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Application of a Satellite-tracked Fishing Vessel Transmitting Terminal to Fisheries Management and Science

R. M. Hayes[1] and J. J. Murray[2]
U. S. Coast Guard Oceanographic Unit
Washington, D. C. 20593, USA

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 autumn of 1980. Utilizing the ARGOS Data Collection System aboard the polar-orbiting TIROS-N series meteorological satellites, fishing vessel transmitting terminals, and a Local User Terminal ground station at the U. S. Coast Guard Oceanographic Unit, Washington, U. S. fishery observers aboard foreign fishing vessels operating in the U. S. fishery conservation zone relayed catch data via the satellite system. Vessel location was determined from Doppler frequency shift measurements of the vessel to satellite transmissions. Daily catch and catch disposition data by species, reported by the observers, were decoded at the ground station and entered into computer storage for easy access through a telephone data terminal. The data collected during the 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 information at a central site. The system could, in the future, be used for the acquisition of fishing effort as well as catch data to provide abundance indices for input to stock prediction models. It is intended that the program be expanded to the entire U. S. fishery conservation zone and include the transmission of meteorological data collected by the observers.

Background

In 1980, the U. S. Coast Guard Oceanographic Unit undertook a project to determine the feasibility of remotely tracking foreign fishing vessels in the U. S. fishery conservation zone and of relaying fish catch and other data via a satellite system. This project was conducted in cooperation with National Marine Fisheries Service enforcement personnel of the Northeast Region, who provided their observers on foreign fishing vessels with transmitters especially built by the Oceanographic Unit. While aboard a foreign fishing vessel, the observer could periodically transmit catch and environmental data to a central site and have the vessel's position fixed independently of that determined by its navigational equipment. These data were entered into a nationwide enforcement managment information system for access by authorized personnel of the Coast Guard and the National Marine Fisheries Service.

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 (Fig. 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 on board. Normally, two satellites are in operation in sun-synchronous orbits at a time. The ARGOS subsystem measures the Doppler-shifted frequency of the 401.65 MHz transmitters whenever they are in the satellites' field of view. Using Doppler information and knowledge of the orbital ephemeris, the position of the transmitters at the time of the satellite overpass can be calculated to an accuracy of ±3 km. Modulation of a portion of the transmitted signal is used to relay data from sensors and data input from switches.

The transmitters are small battery-operated, self-contained units. A limited number of them were especially equipped with 32 digital switches, a digital interface board, and environmental sensors to permit the communication of a variety of data to shore stations. These transmitters, called fishing vessel transmitting terminals (FVTT), are weatherproof and are intended for use on the open deck. A modified version of the FVTT, incorporating improvements derived from experience with the initial FVTTs, is expected to be operational by the autumn of 1981. Changes to the FVTT include 11 additional switches (total of 43) for reporting meteorological data collected by the observer, a 15-m antenna-cable extension to permit operation of the transmitter inside the vessel, and a rugged water-tight carrying-case (Fig. 2).

[1] Present address: Marine Science and Ice Operations Division, U. S. Coast Guard Headquarters, Washington, D. C. 20593, USA
[2] Present address: Short Range Aids to Navigation Division, U. S. Coast Guard Headquarters, Washington, D. C. 20593, USA

