make the readings with methods modified and developed by IATTC for similar studies on yellowfin and skipjack tunas. It is expected that counting otolith rings from albacore thus far recaptured will be completed by mid-May 1979.

Late Season Investigation of Albacore Distribution Migration

Four albacore jigboats on charter to AFRF worked cooperatively with the La Jolla Laboratory to investigate the migration patterns of albacore as they emigrate from waters off California at the end of the traditional fishing season. A secondary objective of the investigation is to evaluate whether the North American albacore fishery can be extended by boats fishing in the offshore waters of California in late season. The vessels conducted exploratory fishing, made oceanographic observations, and tagged and released albacore between October 16 and November 14, 1978. Results from the 1978 survey did not indicate large concentrations of albacore in the area of operations between 33-42° N latitude and westward to 135° W longitude. However, albacore were found in small numbers in most of the areas fished.

Albacore Trolling Exploration in the Western North Pacific, 1978

In 1978, U.S. albacore jig-fishing vessels conducted exploratory fishing for albacore in the western North Pacific in cooperation with the La Jolla Laboratory for the fourth consecutive year. A major objective of the surveys has been to evaluate the feasibility of jig fishing for albacore in the western North Pacific, especially between 35° to 40° N latitude from about the Emperor Seamount chain, near 170° E longitude. Secondary objectives have been to gain information for use in migration studies of North Pacific albacore and the association of albacore with oceanographic features.

Four albacore jig-fishing vessels, chartered by the Pacific Tuna Development Foundation, participated in the exploratory fishing operations in 1978. The vessels conducted exploratory fishing using standard commercial fishing methods. They also cooperated with the La Jolla Laboratory by keeping detailed daily fishing logs, making daily oceanographic observations (including surface and subsurface temperature measurements), making marine weather observations, and conducting albacore tagging operations. The four chartered vessels left from three locations in 1978. One of the vessels departed San Diego on May 5 and fished westward between 32° to 34° N latitude to north of Hawaii near 159° W longitude, where it rendezvoused with two vessels which left Honolulu in mid-May. The three vessels conducted their operations westward between about 32° to 35° N latitude and were eventually joined by a fourth vessel which departed Seward, Alaska on June 7. The vessels continued to conduct fishing and research operations in the western North Pacific until early September. Refueling was done at Midway Island or Honolulu and reprovisioning and unloading of albacore were done in Honolulu.

The vessels caught approximately 560,000 pounds of albacore. Each vessel unloaded full or near-full loads in Honolulu on two occasions. Best catches were made in late May-early June near 34° N latitude, 175° W longitude, in early July near 38° N latitude, 175° W longitude, and in mid-July near 40° N latitude, 177° W longitude. Catches of 100 to 300 fish per day per boat were common and the top catch for a day was 748. Small or no catches were made between San Diego and north of Hawaii in May and between Hawaii and 170° to 175° W longitude. The size of the albacore ranged from about 5 to 45 pounds with 14 to 20 pound fish often predominating. Average fish size for a trip for each vessel was about 18 to 19 pounds. In addition to albacore, very small catches of skipjack and yellowfin tunas were made. Also, a few yellowtail, mahimahi, rainbow runners and one small marlin were caught.

Fishing success was generally related to ocean conditions. Best catches were usually made near oceanic temperature fronts or "edges." Preliminary examination of vertical temperature distribution from expendable bathythermograph drops indicates that best fishing occurred where the 58° F (14.5° C) isotherm shoaled to within about 200 to 250 feet (60 to 75 m) depth and that catches were usually low in areas where the 58° F (14.5° C) isotherm was deeper than about 350 feet (105 m).

The four chartered vessels tagged and released 492 albacore during 1978. The tagging in 1978 brings the total number of albacore tagged in the western North Pacific by U.S. jigboats conducting exploratory trolling there to 802. Nine of the 802 albacore have been recovered and all were recovered by

Japanese live-bait fishermen in the western North Pacific. Six of the recoveries were made the same year as they were released after being at liberty a day to several weeks. All of these recoveries were made east of the locations where they were released, indicating an eastward migration of the tagged fish. Three of the tagged fish were recovered during the fishing season following the one they were released. While there have been no recoveries made off the coast of North America of fish tagged by U.S. boats in the western North Pacific, there have been two recoveries of tagged albacore made off the Columbia River in late September and early October 1974 of fish tagged by Japanese fishery scientists in mid-June 1974 in the Emperor Seamount chain near 34° N latitude, 171° E longitude. The results from albacore tagging in the western North Pacific indicate that albacore move eastward across the North Pacific during the spring and summer months and that fish found in the western North Pacific near the Emperor Seamount can migrate to waters off the Pacific Northwest by early fall of the same year.

Albacore Physiology Studies

An 8-day albacore physiology cruise was conducted on the David Starr Jordan during September 1978. The success of the cruise was limited because of the inability to catch albacore. Nevertheless, some data were collected on cardiac output and blood pressure. In addition, studies on albacore hematology were carried on. Two manuscripts dealing with albacore physiology were published during 1978 and three additional manuscripts were completed for submission for publication.

