7. TUNA/ENVIRONMENT PROGRAMMES AT THE SOUTHWEST FISHERIES CENTER, LA JOLLA, Ca., U.S.A.

by

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7.1 Introduction

Scientists of the Southwest Fisheries Center (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 work has been essentially descriptive. For example, compilations of catch 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 colour and dissolved oxygen content have been used as indicators of distribution and availability (Laevastu and Rosa, 1963; Blackburn, 1963; Green, 1967).

These studies have done much to describe the tuna's habitat and behaviour. Further, they have led us closer to the solutions of problems which are of paramount importance in understanding how the environment affects the availability and exploitation of tunas. These problems include:

(i) The complex manner in which atmospheric, oceanic and biological processes interact to affect survival during the larval stages.

(ii) The feedback mechanisms through which these same atmospheric, oceanic and biological processes are modulated in both space and time.

(iii) The manner in which fluctuations of the marine environment, as well as economic and political factors tend to affect the distribution of fishing effort and consequently the size of the resulting harvest.

These problems are the subject of continuing research at the SWFC where recent studies have established the need for a detailed time series of environmental data from the fishing grounds.

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.

7.2 Background

Fisheries environment related studies at the La Jolla Laboratory take a number of forms but three ongoing programmes stand out because of their cooperative involvement with fishermen and the real-time nature of the data exchanged by the participants. The first programme, the publication of Fishing Information, utilizes "real-time" marine weather observations to create contoured charts of selected environmental variables which are averaged over periods of 15 days and a month. These analyses, together with summary tests are then printed and mailed to fishermen and other interested parties. The second programme,

Chart 3 - One degree Celsius contours [1/] of mean sea surface temperature for the month from the eastern North Pacific (see Fig. 2). The areal coverage of this analysis: 18°-60°N and 113°-180°W. Mean values of sea surface temperature for selected shore stations along the west coast of North America as well as ocean station "Papa" (5°N and 145°W) are also included.

Chart 4 - One degree Celsius contours of sea surface temperature for the month from the western North Pacific. The areal coverage of this analysis: 15°-60°N and 170°W-115°E.

Chart 5 - Deviation of the sea surface temperature in the eastern North Pacific for the month from the long-term mean 1948-67. Areal coverage of this analysis is identical to Chart 3. The deviation from the long-term mean is contoured at ± 1 degree Celsius intervals.

Chart 6 - Deviation of the sea surface temperature in the western North Pacific for the month from the long-term mean 1948-67. Areal coverage of this analysis is identical to Chart 4 and the contour interval is the same as Chart 5.

Chart 7 - Deviation of the sea surface temperature in the eastern North Pacific for the month from the corresponding sea surface temperature values for the same month of the previous year. The areal coverage of this analysis and the contour interval are the same as Chart 5.

Chart 8 - One degree Celsius contours of sea surface temperature for the month from the eastern tropical Pacific. Areal coverage of this analysis: 30°N-~30°S [2/] and 70°-180°W.

Chart 9 - Deviation of the sea surface temperature in the eastern tropical Pacific for the month from the long-term mean 1948-67. The areal coverage of this analysis is identical to Chart 8. The deviation from the long-term mean is contoured at ± 1 degree Celsius intervals.

Chart 10 - Surface temperature, surface salinity and subsurface temperature structure obtained from expendable bathythermograph (XBT) transects taken between west coast ports in the United States and Hawaii. The data for these analyses come from 4 hourly XBT drops and surface salinity samples collected by cooperating merchant vessels along their scheduled routes. The XBT equipment aboard the vessels is provided and maintained by Pacific Environmental Group personnel stationed at Tiburon, California. The Pacific Environmental Group is a laboratory within the Southwest Fisheries Center.

Charts 11 and 12 - Expendable bathythermograph and surface salinity transects similar to the analyses described in Chart 10. These additional analyses are included in FI when more than one transect is available for the month.

Each month the text and charts that comprise FI are drafted, printed and distributed; the product reaching the subscriber near the end of the month following the analysis. The dissemination of Fishing Information is identical to that for the "supplement".

Each month about 18,000 marine weather observations are used to produce FI. These observations are also used to produce additional environmental data summaries for ongoing research projects of the SWFC and the NORPAX (North Pacific Experiment) at the Scripps Institution of Oceanography. At the end of each month the entire observational data

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1/ Sea surface temperatures for the FI monthly publication were changed from Fahrenheit to Celsius starting with the March 1977 issue.

2/ The southern limit of coverage is dependent each month on the amount of sea surface temperature data available in the chart area.

the "Cooperative Tropical Tuna Advisory Programme", utilizes marine weather data and expendable bathythermograph (XBT) data to produce daily weather and sea state charts and weekly sea surface temperature (SST) and mixed layer depth (MLD) charts of the eastern tropical Pacific. These charts are broadcast by radio facsimile (FAX) to cooperating purse-seiners from radio station WWD, a National Marine Fisheries Service licensed radio station in La Jolla, California.

