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# Application of a Satellite-tracked Fishing Vessel Transmitting Terminal (FVTT) to Fisheries Management and Science

by

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## ABSTRACT

An operational demonstration of a satellite data collection and locating system with application to fisheries management and science was conducted in the Northwest Atlantic Ocean in the winter and fall of 1980. Utilizing the ARGOS Data Collection System aboard the polar orbiting TIROS-N series meteorological satellites, Fishing Vessel Transmitting Terminals (FVTT), and a Local User Terminal (LUT) ground station located at the U.S. Coast Guard Oceanographic Unit, National Marine Fisheries Service (NMFS) observers aboard foreign fishing vessels in the U.S. Fishery Conservation Zone (FCZ) relayed catch management data via the FVTT through the satellite system. Vessel location was determined from doppler frequency shift measurements at the satellite of the FVTT transmissions. Daily catch and catch disposition data by species relayed from the observer were decoded at the ground station and entered into computer storage on the Enforcement Management Information System (EMIS) for easy access through a telephone data terminal. The data collected during the FVTT demonstration project are summarized in this paper. This method for the routine acquisition of high quality catch data provides a valuable asset to quota management through rapid logging of catch at a central site. In the future observers could additionally report fishing effort along with the catch data to provide a convenient index of catch per unit effort for input to stock prediction models. It is intended that this pilot program be expanded to the entire U.S. FCZ and to include the ability to report meteorological data collected by the observer as well.

SYMPOSIUM ON REMOTE SENSING

BACKGROUND

In 1980 the U.S. Coast Guard Oceanographic Unit undertook a project to determine the feasibility of remotely tracking foreign fishing vessels (FFV) in the U.S. fishery conservation zone (FCZ) and of relaying fish catch and other data via a satellite system. This feasibility demonstration project was conducted in cooperation with the northeast region National Marine Fisheries Service enforcement personnel who provided their FFV on-board observers with transmitters especially built by the Oceanographic Unit. While aboard the FFV the observer was able to periodically send back catch and other environmental data to a central site and to have his position fixed independent of any of the vessel's navigation equipment. These data were entered into a nationwide enforcement management information system for access by authorized Coast Guard and NMFS personnel.

THE SYSTEM

The system is comprised of three main parts – radio transmitters operating at 401.65 MHz, polar orbiting satellites, and a ground receiving/processing station (Figure 1). The satellites are U.S. meteorological satellites of the TIROS-N series operated by the National Oceanic and Atmospheric Administration, National Earth Satellite Service (NOAA/NESS) with the ARGOS Data Collection System (DCS) on board. Normally two satellites are in operation in sun-synchronous orbits at a time. The ARGOS DCS subsystem measures the doppler-shifted frequency of the 401.65 MHz transmitters whenever they are in the satellites' field of view. Using the doppler information and knowledge of the orbital ephemeris, the position of the transmitter's at the time of the satellite overpass can be calculated to an accuracy of ±3km. Modulation of a portion of the transmitted signal is used to transmit data from sensors, or data input from switches.

The transmitters are small, battery-operated, self-contained units. A limited number of these transmitters were especially equipped with 32 digital switches, a digital interface board, and environmental sensors at the Oceanographic Unit to permit the fisheries observer to communicate data back to shore (Figure 2). These transmitters, called Fishing Vessel Transmitting Terminals (FVTT), are weather-proof and are meant to be operated on an open deck. A modified version of the FVTT incorporating improvements derived from experience with the first FVTTs is in production at the Oceanographic Unit and should be in the field in the fall of 1981. Changes to the FVTT include an additional 11 switches (a total of 43) for reporting

meteorological data collected by the observer, a 50 ft. antenna cable extension to permit locating the FVTT inside the vessel, and a new watertight, rugged carrying case.