Oceanography of North Pacific Transition Zone Described

R. Lynn, Oceanographer, is preparing the text of a manuscript on the oceanography of the Transition Zone in the eastern North Pacific and the subarctic and subtropical ocean fronts which form its boundaries. The manuscript is based on hydrographic data collected during six albacore-oceanography cruises conducted during each June of the years 1972 through 1977. Albacore are associated with these mid-ocean features and their migration, availability and relative abundance is influenced by the degree of development of the fronts. Analyses of oceanographic data from these surveys demonstrate that the ocean fronts are major features of the upper 200 meters of the ocean and that the frontal region has considerable dynamic activity with flows and counterflows. Initial calculations of transport, which integrates the velocity over depth and across broad regions, shows that there is a net eastward flow about the fronts but not within the Transition Zone. These calculations are sensitive to the choice of the grouping of stations and will be compared and checked with other data. Meridional hydrographic sections taken by Scripps Institution of Oceanography in other seasons are being used for comparison.

The manuscript also describes features of the ocean fronts which appear to be characteristic of longitudes east of 150° W, including large-scale inter-leafing of water masses along the fronts, and large-scale meanders of the subarctic front as its position decreases in latitude in an eastward direction. In addition, the paper discusses large interannual variation in frontal development.

NORTH PACIFIC BLUEFIN TUNA

North Pacific bluefin tuna is caught primarily by the United States, Japan and Mexico. The total annual catch has fallen to half the levels recorded in the 1960's and it now stands at about 16,000 MT. United States fishermen land about 54% of the catch, Japanese fishermen, 34% and Mexican fishermen, 12%.

The bulk of the U.S. catch is made by small purse seiners, many belonging to the California "wetfish" (anchovy, mackerel, squid, etc.) fleet; a small portion is landed by the tropical tuna (yellowfin and skipjack tunas) fleet. The catch is made in areas off southern California and Mexico. Mexican catches are made off Mexico by the Mexican tropical tuna fleet. The Japanese catch is made primarily off the Japanese Archipelago and in the Philippine Sea by a fishing fleet that uses an assortment of fishing gears.

Some monitoring of bluefin fisheries suggest that the North Pacific bluefin tuna stock may be heavily fished. To provide more precise information, California Department of Fish and Game has been contracted to compile and organize existing bluefin tuna data.

SOUTH PACIFIC FISHERIES AGENCY

Dr. Richard S. Shomura, Honolulu Laboratory Director, and other NMFS personnel have been involved as advisers to the U.S. State Department in negotiations to develop a South Pacific Regional Fisheries Organization. Mr. Shomura participated in two international meetings to develop a framework for the South Pacific Regional Fisheries Organization.

At the second meeting, held in June 1978, a draft language of the convention was agreed upon by all participants. However, prior to the anticipated signing of the document in the fall of 1978, the South Pacific Forum countries rejected the draft document at a meeting held in September 1978 at Niue. The United Sttes is currently in a "hold" position with regard to its activities in promoting a regional body.

IN SUPPORT OF DOMESTIC REQUIREMENTS

BILLFISH MANAGEMENT PLAN

Under the Fishery Conservation and Management Act (FCMA) of 1976, the U.S. has assumed the responsibility to regulate billfishes in the Fishery Conservation Zone (FCZ). However, U.S. management authority does not extend to tunas, and many policies attractive from the standpoint of controlling billfish harvest also effectively regulate tuna fishing, in contravention of the FCMA.

The FCMA assumes the relevant stocks are contained within the FCZ, so that U.S. management policy can effectively address stock conservation needs and protect U.S. interests. However, in the case of billfishes and oceanic sharks, the stocks range far outside the FCZ. In most cases only a few percent of the total billfish harvest is taken within U.S. jurisdiction, and many experts now believe that effective management for oceanic species would best be accomplished on an international basis.

In compliance with the FCMA which calls for development and implementation of fishery management plans (FMP), a start was made in early 1978 on the preparation of such a plan for Pacific billfishes and sharks by the Western Pacific Fishery Management Council and the Pacific Fishery Management Council for the entire Pacific areas of United States interest. In addition to the species of billfishes and oceanic sharks, two additional species, the wahoo and dolphin are included in the Plan, since these species are taken concurrently with billfish and sharks on longline fishing gear in the central and western Pacific FCZ.

SWFC members on the teams are: M. Adams, R. Mendelssohn, G. Sakagawa, R. Shomura, J. Squire, J. Wetherall, H. Yoshida and H. Yuen. The primary responsibility for integrating the two plans has been assigned to the Western Pacific Team.

There are several major issues that the integrated FMP will attempt to address. There are legitimate differences in the needs of the interested parties involved in the west coast fisheries as opposed to those involved in the central and western Pacific fisheries. Along the mainland west coast and about the Pacific islands there are both commercial and recreational fisheries for billfish and sharks. The major species caught by the U.S. west coast recreational rod-and-reel fishery is the striped marlin. Swordfish can be sold commercially while striped marlin cannot, and the swordfish is commercially fished using harpoon gear. About the Pacific islands both recreational rod-and-reel and commercial rod-and-reel and longline fisheries take all species. The blue marlin is a major recreational rod-and-reel species about the Hawaiian Islands and Guam. In addition, the foreign longline fishery for tunas and billfish operates within the U.S. FCZ in the central and western Pacific and captures a substantial number of billfish, shark, wahoo, and dolphin fish.

The social and economic problems of the commercial and recreational fleet off southern California are complex. The major conflicts involve the coastal management philosophy of the highly migratory billfishes and on the use or non-use of aircraft spotting in commercial swordfish fishing.