A third programme, the Albacore Advisory Programme, provides weekly SST charts and narrative texts of fishing conditions to albacore fishermen off the west coast of North America. The Albacore Advisory Programme is described in detail in section 8.

Both Fishing Information and the FAX Programme depend heavily on "real-time" weather observations. Internationally formatted marine weather observations are received at the SWFC from Washington, D.C. via a 100-word per minute National Weather Service (NWS) teletype circuit. Each weather observation is then converted to a computer card image suitable for computer processing. At weekly intervals these observations are computer edited to remove duplicate and erroneous observations. The resulting data files are then processed using a suite of computer programmes which create weekly, bi-weekly, and monthly summaries of selected environmental variables.

7.3 Data collection and environmental product preparation

7.3.1 Fishing information

Of the Fishery/Environment related advisory programmes at the SWFC, Fishing Information (FI) is the oldest. FI was started in 1957 at the Honolulu Laboratory of what was then the Bureau of Commercial Fisheries (BCF). Monthly charts of sea surface temperature for the North Pacific were prepared to gain a better understanding of albacore migrations. In 1960 the task of preparing these charts was transferred to the Tuna Forecasting Programme at the La Jolla Laboratory, where they were published in the California Fishery Market News Monthly Summary, Part II. At that time, the project was expanded to include the issuance of a bi-weekly SST chart as well as a monthly plot of average SST's for the eastern tropical Pacific. In ensuing years through 1974, the content of FI was altered frequently in response to user requests. In 1970 the publication was expanded to include SST charts of the western North Pacific. In addition, the 1° square plots of SST in the eastern tropical Pacific were converted to contoured charts of SST.

The current bi-weekly component of FI is a sea surface temperature chart for the eastern North Pacific covering an area from the west coast of North America westward to 136.5°W between 25° and 52° N. At 15 day intervals about 1200 SST observations, averaged by one degree squares, are contoured at two degree Fahrenheit intervals to produce the bi-weekly chart (see Fig.1). This chart, entitled "FISHING INFORMATION - supplement", is then mailed to about 725 subscribers on a "no-cost-to-the-subscriber" basis. The mailing list for the supplemental chart as well as for Fishing Information is presently limited to 750 subscribers.

The parent publication of the supplemental chart is a collection of environmental analyses. FI contains narrative descriptions of current meteorological and oceanographic conditions in the north and eastern tropical Pacific as well as 10 to 12 charts of selected environmental variables for the same areas. The content of these charts is as follows:

Chart 1 - Seventeen-year mean (1961-1977) of observed sea level values of barometric pressure, and (by 5 degree squares) the resultant wind direction, resultant wind speed and average wind speed. The areal coverage of this analysis: 20°-60°N and 115°-180°W.

Chart 2 - Observed sea level values of barometric pressure for the current month; and (by 5 degree squares) the resultant wind direction, resultant wind speed and average wind speed. The areal coverage and format of this analysis is identical to Chart 1.

set as well as certain data summaries are archived on magnetic tape and stored at the SWFC. This data set, which has been maintained since June 1960, forms a unique data source for ongoing studies of the environment and climatology of the Pacific Ocean.

7.3.2 Cooperative Tropical Tuna Advisory (FAX) Programme

By 1970 United States tuna purse-seiners were beginning to range further westward from the coast of Central America in search of yellowfin and skipjack tuna. The offshore fishing areas were outside standard shipping routes and it appeared that the purse-seiners might provide useful information from this "data sparse" region. As a result, the SWFC instituted the Cooperative Tropical Tuna Advisory Programme, designed to foster an exchange of environmental data between tropical tuna fishermen and researchers at the SWFC (Eber, 1976).

To effect this exchange of data, two fundamental problems had to be overcome. The first was how to provide useful environmental information to vessels which routinely remained at sea for periods of 3 months or more. A pilot project in the summer of 1970 demonstrated the feasibility of long range communications between the tuna vessels operating in the eastern tropical pacific and radio station WWD. The project indicated however, that the transmission of large amounts of verbal information by WWD and the assimilation of these data by the tuna seiners was difficult and time consuming.

Radio facsimile appeared to offer a viable means of transmitting the needed data to the tropical tuna fleet in "real-time". In late 1970 three facsimile units that were surplused by the U.S. Navy were obtained and modified to copy radio facsimile transmissions. These units were installed on three XBT equipped purse-seiners during the 1971 fishing season.