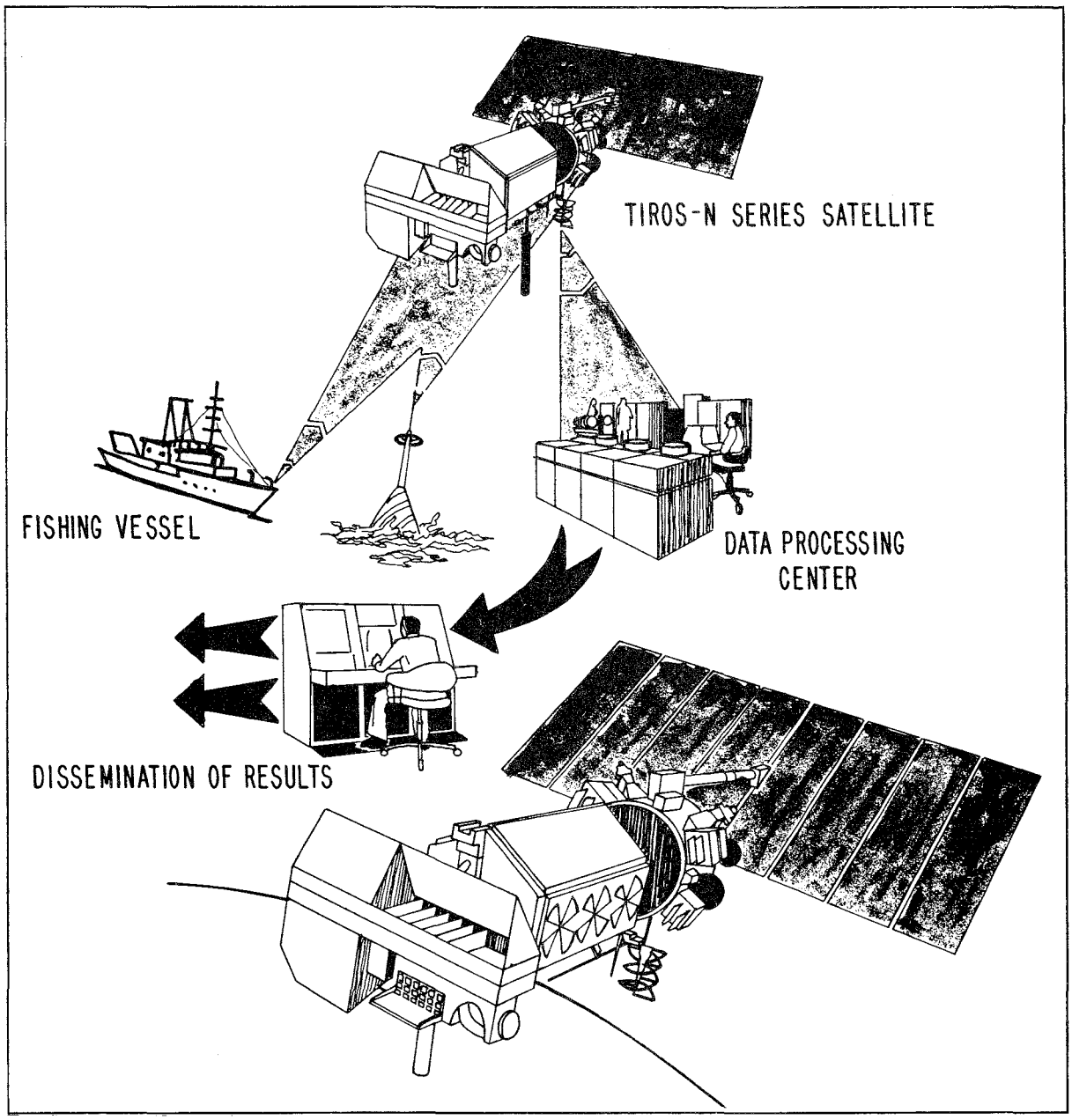

Fig. 1. The TIROS-N series satellite with ARGOS Data Collection System.

The third segment of the system involves ground stations for receiving and processing the data and computing the vessels' positions. The satellites transmit the data from the FVTTs back to earth in two modes. Firstly, the data are recorded on magnetic tape aboard the satellite and the taped data are subsequently transmitted to Command and Data Acquisition stations at Wallops Island, Virginia, and Gilmore Creek, Alaska, in the U. S. and to a receiving site at Lannion in France. These data are then relayed to 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. Secondly, the data are broadcasted in real-time to earth simultaneously with their being recorded aboard 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 (normally a radius of 3,700 km from the LUT site). The FVTT feasibility demonstration