The final segment of the system is a ground station for receiving and processing the data and computing positions. These satellites transmit the data from the FVTTs back to earth in two modes. First the data are recorded on magnetic tape on board the satellite and the tape is played back to Command and Data Acquisition (CDA) stations at Wallops Island, Virginia and Gilmore Creek, Alaska, and at a receiving site in Lannion, France. These data are relayed to the Service ARGOS data processing center in Toulouse, France for position locating and data decoding. This mode allows the acquisition of data from transmitters anywhere in the world. Second, the data are broadcast in real-time to earth simultaneously as they are being recorded on the satellite. This signal, referred to as the VHF beacon, may be received by small, low-cost Local User Terminals (LUT). In this mode the LUT tracks and receives data from transmitters whenever the satellite is in mutual view of the transmitter and the LUT (nominally a radius of 2000 nmi from the LUT site). The FVTT feasibility demonstration project was conducted with an LUT located at the Oceanographic Unit in Washington, D.C. The LUT consists of a directional antenna (Figure 3) and associated cabling, the LUT, itself, containing a receiver, a decommutator, and a microprocessor for reducing the data and computing look angles for the antenna pointing drive (Figure 4), and a line printer for outputting the results (Figure 5). The LUT at the Oceanographic Unit also has the capability to output data to computer compatible tape. After each available pass the data are reformatted and logged. The vessel positions are machine plotted along with the applicable fishing window in mercator projection as a navigational chart overlay to monitor foreign fishing vessel activity (Figure 6). Then a technician keys the information into computer memory in the enforcement management information system (EMIS) via an acoustic telephone data terminal. Through EMIS any authorized Coast Guard or NMFS personnel with access to a telephone and a data terminal can call up an FVTT file (Figure 7). The user of this system can query the computer files and receive up-to-date information summaries by date or by vessel (i.e. by vessel radio call sign). These summaries are valuable for assessing vessel activity, monitoring observer safety, and providing fish catch data for quota management or as input to fisheries stock prediction models.

## RESULTS

A summary of the results for the winter 1980 feasibility demonstration project along the northeast coast of the United States indicates that ten successful deployments by observers to FFVs resulted in a total of 128 at sea days, 393 environmental and fish catch data reports, and

at least 2 position fixes per day. Location accuracy was found to be within ±2 nmi 88% of the time and ±5 nmi 100% of the time. The data reported were 1) Observer identification code, 2) catch date, 3) air temperature, 4) species identification code, daily catch, catch disposition, and cumulative catch since the beginning of the fishing permit period for the three most abundant species in the catch. The data input to the FVTT via the digital switches may be varied to suit the needs of the fishery management and research community reporting up to the maximum of 64 digits which is the limit of the present ARGOS Data Collection System on the satellites.

DISCUSSION

In terms of fishery resource management where a quota-type management scheme is used to regulate the exploitation of fish stocks it is desirable to have current catch statistics readily available to assess the rate at which certain targeted fish species are being taken. The FVTT reporting system provides a convenient, responsive, centralized, semi-automated way of determining exploitation rates and cumulative catch for a part of the fishing fleet. It is common knowledge that exploitation rates are not constant and that fact is reflected in several cases in the analysis of the data from the 1980 FVTT demonstration project (Figures 8 and 9). The exploitation rates may vary for a variety of environmental or human factors which may reflect changes in the abundance and location of fish stocks, increased or decreased fishing effort, gear changes, meteorological conditions, or even changes in the age composition of different stocks. Nevertheless, current cumulative catch values of a few select species for the segment of the foreign fishing fleet for which the data are available may be extracted from the FVTT data set. It may be possible to extrapolate these data to yield a more time-sensitive prediction of quota attainment for vessels of a given nationality fishing under permit if not for the entire fleet-at-large. This service provides the fishery managers with convenient method for monitoring the season's progress.

This procedure for the use of catch data in quota management is nothing more than what is presently being done, except that instead of relying solely upon vessel radio reports from a few vessels and dockside/market censuses it will be possible to have daily catch summaries from a larger portion of the foreign fishing fleet through a legislatively mandated increased observer coverage and a semi-automated, centralized reporting system. Where data were transmitted via radio to shore or were extracted from logs upon the observers' return to shore for later compilation, the catch data reported via the FVTT system will reside in computer storage at a single location where up-to-date catch statistics may be collated frequently for access by resource managers.

Fishery science is concerned with among other things the abundance of fish stocks and especially changes in abundance with time, hence an interest in recruitment of specific year-classes and mortality of the entire stock in general. One of the indices of abundance used by fishery scientists is catch-per-unit-effort (CPUE). In the future in addition to catch and disposition it may be possible for the observer to input the number of hours fished by the vessel for the amount of catch reported for a given species. Thus, one could readily derive CPUE from the FVTT data bank and over a year's time have accumulated sufficient information to have a reliable index of stock density, which combined with other sources of data, permits an estimate of abundance. To this end the FVTT data collection system serves as a valuable asset to fishery research into population dynamics by routinely compiling catch statistics with location. Since the data are maintained in computer storage they lend themselves readily to manipulation for input to a variety of fishery models.