Regarding the latter point, current California regulations prohibit the use of aircraft in order to reduce the efficiency of commercial fishing and increase the competitiveness of recreational fishermen.

In the central and western Pacific the operation of extensive foreign longline fisheries appears as one of the major problems. Longlining captures tunas, billfishes, and related pelagic species indiscriminately. Although tunas are normally the target species, there are areas in which the longline is targeted specifically on billfish. While billfishes and other species of interest in the Plan are taken incidentally to tunas by the foreign tuna longline fisheries, the U.S. has legislation to regulate the harvest of billfishes in the FCZ but not tunas.

Western Pacific Council Billfish Plan Development

The fourth draft of a Billfish Plan has now been completed for presentation to the Western Pacific Fisheries Council in early May 1979.

Among the features of the draft plan are an economic description and analysis of domestic user groups about the Hawaiian Islands, American Samoa, Guam, and the northern Mariana Islands. Also included was information on general biology as it pertains to management, stock distribution of the several species throughout the Pacific and estimates of stock status relative to MSY or trends in CPUE. Data on catches of the charter recreational-commercial and non-charter recreational commercial fleet indicates substantially more billfish being caught than previously estimated.

Pacific Council Billfish Plan Development

On beginning the development of a FMP for billfish in early 1978, the Plan Development Team, with the approval of the Council designated objectives relative to conservation and management, encouragement of international agreements, promotion of domestic commercial and recreational fishing, providing for a continuing optimum yield and encouraging the development of fisheries which are currently underutilized.

An economic and social profile of the California swordfish fishery was developed under contract. This profile outlined many of the economic and social conflicts among various groups in the swordfish fishery.

In late April 1979, the Pacific Council published and distributed to the public the first draft (Part I - Billfish) of the FMP. This draft will be formally presented to the Council in May 1979.

EASTERN PACIFIC -- SOUTHERN CALIFORNIA COMMERCIAL SWORDFISH FISHERY

Swordfish landings in California reached a record high in 1978. California Department of Fish and Game reports, based on landing receipts, indicate a take of 14,640 fish weighing an estimated 3,539,372 pounds (1,609 metric tons) round or live weight. This total exceeds the previous record high annual catch of 1,113,800 pounds, made in 1948.

A start on at-sea sampling was made in 1978 by the National Marine Fisheries Service. During the 4-month program which began on August 25, 1978, observers made seven trips aboard cooperating swordfish vessels and sampled a total of 92 swordfish for morphometric and biological data. The swordfish sampled averaged 251 pounds, with a range in weight from 137 to 436 pounds. The sex ratio of females to males was 1.7 to 1. Data collection will resume next summer.

In late August, a swordfish harpoon tagging program was begun as part of the Cooperative Marine Game Fish Tagging program, with the cooperation of representatives of the International Gamefish Association.

Using tags furnished by the Southwest Fisheries Center, marine anglers tagged 15 swordfish off southern Califoria from late August through October. Of these 15 tags, six tags have been recovered by commercial fishermen, a 40% recovery rate. Recoveries were made in the same general area as the fish were tagged, with times-at-sea of one to 30 days and distances from tag to recapture point range from less than five miles to about 30 miles.

Preliminary results from this limited amount of tagging indicated that within the area of intensive fishing, a possible high exploitation rate exists for swordfish observed at the surface.

PACIFIC -- BILLFISH ANGLER SURVEY

1977 was the eighth year of the Pacific billfish angler survey conducted in the Pacific to determine the trend of billfish fishing in terms of catch per angler day for the major billfish fishing locations. The survey is conducted in cooperation with the International Gamefish Association.

Marine game fish anglers who fished in the Pacific during 1977 were asked to complete a postcard form giving the number of days they fished for billfish, by quarter of the year, and the number of billfish caught (landed or released by quarter).

In 1977 the billfish angler survey data show 10,667 angler days, an increase from the 8,532 angler days reported in 1976 and the 7,303 angler days reported in 1975. The number of billfish reported captured in 1977 was 4,040, up from 3,119 fish in 1976. The overall billfish catch rate (fish per angler day) for 1977 was 0.38, or 2.64 days fishing per fish. This is slightly more than that observed in 1976 (0.36 fish per day, 2.7 days fishing per fish) and is approximately the same as observed in the 1975 survey. This is below the 1969-72 average of 0.55 fish per day, or 1.80 days per fish.

A review of CPUE data obtained for 17 locations about the Pacific is issued annually by the Southwest Fisheries Center.

PACIFIC -- COOPERATIVE MARINE GAME FISH TAGGING PROGRAM

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, Baja California and mainland Mexico, Panama, and Australia. The marine gamefish tagging program is currently supported by the National Marine Fisheries Service in cooperation with the International Game Fish Association.

James Squire, fishery biologist at the La Jolla Laboratory, coordinates the tagging program and reported that in calendar year 1978, 1,054 billfish were tagged, an increase of 143 billfish tagged over the 1977 total of 911. Because the tagging of black marlin off Australia is now being supported by New South Wales Fisheries, the number of tag cards received at the Southwest Center for black marlin tagging is decreasing. However, the total number tagged is estimated to be between 500-600 in 1978. The total number of fish of all species reported tagged by cooperating anglers in 1978 was 1,349, an increase of 227 fish over 1977.