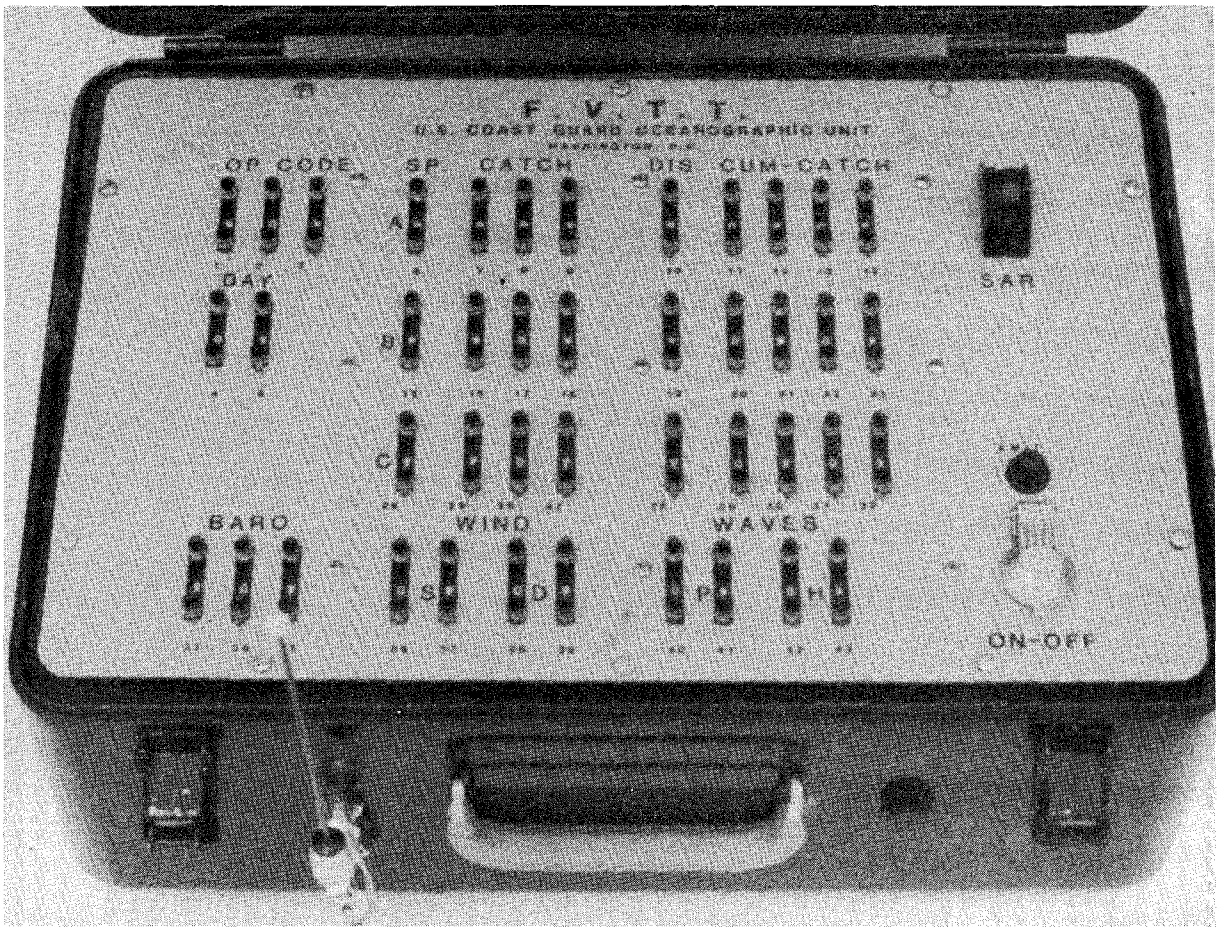

Fig. 2. The portable Fishing Vessel Transmitting Terminal (FVTT).

project was conducted with a LUT located at the Oceanographic Unit in Washington, D. C. The LUT consists of a directional antenna (Fig. 3) and associated cabling, a unit containing receiver, decommutator and microprocessor for reducing the data and computing look angles for the antenna-pointing drive, and a line-printer for outputting the results (Fig. 4). The LUT at the Oceanographic Unit also can output the data to computer-compatible tape. After each available pass of the satellite, the data are reformatted and logged. The vessel positions are machine-plotted, together with the applicable fishing area to which fishing by foreign vessels is restricted, in mercator projection as a navigational chart overlay, in order to monitor foreign fishing vessel activity (Fig. 5). The information is then entered, via an acoustic telephone data terminal, into the Enforcement Management Information System computer, from which any authorized personnel with access to a telephone and a data terminal can retrieve FVTT files (Table 1). The user of the system can query the computer files and receive up-to-date information summaries by date or by vessel (i.e. radio call sign). These summaries are valuable for assessing vessel activity, monitoring observer safety, and providing data on fish catches for quota management or as input to fishery stock-prediction models.

