BUOY TELEMETRY FOR ENVIRONMENT PREDICTION IN FISHERIES RESEARCH

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ABSTRACT

A telemetering buoy has been developed for the Bureau of Commercial Fisheries to provide environmental information in support of salmon research. The buoys are designed to be free-drifting units; sensors are inductively coupled to a 200 m. single conductor cable beneath the buoy. Present sensors measure temperature, conductivity and depth. One buoy is equipped to participate in the IRLS satellite telemetry experiment. Present development includes equipment to have the buoys determine their position by use of the U.S. Navy Navigation Satellite System.

INTRODUCTION

The Bureau of Commercial Fisheries has been measuring the ocean environment for many years as part of its studies of the intricate interrelationships between fish and the waters about them. The interest of the Bureau in buoys is a result of a need for data and information of a breadth and extent which cannot be obtained at reasonable cost from ship observations. For several years the Bureau has had a small project in buoy development as part of its continuing program of oceanographic investigation in the North Pacific Ocean, and presently has several small telemetering buoys and sensors. The course of development of the buoy project has been largely determined by the fishery problems which require the type of data which only buoys appear able to provide.

Pacific sockeye salmon (Oncorhynchus nerka) range over about 1 million square miles of ocean, and have a distribution which is strongly affected by environmental features of the ocean. The southern limit of salmon distribution, for example, is associated with the temperature structure at about 200 m. As they mature, salmon are found in distinctly different environments, and use the ocean current structure in their migration patterns (Figure 1). In the spring, maturing salmon which will spawn that summer, move north into the narrow swift band of westward current called the Alaskan Stream, and are carried far to the vest before they turn north into the Bering Sea and Bristol Bay. If we knew the complete environmental structure of the salmon region, we could position our ships for the best exploratory 0 and sampling program, and would be able to predict accurately the abundance and timing of the salmon runs, the relative effects of high-seas and coastal fishings, and optimum catches and escapement. At present, research vessels are unable to provide the extensive and synoptic oceanographic data which are required.

This has led to work on a buoy system which would measure surface (upper 200 m.) conditions, temperature, salinity and current velocities. The data must be available with short recovery basis, time delay (maximum 1 week), which requires buoy telemetry. The buoys should be able to be serviced and placed by regular research vessels under normal operating conditions (30 kts.) in the North Pacific Ocean. They must be placed on a variable grid, and must not be so expensive that costs exceed the benefits.

The present program uses a spar buoy about 15 ft long with a series of sensor units clamped to a single conductor cable suspended beneath the buoy. The sensors are inductively coupled and may be interspersed in any order and at any depth along the cable. The choice of free drifting as opposed to moored buoys has been influenced by the cost and difficulty of mooring buoys in the North Pacific Ocean. The operational requirements for buoy spacing and location will change seasonally, and as the location of oceanic fronts, currents, and water masses change. At present, it seems that the problem of determining buoy position is easier to solve at reasonable expense than the problems associated with maintaining ane servicing a large grid of fixed buoys. Additionally, one of the quantities we most desire to measure is surface drift. The drift of the buoys serves directly as an indication of surface drift, and the buoys can be drogued to measure subsurface currents. There remain the problems of indeterminate position, and the possibility that the buoy may go aground or drift into locations or areas of low or undesired data. During tests, the buoys have been positioned visually, or by RDF bearings from nearby ship or shore stations. One unit has been adapted for the IRLS program which provides both positioning information and data telemetry via satellite. Another positioning system being developed uses the Navy Navigation Satellite System.

Data from the sensors is digitized at the sensor, recorded on magnetic tape, and telemetered from the tape on commond by a high frequency radio link to a shore station. The units have been tested at sea for periods of from one week to one month. In May 1967, two buoys, with three sensors each, were drifted for one week at a location 200 miles off the coast of Oregon. The buoys drifted 40 miles during the week. The units remained in calibration, and no electronic or mechanical malfunctions were experienced. Data was radio telemetered without difficulty to Seattle, a distance of approximately 350 miles (Figure 2). No significant fouling of sensors or buoys was observed during the week test; some fouling had been observed during a previous thirty day test period.

BUOY PLATFORM AND SENSORS

The buoy platform is a Concord Control Buoy model M159 which has been modified slightly internally to accommodate the present sensor electronics. The flotation assembly has been modified to handle the cable attachment assembly.(Figure 2). The units contain a fixed-frequency crystal controlled command receiver designed to operate tone-sensitive reed relays.