Cooperating anglers tagged and released 542 striped marlin (Tetrapturus audax), comprising 51.4% of the total billfish tagged. Tag totals and percentages for the other billfish species are: black marlin (Makaira indica) 250 tagged (23.7%); sailfish (Istiophorus platypterus), 217 tagged (20.6%); blue marlin (Makaira nigricans), 29 tagged (2.8%); swordfish (Xiphias gladius) 15 (1.4%); and shortbill spearfish (Tetrapturus augustirostris) 1 tagged (0.09%).

Recoveries of tagged billfish reported to the Southwest Fisheries Center in 1978 (January 1-December 31, 1978) totaled 26, 7 more than recorded in 1977.

Recoveries by species and area are: black marlin, 9 recoveries in the Coral Sea; striped marlin, 3 recoveries, one at the mouth of the Gulf of California, Mexico, and two from southern California, U.S.A.; one sailfish from the tip of Baja California, Mexico; and 6 swordfish off southern California, U.S.A.

A complete review of the results of the tagging program is published annually by the SWFC.

EASTERN PACIFIC -- MARINE WEATHER DATA ACQUISITION SYSTEM UPDATED

Collection of surface marine weather observations by the La Jolla Laboratory began in 1959 and has continued to the present. Under the current system, the data are collected from a Federal Aviation Administration (FAA 6052) circuit and punched on paper tape. The data are transferred from paper tape to cards and are processed on the Burroughs 6700 computer at the University of California (UCSD). Products from the processing of these data are plots of sea surface temperature, wind direction and speed, and mixed layer depths. Several of these plots are analyzed and transmitted weekly to vessels at sea via radio station WWD. The processed data are also archived for future research, while others are used in the preparation of the monthly publication, "Fishing Information."

In May 1977, permission was obtained to update and automate this data system. A new system was designed and equipment purchases initiated. The new system was to employ a 1200-wpm teletype and dedicated microprocessor to collect, edit, and store marine weather data on magnetic disk. At frequent intervals, the data would be further edited using a CRT terminal and semi-processed before entry into the Burroughs 6700 computer for more complicated processing. The transfer of the data to and from the Burroughs was to be facilitated by a dedicated telephone line.

By December of 1977, the hardware for the new system had been purchased and the new high speed data line (FAA 604) installed. An analysis begun of the data from the new high speed line in early 1978, indicated no significant increase in the marine weather data available. Consequently, a data source was sought and in September of 1978 the 604 circuit was terminated and a 100 wpm circuit, the West Coast Marine Circuit (WCMC) was installed. The WCMC, a circuit controlled by the National Weather Service and designed to handle only marine weather data, proved to have significantly more (36%) marine surface observations.

By March of 1979, the initial software for the new system had been developed and a comparison of the new system and the old system started. This comparison of the two systems is in its final stages and all test results to date indicate that the new system will permit the acquisition of more data, more efficiently with a substantial reduction in recurring data processing costs.

EASTERN PACIFIC -- FISHING INFORMATION

The NMFS publication "Fishing Information" is designed to provide timely environmental information of the North Pacific and Eastern Tropical Pacific Ocean to the fishing and scientific community. The monthly and biweekly charts of sea surface temperature, barometric pressures, wind fields, ocean thermal structure and text are edited by James A. Renner of the SWFC and have been published routinely at that laboratory since 1960. The preparation of "Fishing Information" involves the acquisition, processing, editing and analysis of about 15,000 marine weather observations each month. These observations are collected in real-time from a National Weather Service teletype circuit and punched on tab cards prior to computer analysis. This system will be replaced by a computer system in order to streamline the preparation of "Fishing Information." The new system is currently undergoing test and evaluation.

EASTERN PACIFIC -- TUNA VESSEL PARTICIPATION IN FAX ADVISORY PROGRAM

During the period January through April 1979, 27 tuna seiners and 2 research vessels contributed synoptic weather data to the NMFS FAX Advisory Program. A total of 1,027 weather and 33 XBT (expendable bathythermograph) observations were reported via NMFS-licensed radio station WWD. The table below lists data pertaining to program participation during these months for 1978 and 1979. The numbers of total observations and boats reporting in 1979 show an increase over 1978 during the same period.

	TOTALS January - April 1978	1979
Number of vessels with equipment	54	48
Number of vessels reporting	27	29
Number of weather observations reported	765	1,027
Number of XBT observations reported	103	33
Total Observations	868	1,060

CENTRAL PACIFIC -- SKIPJACK

Tuna Aggregating Project

Work continued in the joint Honolulu Laboratory-Pacific Tuna Development Foundation (PTDF) tuna aggregating project. To familiarize the Hawaiian fishing community with the experimental fish aggregating program, a series of informal public meetings were held on Oahu, Maui, Lanai, Kauai, and Hawaii from May to August 1978. The meetings were cosponsored by the Honolulu Laboratory, the Governor's Marine Affairs Coordinator's Office, and the Hawaii Division of Fish and Game (HDFG). At the meetings presentations were made describing events leading to the implementation of the buoy project and/or results of the ongoing experiments. Another purpose of the meetings was to describe a proposed statewide fish aggregating system and to obtain input and reactions from the fishing community to the proposal.

In cooperation with the Hawaii Division of Fish and Game a proposal, "A statewide fish aggregating system," which incorporated input provided at the public meetings, was completed. The proposal was distributed to key Hawaii legislators by HDFG and a bill to implement the proposal is currently under consideration at the present session of the Hawaii legislature.