Results

The feasibility study in the winter of 1980 involved 10 successful deployments of observers to foreign fishing vessels operating off the northeastern United States, resulting in 128 days at sea, 393 environmental and fish catch data reports, and at least two position fixes per day. Location accuracy was found to be within '3.7 km for 88% of the observations and within '9.3 km for 100% of the observations. The data reported were observer identification code, catch date, air temperature, 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 FVTT input via the digital switches may be varied to suit the needs

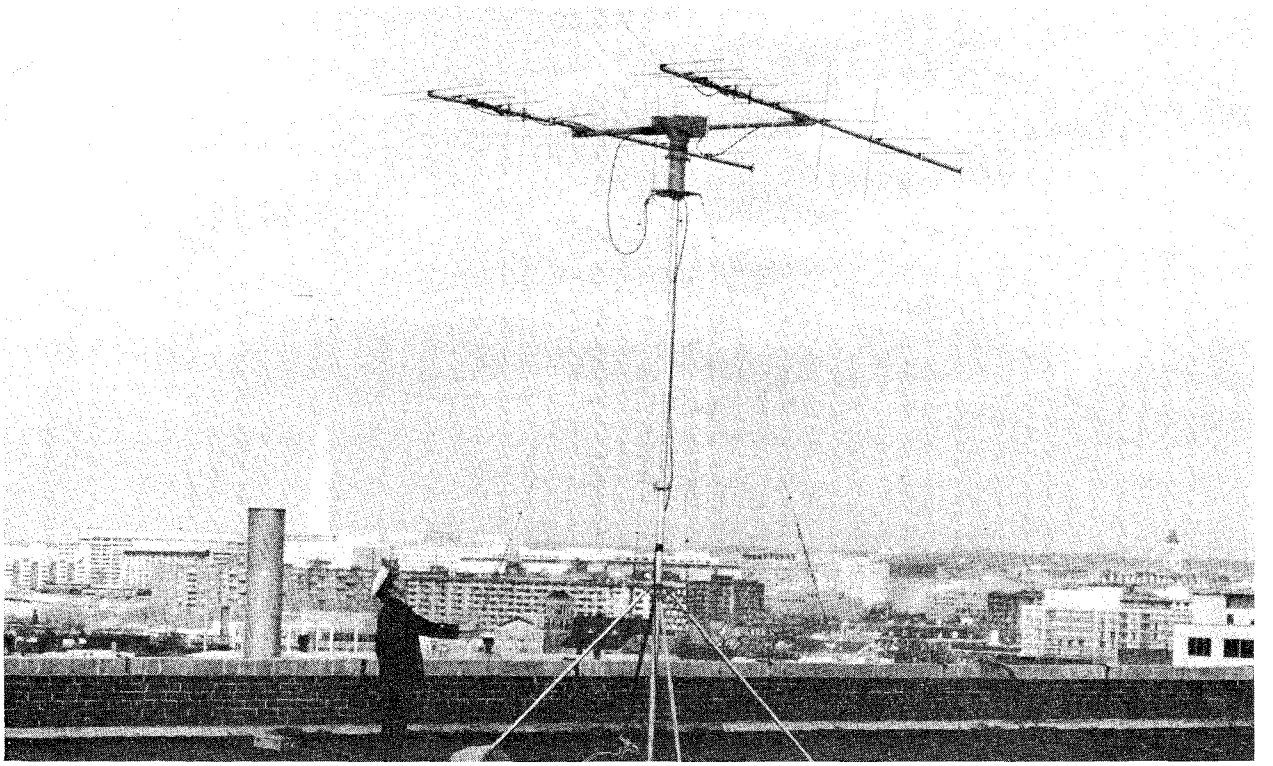

Fig. 3. Directional antenna of the on-shore Local User Terminal (LUT).