A 3 tone command Signal is used to trigger the buoys. Each buoy has 3 response modes: identification, tape readout, single scan. The units have been interrogated successfully by a 1 KW 250 watt transmitter at a distance of 2,000 miles. We have used a 4 megacycle channel in the Ocean Data Service. The transmitter provides an output power of 25 watts. Data has been transmitted by CW at 62 bits per second, future transmission will be FSK. Data words consist of 16 bits, with 16 sensors, a 256 bit scan requires about 4 seconds6 The sensors and programing unit have been purchased from Geodyne (Figure 3).

The measurement cycle may be initiated either by telemetry command, or by a timer in the buoy which will trigger the start circutry at pre-set intervals. We have used a twelve hour interval, which allows several weeks data to be recorded on magnetic tape. Upon receiving a start signal, the measurement cycle begins by: starting a master clock oscillator, supplies internal power to the data control and record circuits, generates a two-second delay before generating a reset pulse. The master clock oscillator produces a 62.5 Hz square wave timing signal. Both the 625 H_3 signal and the reset signal occur throughout the system and assure that the subsurface data recovery units are operating in synchronization with the surface unit. When the 62.5 Hz signal is present on the cable, it is sensed, through the inductive coupling, by each subsurface sensor, and initiates power in each sensor for the control and record circuitry. Sensor power is supplied only as long as the 62.5 Hz signal is present. Two seconds after power is on, a wide, 32 msec pulse occurs, which generates a reset pulse instantaneously in each sensor unit, and establishes initial synchorization through the system. A simple counter keeps track of the pulse count of the 62.5 Hz square move with reference to the synchronizing pulse at the start of the cycle. A sequence of 256 pulse counts with a synchronizing pulse at the start of each sequence is used. This allows 16 sixteen-bit words. The system may be expanded to accomodate more sensors by extending the sequence length. Any sensor may be addressed at any location in the readout. The first word is presently a code identification and the second word is a clock word. Data is transmitted beginning with the 33rd bit. The subsurface data are impressed on the cable and on the timing signal in the form of a 5 KHz burst, each burst representing a binary one. If no burst is impressed the formatting registers a binary zero. The 5 KHz bursts are detected as +8V and the absence of bursts as OV. They are then shaped into digital ones and zeros, formatted and recorded. At the close of the cycle, a stop command removes power from the buoy station; since no 62.5 Hz cycle timing signal is present, all the subsurface units also shut down.

The temperature sensor uses a platinum wire temperature transducer and a self-balancing bridge. The transducer is a temperature dependent resistor which comprises one leg of a self-balancing bridge with a range from 0°C to 20°C. The switching cycles of the registers as they balance the bridge reproduce the temperature as binary coded data. The operation of the pressure and conductivity sensors are essentially the same as the temperature sensor; the conductivity sensor uses an inductive conductivity head to measure the conductivity. Conversion to salinity requires simultaneous temperature and pressure readings.

DATA RECOVERY

Data telemetered from the buoy is recorded on magnetic tape and may be reproduced on a high speed strip chart recorder. The tape record is processed to remove noise, and is then interfaced to a small PDB-8 computer which provides a direct print out of the sensor readings.

POSITION

One problem with a drifting buoy is the uncertainty in position. Two possible solutions to the position problem, both using satellites are being investigated: one is the NASA IRLS program (Cressey and Hogan, 1965), and the other uses doppler counts from navigation satellites. For use of the buoy platform in the IRLS program, the command telemetry unit has been replaced by an IRLS unit. The same sensors and formatting system will be used and sensor scans are made at preset intervals. The data is then read into a 256 bit core memory rather than stored on tape. Upon receipt of the IRLS command signal the contents of the 256-bit register are read. Thus the sensor digitization-format system and the command telemetry system are essentially independent, communicating only thru the common core memory. The position is calculated from analyses of the satellite supplied data.

A potentially simpler and less costly approach is a doppler-shift count system. We prepare to use the Navy Navigation Satellites (Kershner, 1965). Doppler counts will be received at the buoy and stored identically to a sensor signal (Figure 4). The receiver will be a simplified version of the navigation satellite receiver now in use on various survey vessels. Only one frequency (400 MHz) will be monitored. Only the doppler-shift count and one code word will be stored in the buoy. Data will be stored in 15 bit words, similar to the storage of regular sensor data. The last pass stored will be read onto the tape each time the sensors are scanned. All computation, including the acquisition of message data for the satellite position, will occur at the shore receiving station. System accuracy is expected to be on the order of one nautical mile (1,500 km.).