At the request of PTDF an informal workshop on fish aggregating buoys was also conducted by the Honolulu Laboratory. The workshop was for the benefit of fishery officials of various Pacific island governments and involved the presentation of construction details of fish aggregating buoys and other related matters. In addition, Walter Matsumoto, fishery biologist, who is in charge of the Laboratory's fish aggregating project described the history of the project, the criteria used in selecting buoy sites and the catches made around the buoys.

Physiological Thermoregulation in Tunas

Work done by Dr. Andrew Dizon, leader of the Experimental Ecology of Tunas, to determine physiological thermoregulation in yellowfin tuna, Thunnus albacares, was reported last year. Dizon continued work on an experiment designed to demonstrate physiological thermoregulation this time in skipjack tuna, Katsuwonus pelamis. Fish were equipped with temperature-sensitive ultrasonic transmitters and observed in a temperature-controlled environment. Increases in activity levels of the fish were induced by force-feeding them with lead slugs (i.e., the fish must maintain higher swimming speeds to counteract its artificially increased density or sink to the bottom of the tank). The experiment then called for an increase in environmental temperatures. In response to higher ambient water temperatures, the fish could not reduce heat production by slowing down (it would sink) so this form of behavioral thermoregulation was unavailable. It was expected that the fish would have to employ physiological means to increase heat dissipation to prevent developing

excessively high body temperatures and indeed this was observed in the three fish that last long enough to experience the higher temperatures. Most of the fish died before or during the temperature change from 25° to 30° C, the latter being the test temperature. Experiments were conducted on 10 fish during the month of July 1978; all were unsuccessful.

Relationship Between Fish Density and Hydrostatic Equilibrium

Dr. Dizon, reported that work was started on an experiment to investigate the relationship between fish density and the minimum swim speed required for fish to maintain hydrostatic equilibrium. Theoretical relationships between density and minimum hydrostatic speed have been determined (Magnuson, John J. 1973. Comparative study of adaptations for continuous swimming and hydrostatic equilibrium of scombroid and xiphoid fishes. Fish. Bull., U.S. 71:337-356) but these results have never been experimentally verified. In the experiment procedure, tungsten weights will be used to vary fish density. Tungsten was chosen because it is high in density (19.3 g/cc), relatively inexpensive, and one of the least reactive of metals (to resist the acid environment in the stomach). The weights will be force-fed to skipjack tuna prior to monitoring swim speed for 72 h.

Tests were conducted on five fish, including two fish which served as controls (Table 1). The control fish were handled identically to the weighted fish with the exception that no weights were inserted into the stomach of the controls. The other three fish were weighted with 85, 183 and 244 g tungsten rods which increased their density 6.8%, 12.6% and 20.3%, respectively. Table 1 also provides a first-cut estimate of the sustainable swim speeds.

Table 1

Fish length (cm)	Fish weight (g)	Tungsten weight (g)	Observed speed (cm/s)			Theoretical min. speed (cm/s)	Percent change
			No. of observations	$\bar{X}$	SD		
46.5	1,730	0	245	55.29	5.49	71.2	-22
42.5	1,381	0	250	59.26	6.23	70.4	-16
42.8	1,253	85	232	75.54	7.18	66.5	+13
43.7	1,450	183	318	91.60	5.22	69.9	+31
42.8	1,197	244	11	109.00	3.92	65.1	+67

Using Magnuson's methods minimum hydrostatic speeds have also been calculated for each fish. Theoretical swim speeds of the control fish were about 20% above those observed. Nevertheless, it is clear that density is directly proportional to swim speed. The results show that a density increase of only 20.3% produces at least a swim speed increase of 67% over the speed predicted as the minimum hydrostatic equilibrium speed.

Burnt Tuna Study

Dr. Jean Cramer, under contract to the Honolulu Laboratory, has been conducting a study to determine if the stress suffered by tunas while struggling on a hook and line is a significant factor in a condition referred to in Hawaii as "burnt" and in Japan as "yake." Tuna flesh that is burnt is opaque, light in color, and sour to the taste. Tuna in this condition are satisfactory for cooking, smoking, and canning but not so desirable as "sashimi" and, therefore, does not command a premium price.

The flesh of burnt tuna appears to be similar to pale, soft, exudative pork (PSE). In both conditions, the muscle is pale and soft compared to normal muscle. PSE in susceptible pigs is induced by stress which results in malignant hyperthermia (elevated temperature), increased creatine phosphokinase (CPK), and increased acidity of the muscle.

Burnt tuna occurs most frequently during the summer and in areas where fish are caught in relatively shallow water (10 fathoms or less). Various techniques of chilling and bleeding the fish after capture have had no obvious effect on decreasing this condition.

Dr. Cramer collected body temperature data and blood and muscle samples from yellowfin and bigeye tunas immediately after they were caught. Additional tissue samples were collected at regular intervals after death. All blood and muscle samples were analyzed for acidity, glucose, and lactic acid and the blood sera were analyzed for CPK content. The data seem to support the hypothesis that the burnt tuna condition is related to stress. Blood lactate and tissue acidity at death were higher in burnt tuna than in normal tuna. Dr. Cramer is preparing a manuscript to describe this work.

Experiments to Induce Spawning in Captive Tunas

Dr. Calvin Kaya, visiting scientist from Montana State University, has begun work to evaluate the practicability of inducing spawning in kawakawa, *Euthynnus affinis*, in captivity and rearing the resulting larvae. The evaluation will be based on preliminary observations to determine whether suitable maintenance and handling techniques can be developed, whether captive specimens will attain the prerequisite advanced stages of sexual maturation, and on the results of preliminary trials with different hormone dosages and combinations.