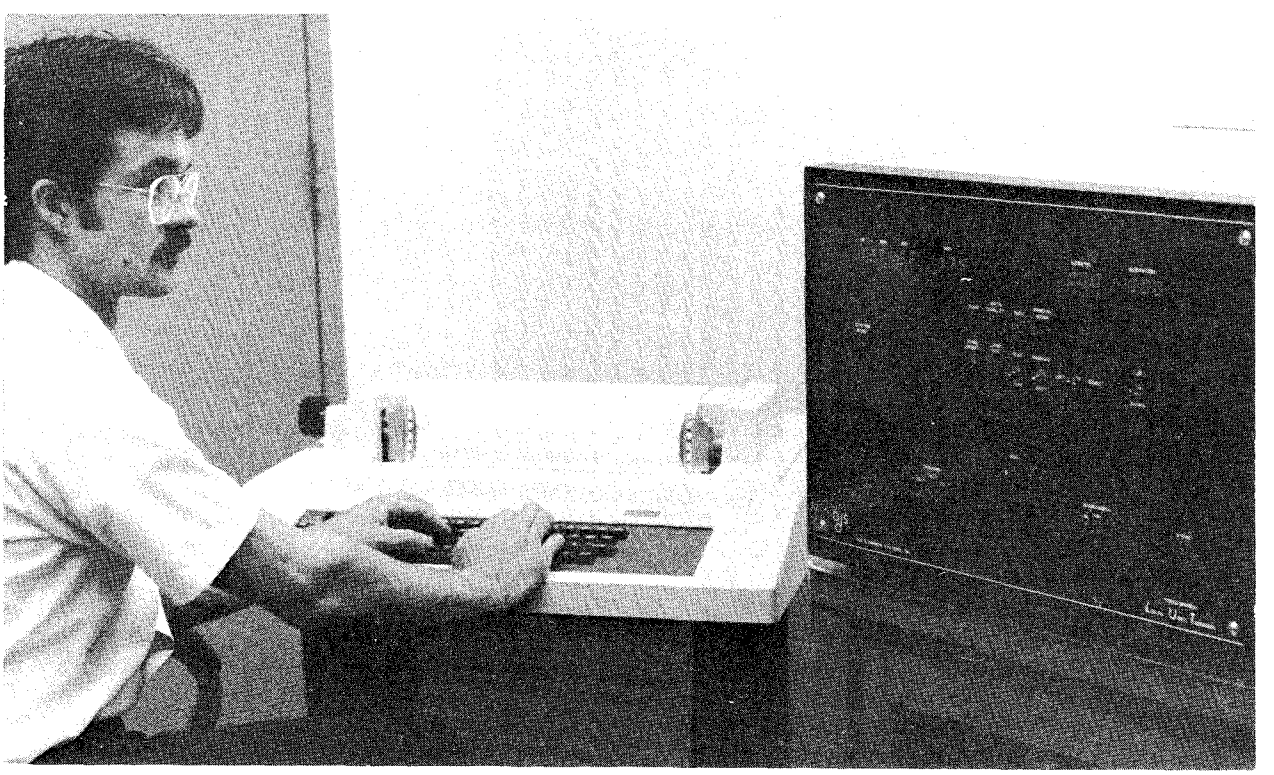

Fig. 4. Local User Terminal (LUT) comprising receiver, decommutator, and micro-processor for acquisition of ARGOS data in real-time. (Operator communicates with LUT via a line-printer which also outputs the processed data.)