With the addition of eleven switches to the new FVTT the observer will be able to report barometric pressure, wind speed and direction, and sea state. These data will be relayed to the U.S. National Weather Service for use in meteorological analyses.

(Note: Ambient air temperature is automatically sampled by a sensor in the FVTT and is relayed along with the catch data via the ARGOS DCS). These on scene meteorological observations will contribute to improving forecasts by providing data from under-sampled maritime areas as well as to help evaluate effect of the physical environment on fishing success.

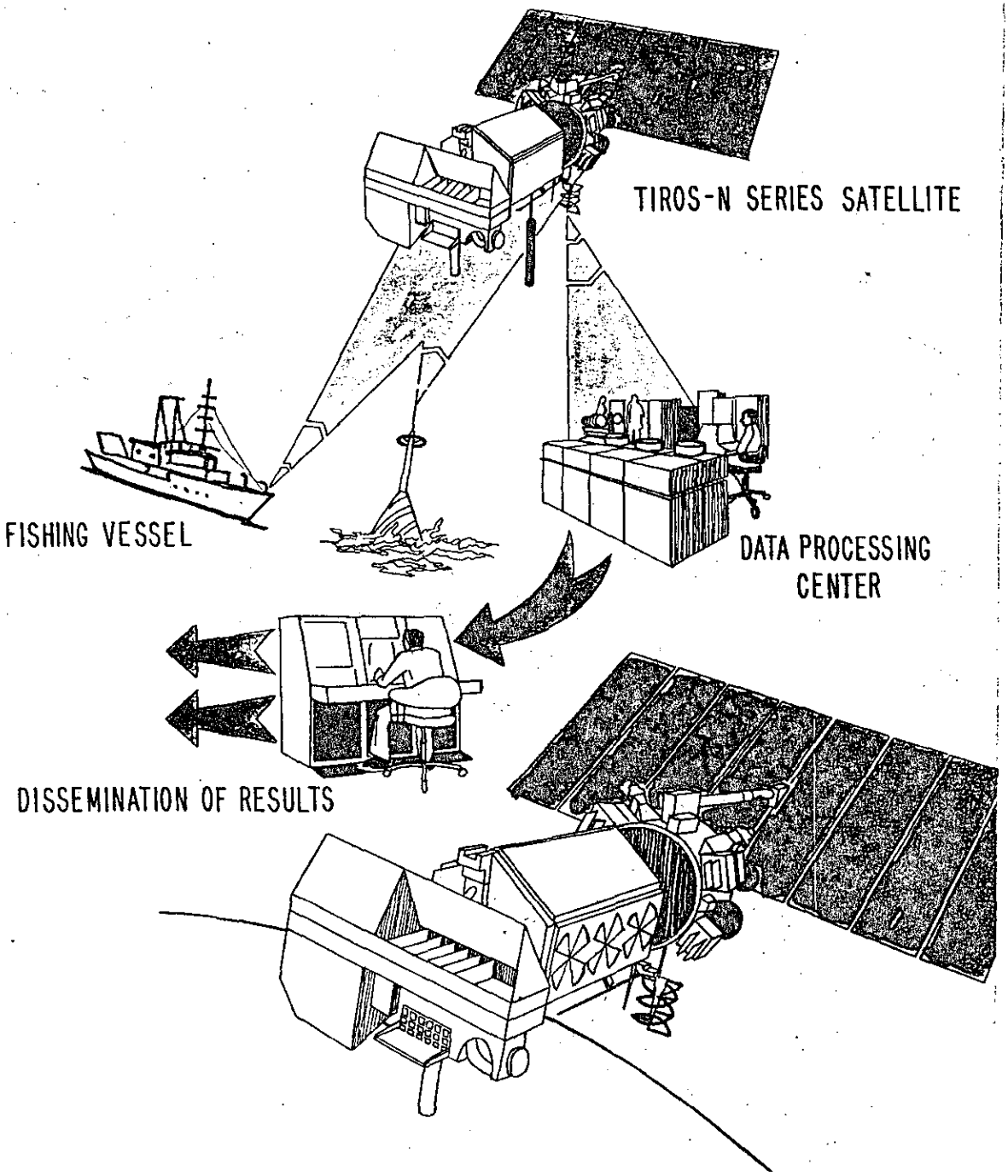
## THE FUTURE

It is expected that this program will expand such that all U.S. fisheries observers will carry an FVTT whenever they are aboard a foreign fishing vessel in the U.S. fishery conservation zone. A pilot program in the Northwest Region is anticipated to begin in the fall 1981 for the Gulf of Alaska and Bering Sea. Vessel location, catch, and other environmental data will be relayed by satellite to the Coast Guard and this information will be disseminated to authorized field personnel in the Coast Guard and NOAA for action.