The second problem that had to be solved was how to allow the participating vessels to radio positional and environmental data to WWD without revealing their positions to other purse-seiners. Since the tropical tuna fishery is so competitive and covers such a large area of the eastern tropical Pacific, fishermen tend to operate independently or in small groups. The geographical location of these operating units is a closely guarded secret and is considered by many fishermen to be essential to the success of the fishing operation. To allow the cooperating fishermen to keep their position secret it was necessary to devise a coding system for them to use in reporting the position of their observations. This was done by providing each participant with his own unique location code. The use of this code has allowed each vessel to radio XBT and marine weather data to WWD without compromising its location.

The coding scheme is administered by the U.S. Navy's Fleet Numerical Weather Central (FNWC) at Monterey, California. FNWC maintains each vessel's location code in their computer for decoding the participating vessel's geographic position. The computer programme that decodes the vessel's position outputs the data without including any vessel identification. This ensures the confidentiality of the vessel's location in all instances.

To implement this decoding scheme, environmental observations radioed to WWD by the participants are relayed to the SWFC via teletype (see Fig. 3). The observations are then transmitted to FNWC over the Navy Environmental Data Network tieline. After decoding at FNWC, the XBT and marine weather observations from the participating vessels are returned to the SWFC in decoded form. These observations are also sent via teletype from FNWC to the National Weather Service Forecast Center at Redwood City, California.

Currently WWD collects XBT and marine weather observations from the participating vessels between the hours of 2200 and 2300 GMT. These data, as well as environmental products from FNWC, the National Weather Service and APT (Automatic Picture Taking) satellite photos are utilized by the SWFC staff to create analyses for broadcast to the participating vessels. Initially, two products - the wind and weather analysis and the sea state analysis - were broadcast daily (Monday through Friday) at 2300 and 2310 GMT each day. A third chart, the weekly mean sea surface temperature analysis, was added for broadcast each Thursday at 2320 GMT (Fig. 4). A summation of all of the environmental advisories currently offered by radio station WWD is included in Table 1.

During the past six years the format and content of the FAX products offered to the participants has varied in response to user needs. A verbal advisory describing tropical storms or areas of high winds now accompanies the facsimile charts when conditions warrant. In January of 1973 a weekly mean mixed layer depth analysis (see Fig. 5) was added for broadcast at 2320 GMT each Friday. In April of 1974, the National Weather Service Forecast Center (NWSFC) in Redwood City, California became a participant in the programme by providing the wind and weather and sea state analyses for broadcast by WWD on weekends (see Fig. 3). In August of 1974 the NWSFC assumed responsibility for the preparation of these two charts. At present, the wind and weather and sea state advisories are being offered by the NWSFC through WWD twice daily, seven days a week (see Table 1).

As indicated, the services offered by the Tropical Tuna Advisory Programme have expanded dramatically since 1971. No less dramatic has been the expansion in the number of participants and the data they have provided to the SWFC. During 1971, FAX units owned and maintained by the SWFC were installed on a total of 25 purse-seiners. These participants radioed 1528 weather and XBT observations to WWD. By the end of 1975 the number of programme participants had risen to 75, who contributed 7653 environmental observations during the year. To date, more than 30,000 observations have been received, utilized and archived at the SWFC.

7.4 Programme effectiveness

An analysis of the effectiveness of the FI and FAX programmes is complicated by the fact that these are cooperative programmes that are of benefit to fishermen and researchers alike. In light of this, we must first consider the utility of the information provided to the user of environmental products, basically the fishermen. Second, we must consider the contributions to fishery-environment research that are realized from the "real-time" data and various information from the fishermen. The analysis, however, at the present time must rely on primarily qualitative rather than quantitative standards because data on a "real" value of the information to the research or fishermen have not been gathered.

Several attempts have been made by the SWFC to evaluate the utility of FI. In 1967, 1974 and 1975, surveys were conducted to characterize the subscribers and how they used the FI charts and text. In the 1975 poll, to which 548 subscribers responded, the largest single user group (33%) were commercial fishermen. Of this group, 92.1% indicated that the FI products were used in developing their fishing strategy and 77.3% indicated that the sea surface temperature charts were the most useful information contained in the publications. Of the two FI publications (monthly and bi-weekly supplement), the bi-weekly publication (see Fig. 1) was favoured over the monthly publication.

In addition to commercial fishermen, FI is also used by sport fishermen, fish processors, fisheries researchers, oceanographers, and meteorologists. Respondents in these categories indicated that the FI products were most useful in environmental and fishery research, respectively. Again the SST charts were indicated as being the most useful.

The FI programme also provides information in the form of processed data and data summaries for fisheries and marine environment research. Researchers at the SWFC, the Scripps Institution of Oceanography and elsewhere routinely use the FI databases for monitoring long-term sea surface temperature anomalies and ocean-atmosphere heat exchang fluctuations. The FI data have also been used for locating ocean frontal boundaries and as ground truth for satellite derived SST values. In fact, the FI data base is unique in that it is the only readily available source of quasi-current information on abnormal ocean conditions, such as El Niño occurrences, for the eastern Pacific.