Dr. Kaya has developed a technique to catch and immobilize tunas for biopsy procedures to determine their stage of sexual development. The technique involves the use of a guiding barrier and a funneling device to entrap the fish in a plastic bag. Then, one of two methods is used to immobilize the fish. One method involves the use of quinaldine to anesthesize the fish; in the other method, the unanesthesized fish is tightly restrained by the use of a foam rubber cushion. The development of these techniques will make it possible to biopsy fish and administer hormone treatments without seriously injuring the fish.

Studies on other teleosts have indicated that the ova must attain certain critical sizes before the fish can be expected to respond to hormone treatments and release viable ova. Dr. Kaya believes the critical size for E. affinis ova is about 0.6 to 0.7 mm in diameter.

Examination of the gonads of wild E. affinis taken in Hawaiian waters indicates a trend towards increasing maturity in late January and mid-February. At the beginning of the experiments, 39 E. affinis specimens were available in two holding tanks (D and E) at the Kewalo facility. Kawakawa in tanks D and E were biopsied on March 13 and 20, respectively, to determine their gonadal maturation states. Those in tank D had been originally captured on January 25, 1979 and, therefore, had been in captivity for about 6.5 wk, while those in tank E had been captured on February 14 and had been in captivity for about 5 wk. Of the 20 fish in tank D, 11 were biopsied before the exercise was terminated by equipment failure. Catheterized from these 11 fish were small amounts of viscous milt from 4 males, ovarian tissue from 4 females, and no identifiable material from 3 (probably immature males). The four confirmed females were all immature; the mean diameters of the largest size-class of ova in the samples ranged from 0.09 to 0.12 mm (mean of means, 0.11 mm). One specimen was lost to accidental mortality during the biopsies, while another, in advanced stage of "puffy snout," was sacrificed for further handling and injection trials. The biopsies of those in tank E were conducted much more effectively because of modifications in the capture equipment and because of the experience acquired on the previous exercise. All 19 fish were successfully biopsied; small amounts of viscous milt were obtained from 4 males, ovarian tissue from 12 females, and no identifiable material from 3 (probably immature males). Again all the females were immature, the mean diameters of the largest size-class of ova in the samples ranging from 0.11 to 0.25 mm (mean of means, 0.14 mm).

If the gonadal development of the kawakawa in captivity parallels that of wild fish, Dr. Kaya is hopeful that they should attain advanced stages of gonadal development and be physiologically responsive to hormone treatments to induce spawning within the next few months. Gonadal biopsies will be continued to follow the sexual development of the fish during the next several months.

Investigations to Evaluate New Predictive Methods

Dr. Roy Mendelssohn, Operations Research Analyst at the Honolulu Laboratory, has been analyzing the skipjack tuna landings at the Hawaiian Tuna Packers cannery to examine how well certain time series techniques and environmental variables perform in making simple predictions about fish catch. These new methodologies are being examined because the data show highly seasonal and highly autocorrelated effects so that standard least square techniques are not appropriate.

Another purpose of the analysis is to improve techniques to predict the landings, and increase understanding of the major causal influences on fluctuations in catch. This modeling effort is a first step in an integrated bioeconomic study of the landings being performed at the Honolulu Laboratory.

Preliminary analysis of the data shows a marked change from approximately 1973 onwards in the relationship between the total skipjack tuna catch and the relative proportions of the dominant size classes of the catch. Total catch and catch of large fish "tracked" closely up until about 1973; however, no such simple relationship was evident after 1973. Several factors are being explored to explain this change, including increased fishing elsewhere in the Pacific; increased foreign fishing near Hawaii; and changes in the relative prices of the different fish sizes.

TUNA/PORPOISE INTERACTION AND THE MARINE MAMMAL PROTECTION ACT OF 1972

In implementation of the Marine Mammal Protection Act (MMPA) of 1972, the Southwest Fisheries Center conducts research on dolphin (porpoise) populations and their relation to the yellowfin tuna purse seine fishery in the eastern tropical Pacific. The objectives of the research program at the Center are:

1) develop and refine methods and technology to reduce further dolphin mortality incidental to the yellowfin tuna purse seine fishing;

2) determine the status of the dolphin stocks; and

3) monitor incidental mortality by the U.S. fleet throughout the year against established quotas.

New and promising avenues of research started include the areas of ecological and physiological effects of pursuit and capture and of ecosystems dynamics and development of technology to provide alternate modes of tuna fishing to chasing and encircling marine mammals.

For the first time also, U.S. trained observers will be on board non-U.S. tuna seiners to monitor the dolphin kill as part of an Inter-American Tropical Tuna Commission (IATTC) research program. The observers will be Nationals of the vessels' flag country.

One of the most significant and encouraging developments during 1978 has been the progress made in the reduction of incidental dolphin mortality. In the span of six years, the number of dolphins killed in association with purse seine fishing for yellowfin tuna has dropped

almost 95 percent. During 1978, the estimated kill by U.S. fishermen was approximately 15,000 compared with 27,000 in 1977. The quota for 1978 was 51,945. 1979 will be the second year of a 3-year declining quota program.