## ACKNOWLEDGEMENTS

We wish to commend the efforts of the observers of the Northeast Region, National Marine Fisheries Services for making the FVTT demonstration project a success. The logistical support provided by Commander, Atlantic Area, Marine Sciences Branch, U.S. Coast Guard is much appreciated.

Figure 1. The TIROS-N series satellite ARGOS Data Collection System



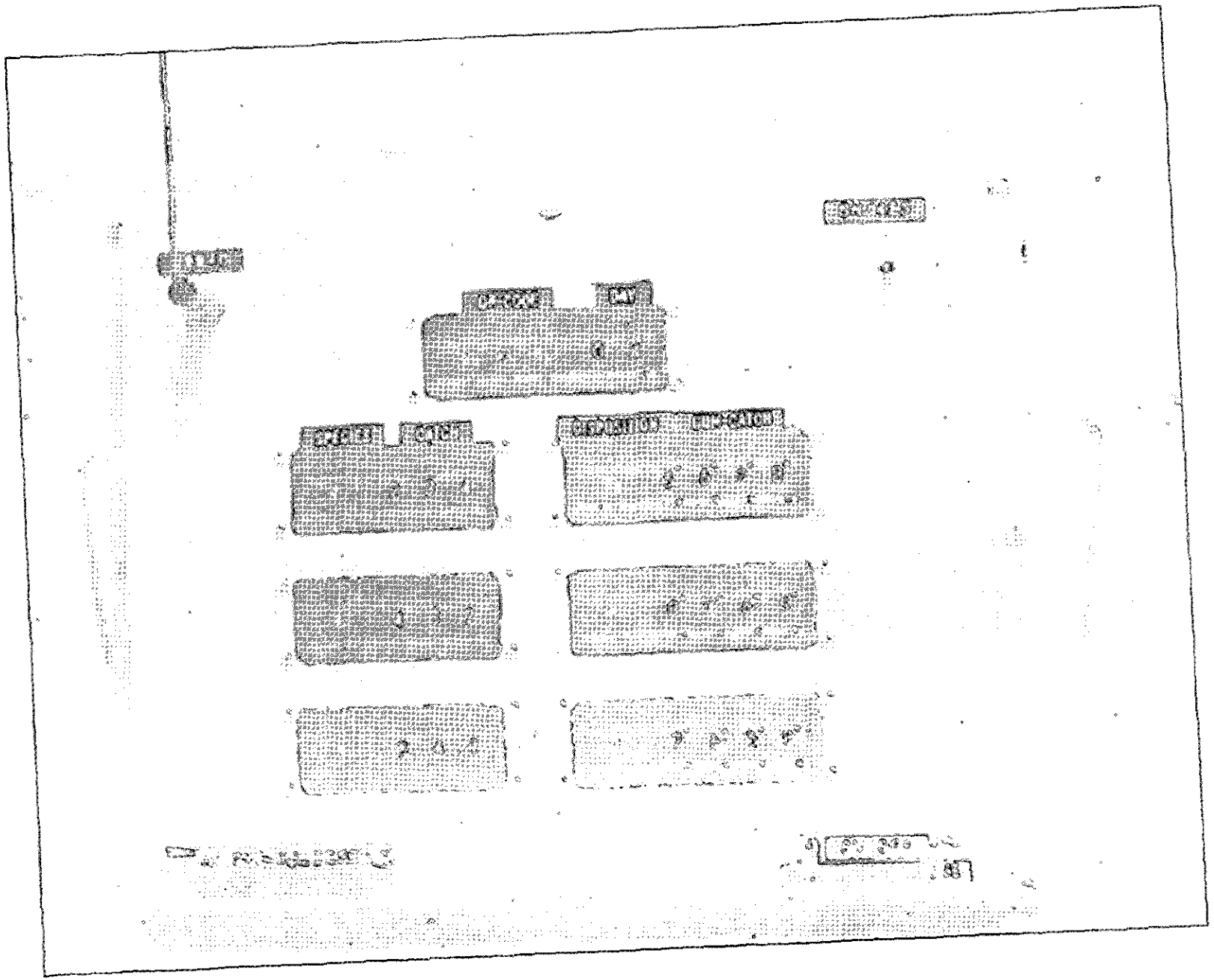


Figure 2. Fishing Vessel Transmitting Terminal

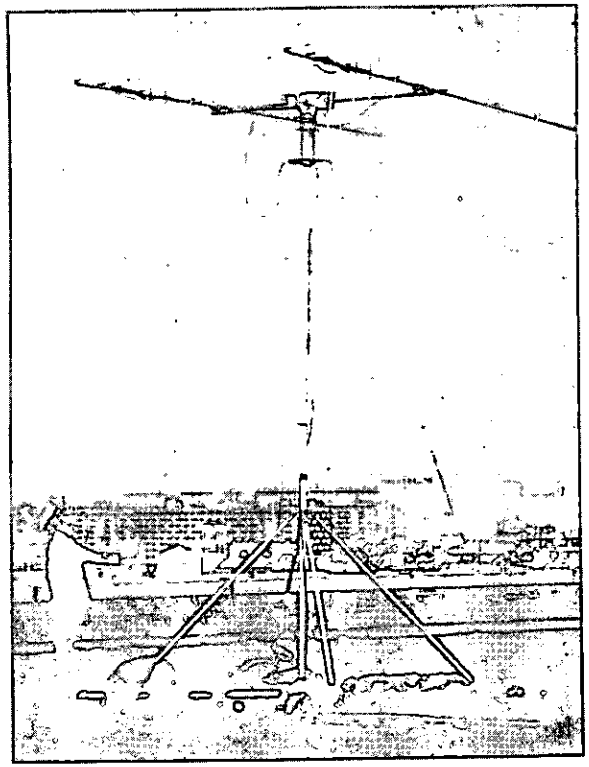