Attempts have also been made to evaluate the utility of the FAX programme to tropical tuna fishermen. During 1973 and 1974, 22 tuna purse-seine skippers were interviewed by SWFC staff members. Nearly all of those interviewed indicated that they copied the FAX charts daily and also listened to the verbal advisories. The fishermen indicated that the wind and weather sea state charts were of the greatest use to them. These charts allowed them to fish in the productive areas along the Inter-Tropical Convergence Zone while avoiding the tropical

cyclones that frequent the area during the summer months. They also indicated that the SST and MLD charts were useful in the development of fishing strategy and day-to-day tactics.

Further information concerning the utility of the FAX charts has been obtained at annual meetings where tuna fishermen and SWFC researchers gather to discuss the FAX programme and suggest ways to improve it. These meetings, which have been held each December since 1972, provide a forum for an interchange of ideas concerning the content of the FAX advisories and the programme in general. In this way advisories of the greatest potential use to the fishermen are ensured.

In conclusion, it is impossible to state unequivocally that FI and the FAX programme are "cost effective" or have a profound influence on the cost of fish at the market place. We can only surmise from the existing information that these programmes are important to fishermen and of value to the research community.

7.5 References

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Table 1

Synopsis of Fishery-Environment Products Offered by the Southwest Fisheries Center through Radio Station WWD

Type of Product	Mode of Dissemination*	Broadcast Frequency	Frequency of issue	Time of Issue (GMT)	Product Valid Time (GMT)	Areal Coverage	Product Originator	Prime User	Product Content
1. Wind & weather analysis and forecast	Radio facsimile	8644.1 & 17,408.6 kHz	Daily	1500 2300	0600 1800	From the west coast of N&S America to 160°W between 20°S and 37°N	National Weather Service	Tropical Tuna Fleet	Wind speed, wind direction, position of the Inter-Tropical Convergence Zone (ITCZ), cloud cover, positions of severe weather, initial and forecast positions of tropical disturbances.
2. Sea & swell analysis & forecast	Same	Same	Same	2310	1800	Same	Same	Same	Wave height, swell height, swell direction, swell period, and areas of rough seas.
3. Weekly mean sea surface temperature analysis (tropical area)	Same	Same	Weekly on Thursday	2320	Previous 7-day period	From the west coast of N&S America to 140°W between 6°S and 30°N	Southwest Fisheries Center	Same	Weekly mean sea surface temperature (SST) isotherms derived from weekly 1° square averages of SST. Contour interval 1°C with areas of sparse data coverage indicated by dashed contours.
4. Weekly mean mixed layer depth analysis (tropical area)	Same	Same	Weekly on Friday	2320	Same	Same	Same	Same	Weekly mean mixed layer depth (MLD) derived from energy numerical models, computed for 5° squares. The results are hand contoured at 50 foot depth intervals. Areas of sparse data are indicated by dashed contours.
5. Tropical storm advisories	Verbal broadcasts	Same	As required	1510 2310	As indicated in broadcast	Same	Same	Same	Information concerning tropical storms or other areas of inclement weather. The broadcasts contain present and forecast positions of storms, areal extent, expected winds, direction and speed of the storm, pertinent sea state information, and other information as required.
6. Weekly mean sea surface temperature analysis	Radio facsimile	Same	Weekly on Friday during albacore season (~July-Oct.)	1700	Same	From the west coast of N. America to 141°W between 28° and 52°N	Same	Albacore fishermen	Weekly mean sea surface temperature (SST) isotherms derived from weekly 1° square averages of SST and hand contoured. Contoured interval 1°C.

*All broadcasts from radio station WWD are upper sideband carrier frequencies. The facsimile scan rate is 120 lines/minute with an international index of cooperation of 576.