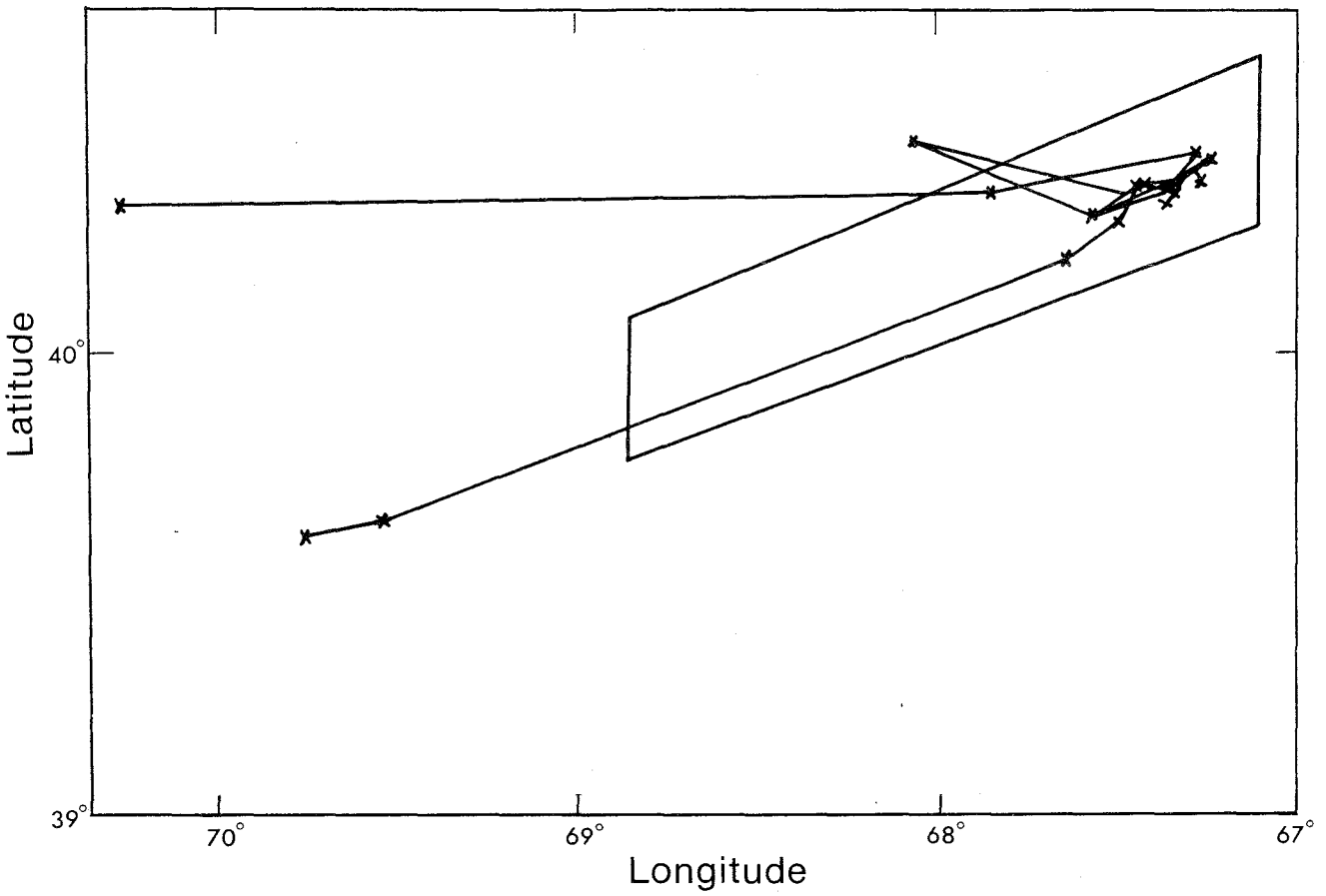

Fig. 5. Mercator projection machine plot of a fishing vessel's activity for overlay on a navigation chart. The parallelogram represents the limits of the permitted fishing area.

of fishery management and research community, using up to 64 digits, which is the limit of the present ARGOS Data Collection System on the satellites.

Discussion

For fishery resource management where quota regulations are imposed to control the exploitation of fish stocks, it is desirable to have current catch statistics readily available to assess the rate at which certain targetted fish species are being taken. The FVTT reporting system provides a convenient, centralized, semi-automated way of obtaining exploitation rates and cumulative catch data for a part of the fishing fleet. It is common knowledge that exploitation rates are not constant, as reflected in the analysis of data from the 1980 FVTT demonstration project (Fig. 6 and 7). The exploitation rates may vary for a variety of reasons which may reflect changes in abundance and location of fish stocks, increased or decreased fishing effort, gear changes, meteorological conditions, or even changes in age composition of the stocks. Neverthe-

TABLE 1. Example of an FVTT data file for 20 January 1980.