Figure 3. Local User Terminal Directional Antenna

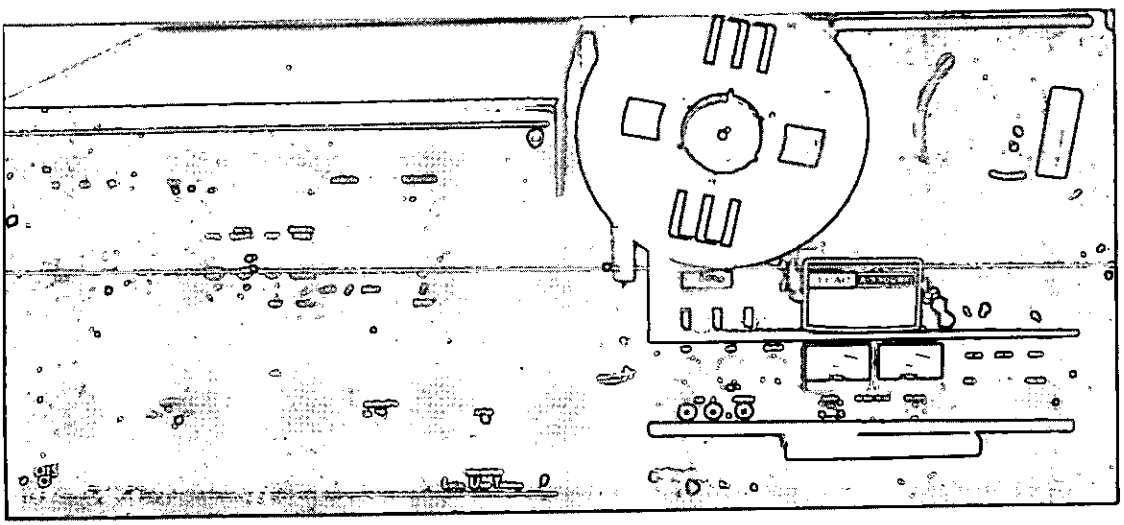


Figure 4. Local User Terminal receiver, decommutator, and microprocessor

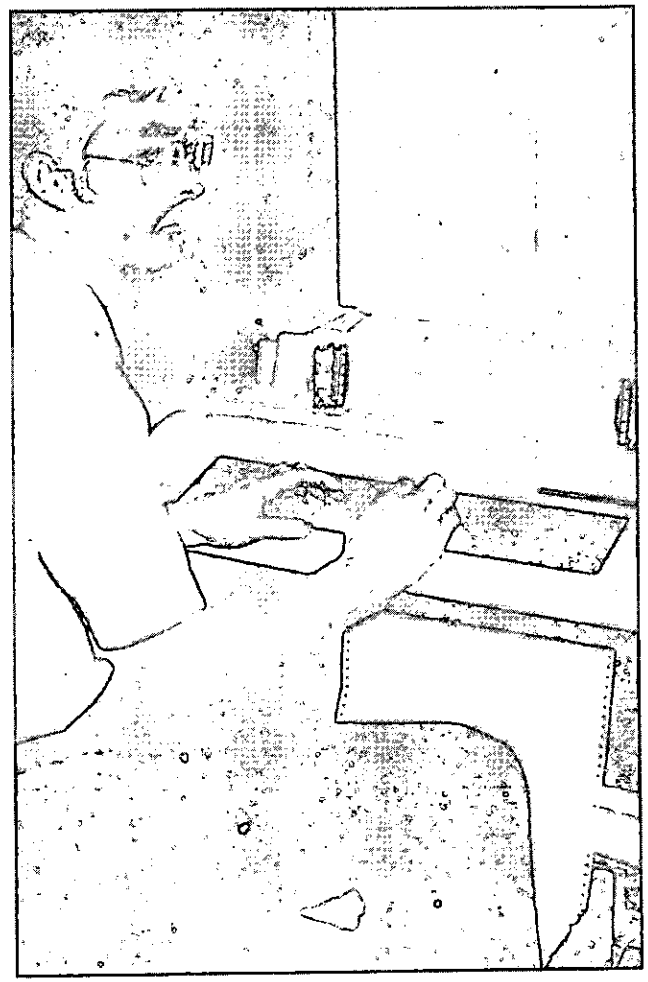


Figure 5. Local User Terminal. Processed data automatically output to lineprinter.

Figure 6. A mercator projection machine plot of a foreign fishing vessel's activity for overlay of a navigation chart. The parallelogram represents the limits of the fishing window.