FISHING INFORMATION - supplement

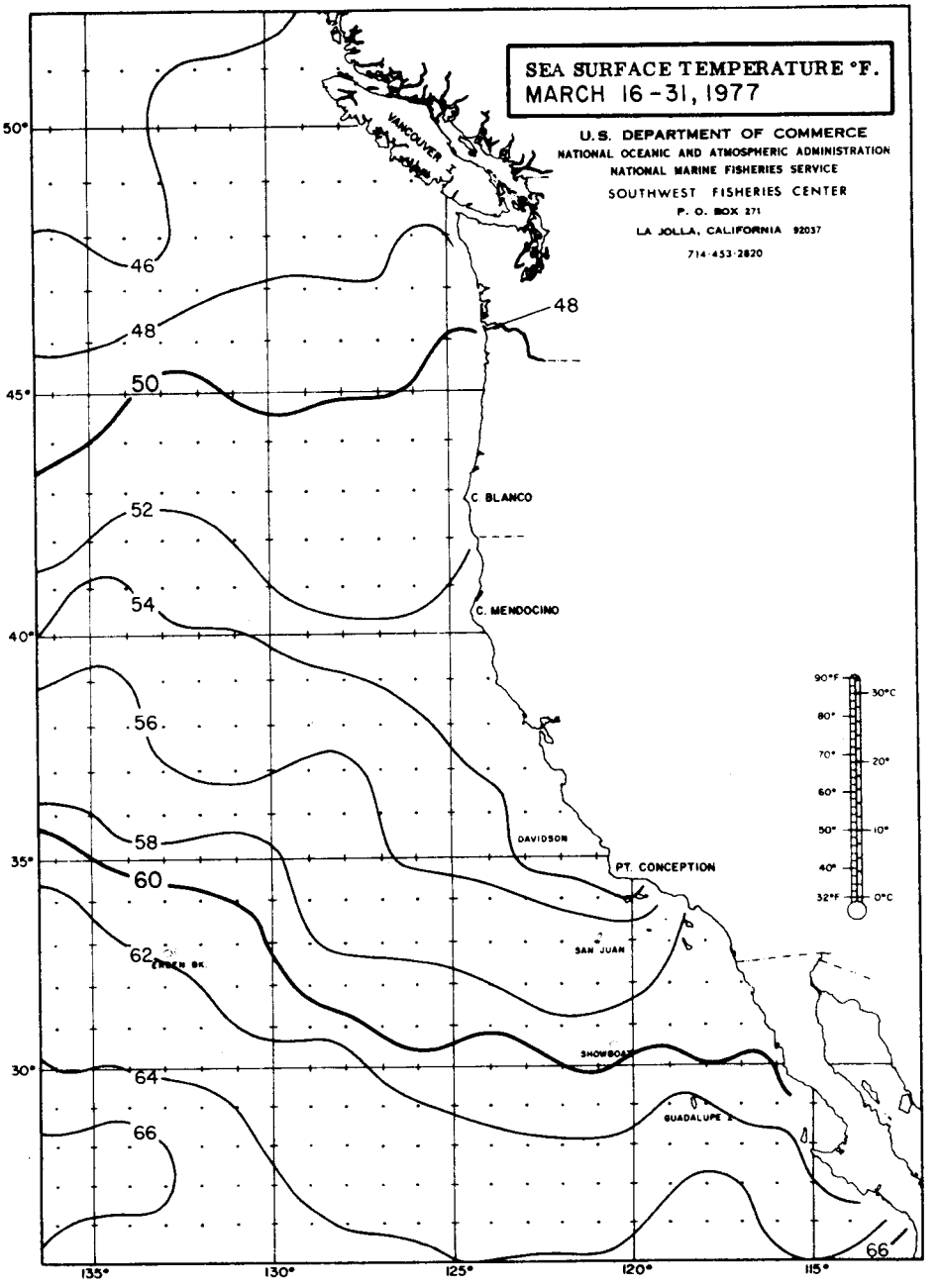

Figure 1: Example of biweekly SST chart distributed to albacore fishermen

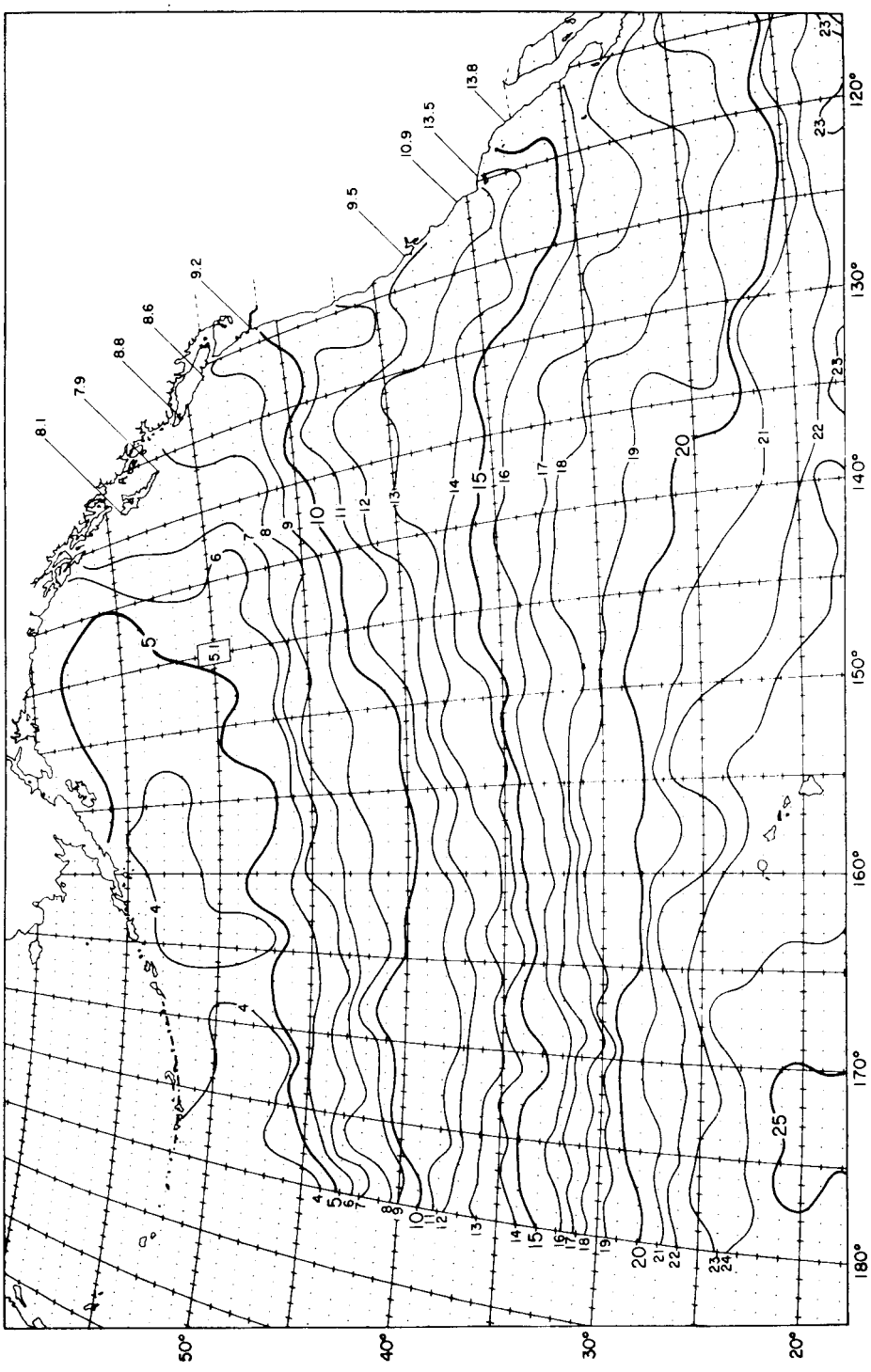

Figure 2: Example of a mean sea surface temperature map (month of March 1977)