The following table shows the observed reductions in mortality on U.S. vessels for the past 3 years and the quotas for 1979 and 1980:

	Cumulative Mortality	
	Allowed Quota	Annual Estimate
1976	78,000	107,000
1977	62,429	27,000
1978	51,945	15,000
1979	41,610	
1980	31,150	

These dramatically declining mortalities, far below the allowed quotas, have greatly increased public confidence in industry and government efforts to reduce mortality.

These results have been achieved through the combined efforts of the U.S. tuna industry and the government. The latest gear that has proven effective in reducing mortality is presently in use by the U.S. fleet. Regulations that became effective in December 1977 required tuna purse seine vessels certified to fish on dolphins to install a "porpoise apron" (Super Apron) in their existing fine mesh release panels (a refinement of the early "Medina Panel"). The regulations also require specific release procedures to be used on each set involving dolphins. A study evaluating the relative release success or failure of each required piece of gear or procedure was completed. The study showed that dolphin rescue procedures reduced the kill rate by 60 percent in 1977. A NMFS observer was placed on each tuna vessel for at least one trip in 1978 to record mortality and the performance of the required release gear and procedures. Monitoring and reporting by the observers of total mortality will continue.

Throughout the year, NMFS technicians supervised the manufacture and installation of the Super Apron, an insertion of 1-1/4 inch webbing into the "porpoise-release" area of the nets of U.S. and foreign tuna purse seiners. These installations have taken place in San Diego, Panama, and Puerto Rico. To date 73 aprons have been installed: 64 on Class III U.S. flag seiners, 2 on Class II U.S. seiners and 7 on foreign flag seiners. Six Class III U.S. vessels are scheduled to install their aprons in Panama before the 1979 fishing season: 12 are fishing under various exemptions from the regulations and 5 are in the Atlantic where there is no apron requirement.

A vessel, the purse seiner Queen Mary, was dedicated by the U.S. Tuna Foundation for dolphin/tuna research in 1978, making is possible for the first time to observe the overall performance of net dynamics, particularly the backdown procedure. "Backdown" is one of the most effective methods, if done properly, for getting dolphins out of the purse seine. Scuba divers entered the net during three of the five cruises and were able to determine the cause of a backdown characteristic known as "stern sway", a major contribution to mortality that could not be previously observed.

With the use of the dedicated vessel, an engineering assessment of the entire purse seine operation was started. Data were collected through both surface and underwater measurements to verify and alter existing mathematical functions describing fishing gear behavior. NMFS gear specialists are working closely with a contractor to develop the mathematics necessary to allow eventual construction of a computer model of the purse seining process. When complete the model will be used to study gear modifications before actual construction and field test. These studies have provided information essential to the development of techniques and gear for alleviating porpoise mortality.

Using data from the 1978 "porpoise observer program," analyses are being made of the specific causes of mortality. Comparison of total mortality between years, as a measure of dolphin release performance, is difficult because fishing seasons vary greatly. The 1977 fishing season was delayed several months, and the 1978 fishing season was a record skipjack tuna year (dolphin do not associate with this species of tuna), which resulted in a reduced number of sets "on porpoise." Although the total number of dolphins killed was reduced 44 percent between 1977 and 1978, the rate of mortality, that is the number killed per set and the number killed for each ton of yellowfin tuna increased 27 percent and 31 percent, respectively.

A procedure has been developed to estimate cumulative kill by stock on a weekly basis from radio reports from observers and computer-statistical analysis of the data. The procedure is used to closely monitor and continue analysis of the kill rate and incidental mortality of dolphins by the U.S. fleet. The quota or allowable mortality by individual stock is thus estimated and monitored during the fishing season.

In continuing effort to determine the status of stocks, previous surveys of populations were analyzed in 1978, and methods of tagging were tested. Population models and statistical methodologies were computerized to examine data from combined aerial and shipboard surveys. That analysis indicated that the research vessels and airplanes employed in the surveys, therefore, were changed to allow for a comparison.

Considerable effort was devoted to development of methods to capture, hold, handle and tag large groups of dolphins in their natural environment, as well as the effects of tags and marks on the animals. Dolphins were tagged in 1978 on the tuna purse seiner, Queen Mary, and results of research carried out during two 50-day curises established the capabilities and limits of tagging.

SWFC PUBLICATIONS ON TUNA AND TUNA-RELATED RESEARCH

APRIL 1, 1978 TO MAY 1, 1979

PUBLISHED

Barkley, Richard A., William H. Neill, and Reginald M. Gooding. 1978. Skipjack tuna, Katsuwonus pelamis, habitat based on temperature and oxygen requirements. Fish. Bull., U.S. 76(3):653-662.

The habitat of skipjack tuna, Katsuwonus pelamis, has generally been assumed to be the warm surface layers of tropical and subtropical ocean, where most of these fish are seen and caught. But experiments with captive Hawaiian skipjack tuna imply that their habitat is more restricted, with boundaries defined by both temperature and dissolved oxygen. The lower temperature limit appears to be about 18° C. The upper temperature limit apparently varies with size of the fish, from 30° C or more for small individuals to as little as 20° C for the largest. Skipjack tuna also require water with unusually high concentrations of dissolved oxygen, at least 3.0-3.5 ml/liter (4-5 ppm), for long-term survival. If our Laboratory findings with captive skipjack tuna accurately define their natural habitat, only the smallest of these animals can inhabit the warm surface waters of the tropics; those larger than 4.5 kg must inhabit the thermocline. Our hypothesis, which can be tested, explains many features of the known distribution of skipjack tuna in the eastern and central Pacific Ocean.