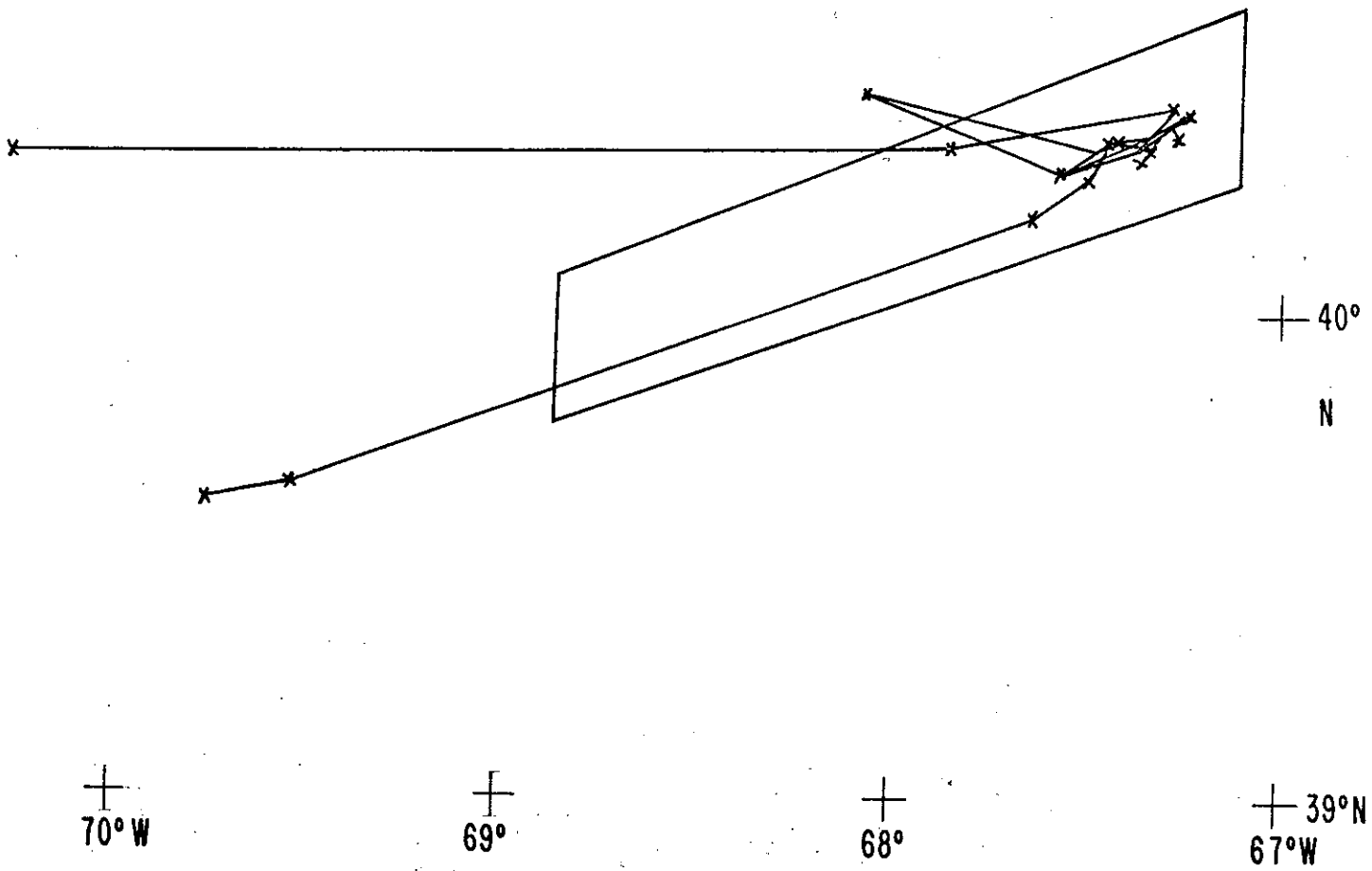


Figure 7. Example of an FVTT data file summary for 20 January 1980.

```
CALL SIGN    REP DATE  TIME  LAT          LONG          TEMP   CATCH DATE   CODE
   EATB       1/20/80  1154  40.063000    70.469000    -1.8    1/18/80      611
        CS 1: 1          DC 1: 3       DS 1:  1                CC 1: 28
        CS 2: 3          DC 2: 0       DS 2:  2                CC 2: 0
        CS 3: 5          DC 3: 25      DS 3:  2                CC 3: 0

   EATB       1/20/80  858   40.086000    70.590000    -2.4    1/18/80      611
        CS 1: 1          DC 1: 3       DS 1:  1                CC 1: 28
        CS 2: 3          DC 2: 0       DS 2:  2                CC 2: 0
        CS 3: 5          DC 3: 5       DS 3:  2                CC 3: 0

   XCCJ       1/20/80  2313  40.062000    70.380000    -2.5    1/19/80      781
        CS 1: 1          DC 1: 3       DS 1:  1                CC 1: 32