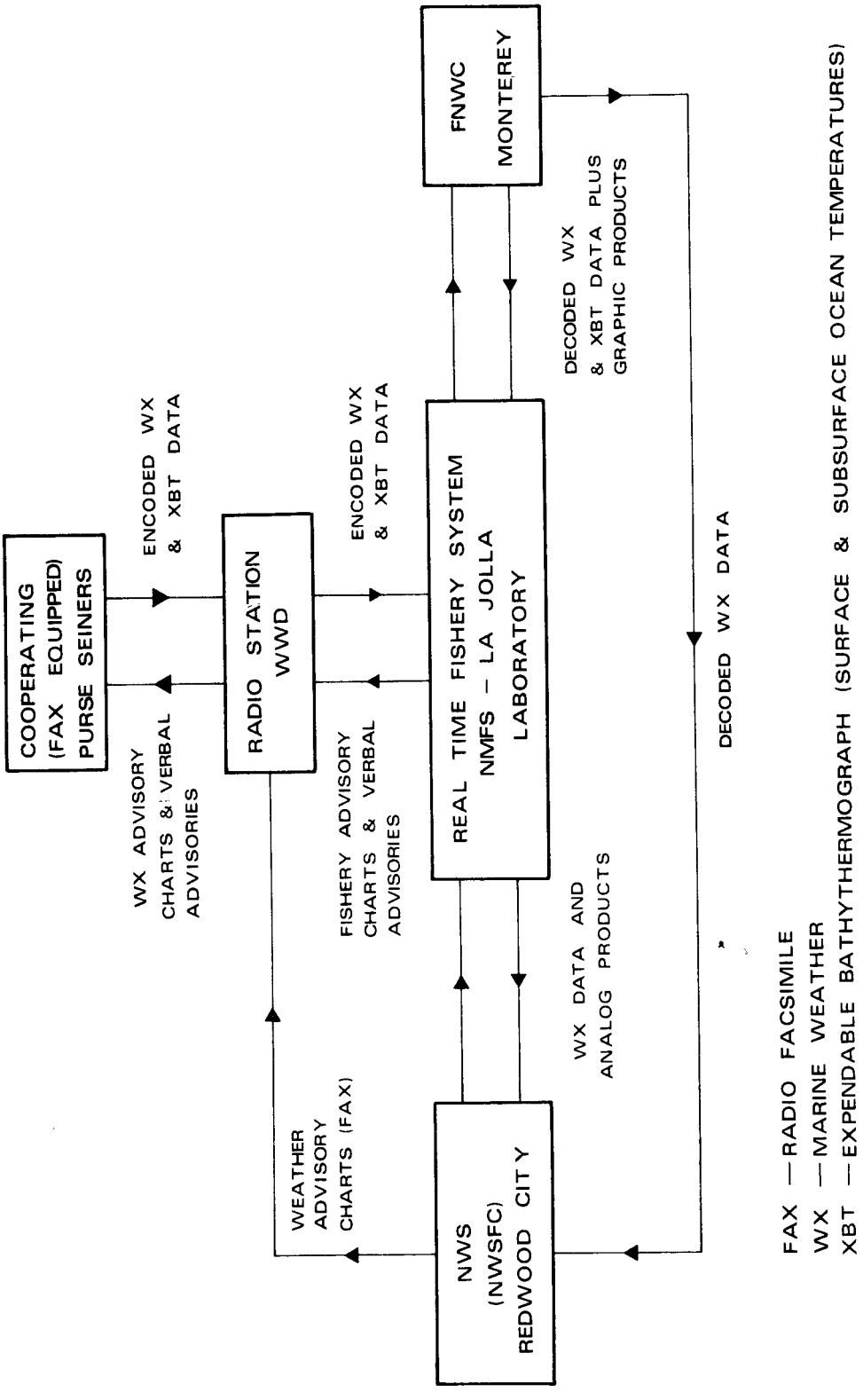

Figure 3: Flow of information within the NMFS Cooperative Tropical Tuna Advisory Program