CALL SIGN	REP DATE	TIME	LAT	LONG	TEMP	CATCH DATE	CODE
EATB	01/20/80	1154	40.0630	70.4690	-1.8	01/18/80	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	01/20/80	0858	40.0860	70.5900	-2.4	01/18/80	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	01/20/80	2313	40.0620	70.3800	-2.5	01/19/80	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	01/20/80	1146	40.0620	70.4700	-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	01/20/80	1040	40.0670	70.5180	-1.8	01/18/80	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	01/20/80	1150	40.0620	70.4700	-1.2	01/19/80	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	
EHXM	01/20/80	1844	39.0600	72.1420	.19	01/18/80	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	

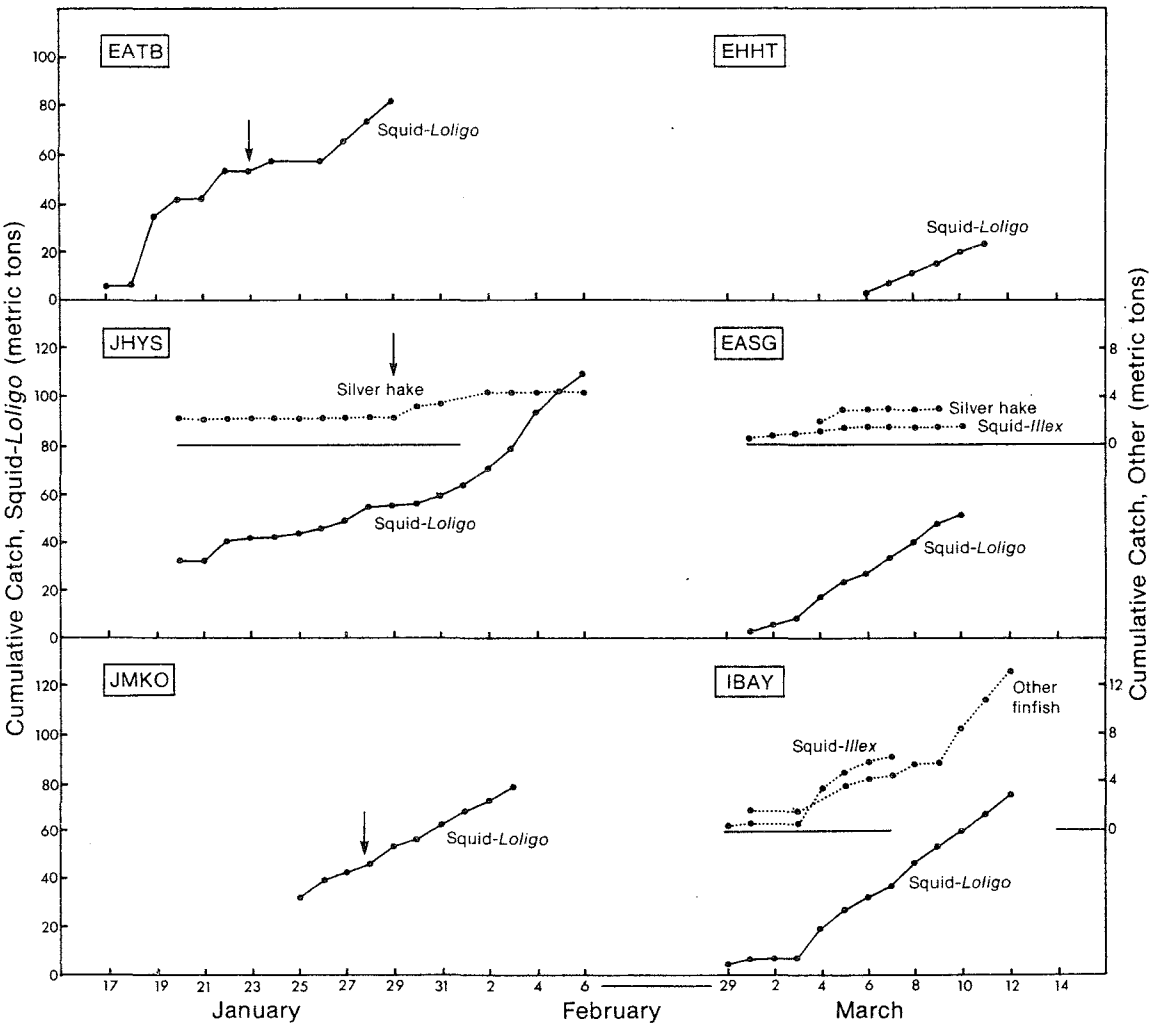

Fig. 6. Cumulative catch summaries for foreign fishing vessels with U. S. fishery observers aboard off northeastern United States during directed fishing for squid (*Loligo pealei*) in January–March 1980. (Four-letter codes represent different vessels. Arrows indicate changes in fishing locale.)