Dizon, Andrew E., Richard W. Brill, and Heeny S.H. Yuen. 1978. III. Correlations between environment, physiology, and activity and the effects of thermoregulation in skipjack tuna. In Gary D. Sharp and Andrew E. Dizon (editors), The physiological ecology of tunas, p. 233-259. Acad. Press, N.Y.

Dizon, Andrew E., and Gary D. Sharp. 1978. II. Perspectives: The past, present, and future of tuna physiology. In Gary D. Sharp and Andrew E. Dizon (editors), The physiological ecology of tunas, p. 451-458. Acad. Press, N.Y.

Dotson, Ronald C. 1978. Fat deposition and utilization in albacore, pp. 343-355. In Gary D. Sharp and Andrew E. Dizon (eds.), The The physiological ecology of tunas. Academic Press, Inc., New York.

Evans, R.H. 1977. Tuna/environment programs at the Southwest Fisheries Center, La Jolla, California. U.S.A., pp. 98-109. In G.H. Tomczak (ed.), Environmental analyses in marine fisheries research - fisheries environmental services. FAO Fish. Tech. Paper, 170.

Scientists of the SWFC, the Inter-American Tropical Tuna Commission and others have for a number of years studied the effects of the marine environment on the distribution, abundance, and availability of tropical and temperate tunas. Much of this has been essentially descriptive. For example, compilations of catch

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statistics and the results of tagging experiments have been used to define distribution limits and migration patterns (Schaefer et al., 1961; Fink and Bayliff, 1970), and atmospheric and oceanic climatology has been used to describe the current structure and water mass characteristics within these limits (Sette, 1955, Owen, 1968). Also environmental variables such as wind speed, sea surface temperature, mixed layer depth, water color and dissolved oxygen content have been used as indicators of distribution and availability (Laevastu and Rosa, 1963; Blackburn, 1963; Green, 1967).

Traditionally, environmental data for fisheries research have been collected from cruises aboard research vessels. More recently these same data have been acquired from merchant ships and ships of opportunity. The latter has proved to be the more economical approach, but incoming data still tend to be sporadic in both areal and temporal coverage. SWFC researchers have moved to alleviate this problem by supplementing these traditional sources of environmental data with satellite data and data collected by tuna fishermen on the fishing grounds.

Fox, William W., Jr. 1978. Tuna/dolphin program. Oceans 3:57-59.

This article is a comprehensive look at the achievements of the National Marine Fisheries Service in response to the mandate of the Marine Mammal Protection Act of 1972, with particular emphasis on the unique problem of dolphins taken incidentally in the tuna purse seine fishery in the eastern tropical Pacific.

Kitchell, James F., William H. Neill, Andrew E. Dizon, and John J. Magnuson. 1978. III. Bioenergetic spectra of skipjack and yellowfin tunas. In Gary D. Sharp and Andrew E. Dizon (editors), The physiological ecology of tunas, p. 357-368. Acad. Press, N.Y.

Laurs, R.M. 1977. Albacore advisory program at the Southwest Fisheries Center, La Jolla, California, pp. 110-119. In G.H. Tomczak (ed.), Environmental analyses in marine fisheries research - fisheries environmental services. FAO Fish. Tech. Paper, 170.

The National Oceanic and Atmospheric Administration, NMFS, La Jolla Laboratory (and predecessor organizations) has operated an albacore fishery forecasting/advisory services program since the early 1960's. For the past several years this program has been a sub-unit of a multidisciplinary research program on North Pacific albacore, intended to develop optimal management policy recommendations with respect to U.S. interests in North Pacific albacore fisheries and to produce information for planning and operating decisions in the U.S. albacore industry.

Laurs, R. Michael, Richard Ulevitch and David C. Morrison. 1978. Estimates of blood volume in the albacore tuna, pp. 135-139. In Gary D. Sharp and Andrew E. Dizon (eds.), The physiological ecology of tunas. Academic Press, Inc., New York, N.Y.

Lenarz, William H. and James R. Zweifel. 1978. A theoretical examination of some aspects of the interaction between longline and surface fisheries for yellowfin tuna, Thunnus albacares. Fishery Bulletin, U.S. 76(4):807-825.

This paper explores several aspects of a dual fishery (surface and longline) on yellowfin tuna, Thunnus albacares. The work is exploratory in nature and results, though indicative, are not conclusive for any specific fishery. Results indicate that the yield per recruit is higher for the longline fishery than for surface gear if all fish are available to both gears and higher for the combined gears than for either gear fishing alone. The effect of fishing by one gear on yield to the other gear and the effect of the fishery on stock fecundity is shown to be greater for the often assumed 1:1 sex ratio than for the ratios usually observed. A simulation model was used to examine the interrelations of pattern of movement of fish, pattern of recruitment, and fishing strategy. It was assumed that movements were random and recruitment occurred either only along the coast or throughout the fishing area. The results indicated that either of these patterns of recruitment could allow for increased catch as the surface fleet moved offshore. However, location or pattern of recruitment is shown to be important when measuring natural mortality and for examining the potential of a localized fishery, primarily on younger fish, relative to a fishery exploiting the full range of the stocks or to one taking primarily older fish. Tagging and fecundity studies are suggested for further investigation of the questions examined in this paper.

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