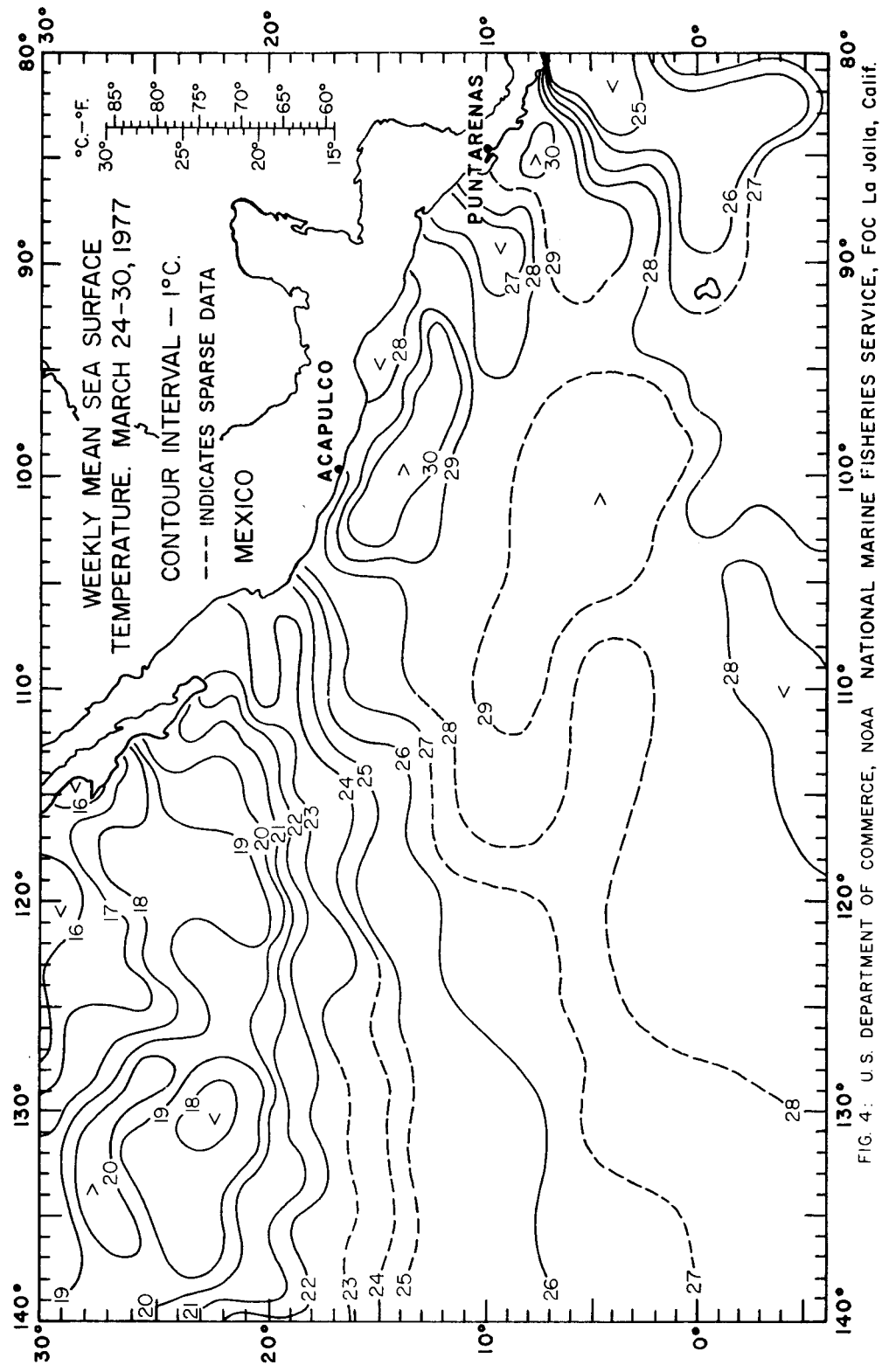

FIG. 4: U.S. DEPARTMENT OF COMMERCE, NOAA NATIONAL MARINE FISHERIES SERVICE, FOC La Jolla, Calif.