        CS 2: 5          DC 2: 0       DS 2:  2                CC 2: 0
        CS 3: 7          DC 3: 3       DS 3:  2                CC 3: 0

   XCCJ       1/20/80  1146  40.062000    70.470000    -1.6                 781
        CS 1: 1          DC 1: 3       DS 1:  1                CC 1: 28
        CS 2: 3          DC 2: 0       DS 2:  2                CC 2: 0
        CS 3: 5          DC 3: 5       DS 3:  2                CC 3: 0

   XCCJ       1/20/80  1040  40.067000    70.518000    -1.8    1/18/80      781
        CS 1: 1          DC 1: 3       DS 1:  1                CC 1: 28
        CS 2: 3          DC 2: 0       DS 2:  2                CC 2: 0
        CS 3: 5          DC 3: 5       DS 3:  2                CC 3: 0

   XCCJ       1/20/80  1150  40.062000    70.470000    -1.2    1/19/80      781
        CS 1: 1          DC 1: 3       DS 1:  1                CC 1: 32
        CS 2: 5          DC 2: 0       DS 2:  2                CC 2: 0
        CS 3: 7          DC 3: 3       DS 3:  2                CC 3: 0

   EBXM       1/20/80  1844  39.060000    72.142000    .19     1/18/80      651
        CS 1: 5          DC 1: 6       DS 1:  1                CC 1: 25
        CS 2: 2          DC 2: 8       DS 2:  1                CC 2: 0
        CS 3: 3          DC 3: 60      DS 3:  1                CC 3: 0
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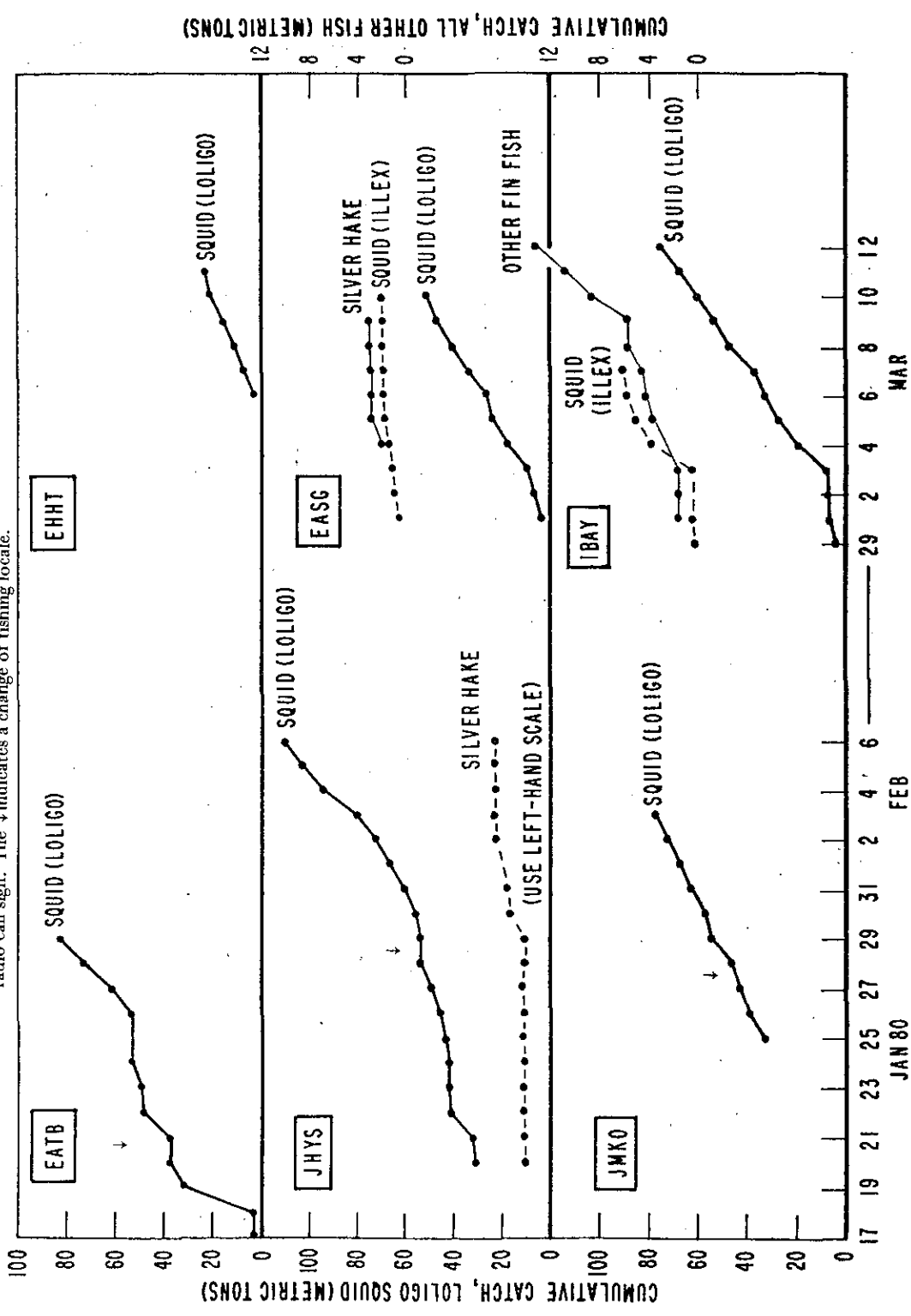


Figure 8. Cumulative catch summaries for foreign fishing vessels with NMFS observers aboard off the northeast coast of the U.S. during the winter 1980. The vessel is identified by its radio call sign. The ↓indicates a change of fishing locale.

Figure 9. Cumulative catch summaries for foreign fishing vessels with NMFS observers aboard off the northeast coast of the U.S. during the late summer-fall 1980. Vessels are identified by their radio call sign.