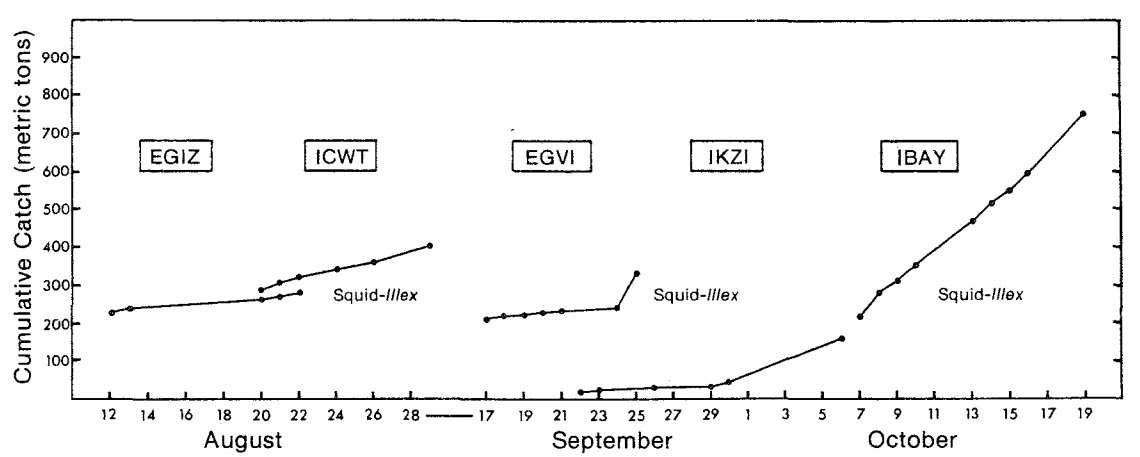

Fig. 7. Cumulative catch summaries for foreign fishing vessels with U. S. fishery observers aboard off northeastern United States during directed fishing for squid (*Illex illecebrosus*) in August–October 1980. (Four-letter codes represent different vessels.)

less, the FVTT data base allows a more time-sensitive prediction of quota attainment for selected fishing vessels if not for the entire fleet. The service provides fishery managers with a convenient method of monitoring the spatial and temporal fishing activity of fishing vessels equipped to transmit data.

Fishery science is concerned with, among other things, abundance levels of fish stocks, and especially changes in abundance with time; hence, there is an interest in recruitment of specific year-classes and mortality of the stock in general. One of the indices of abundance used by fishery scientists is catch-per-unit-effort (CPUE). In the future, additional to reporting data on catches and their disposition, the observer may be able to input the number of hours fished by the vessel for the amount of catch reported for a given species. Thus, when sufficient information has been accumulated, the CPUE data derived from the FVTT data bank could provide reliable indices of stock density, which, combined with other data, would permit estimates of stock abundance. To this end, the FVTT data-collection system would serve as a valuable asset to fishery research into population dynamics by routinely compiling fishery statistics by date and location of catches. Computer storage of the data readily permits manipulation for input to a variety of fishery models.

With the addition of 11 switches to the new FVTT, the observer will be able to report barometric pressure, wind speed and direction, and sea state. These data, together with the currently reported air temperatures, will be relayed to the U. S. National Weather Service for use in meteorological analysis. These on-site meteorological observations will contribute to improving forecasts with additional data from traditionally under-sampled maritime areas as well as to evaluating the effects of the physical environment on fishing success.

The program is expected to be expanded, along with an increase in observer coverage, such that a FVTT will be carried by every U. S. fishery observer aboard a foreign fishing vessel in the U. S. fishery conservation zone. A pilot program in the U. S. Northwest Region is anticipated to begin in the autumn of 1981 for the Gulf of Alaska and Bering Sea.

Acknowledgements

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