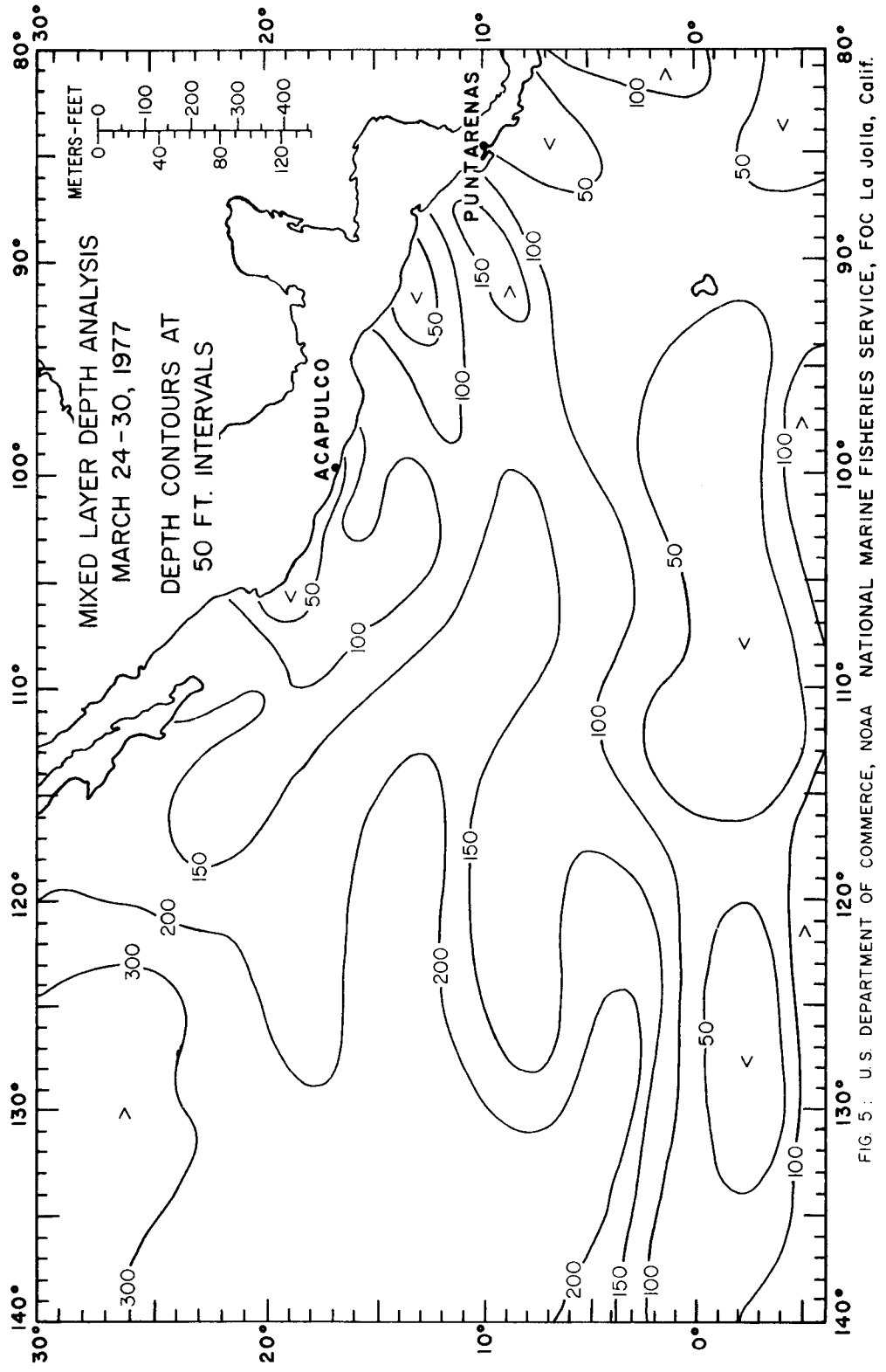

FIG. 5: U.S. DEPARTMENT OF COMMERCE, NOAA NATIONAL MARINE FISHERIES SERVICE, FOC La Jolla, Calif.