REFERENCES

Cressey, J. R. and G. D. Hogan, "The Interrogation, Recording and Location System Experiment", Proceedings 1965 Telemetering Conference, p. 96-101; 1965

Kershner, R. B., "Present State of Navigation by Doppler Measurements from Near Earth Satellites", APL Technical Digest, November-December 1965, p. 2-9

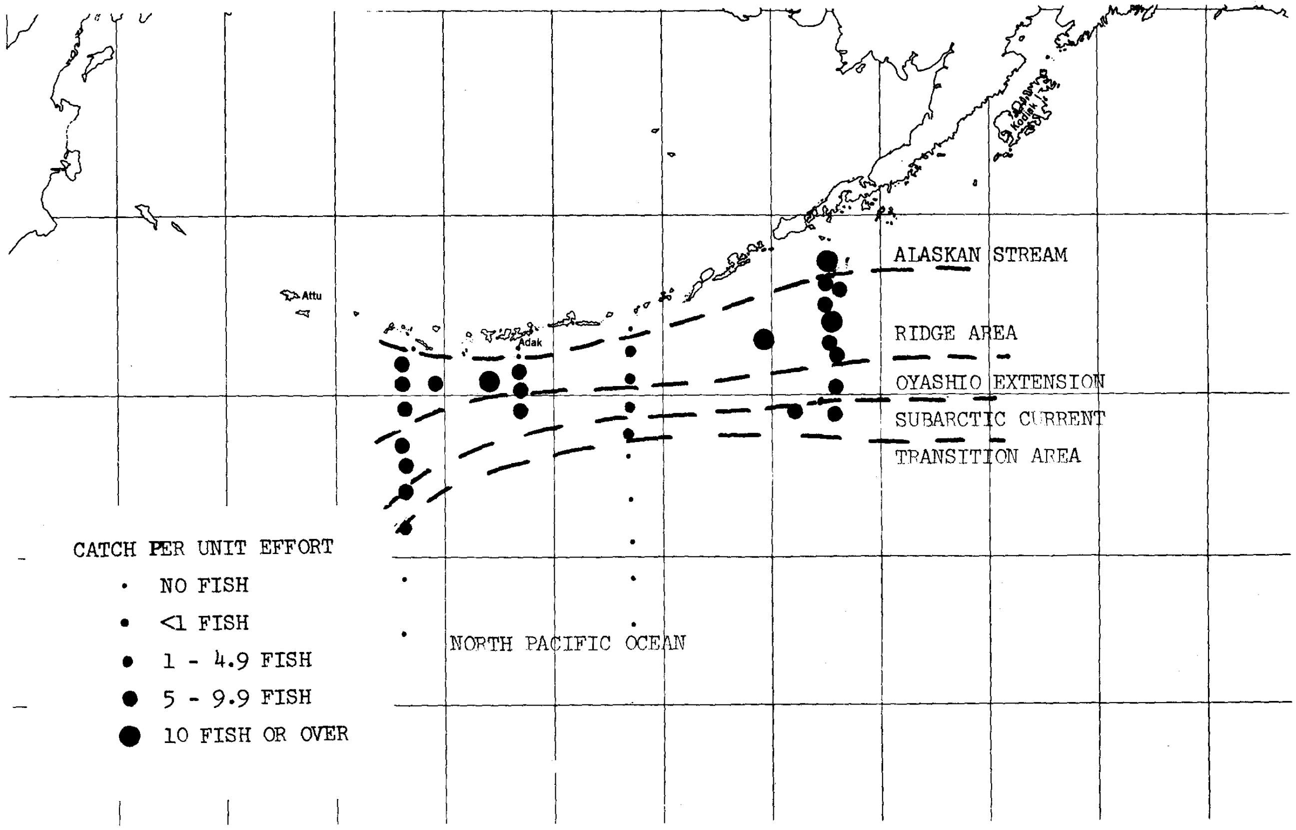

Figure 1. Relative abundace of maturing sockeye salmon, May, 1968

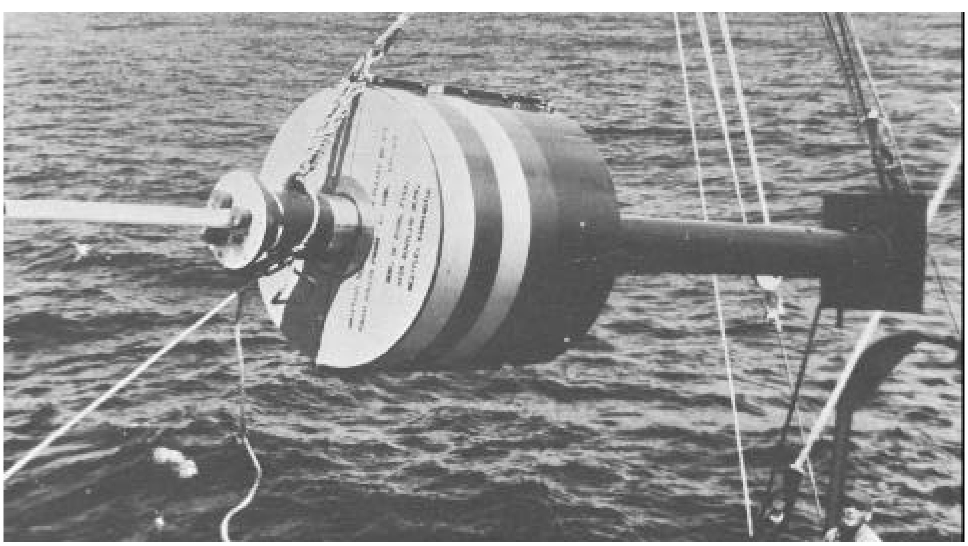

Figure 2. BCF Telemetry Buoy

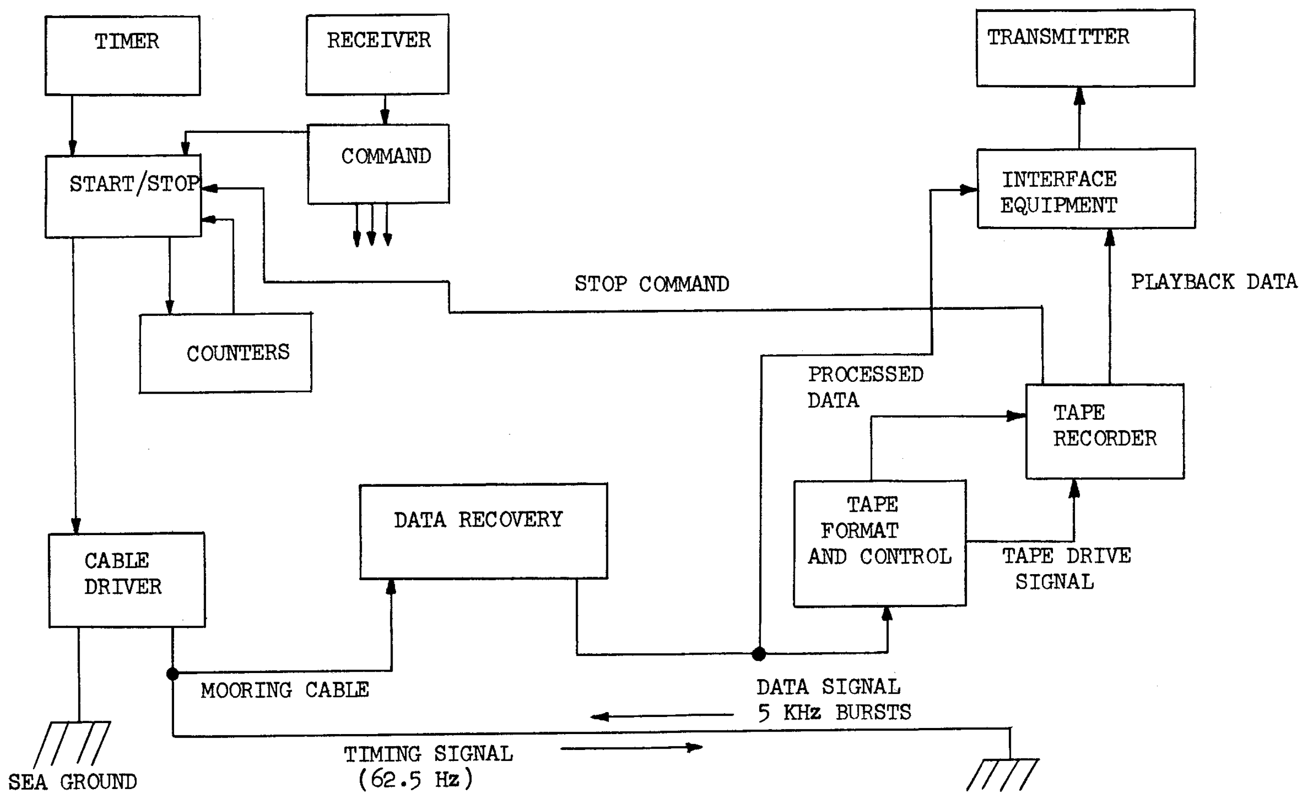

Figure 3. Buoy platform station block diagram

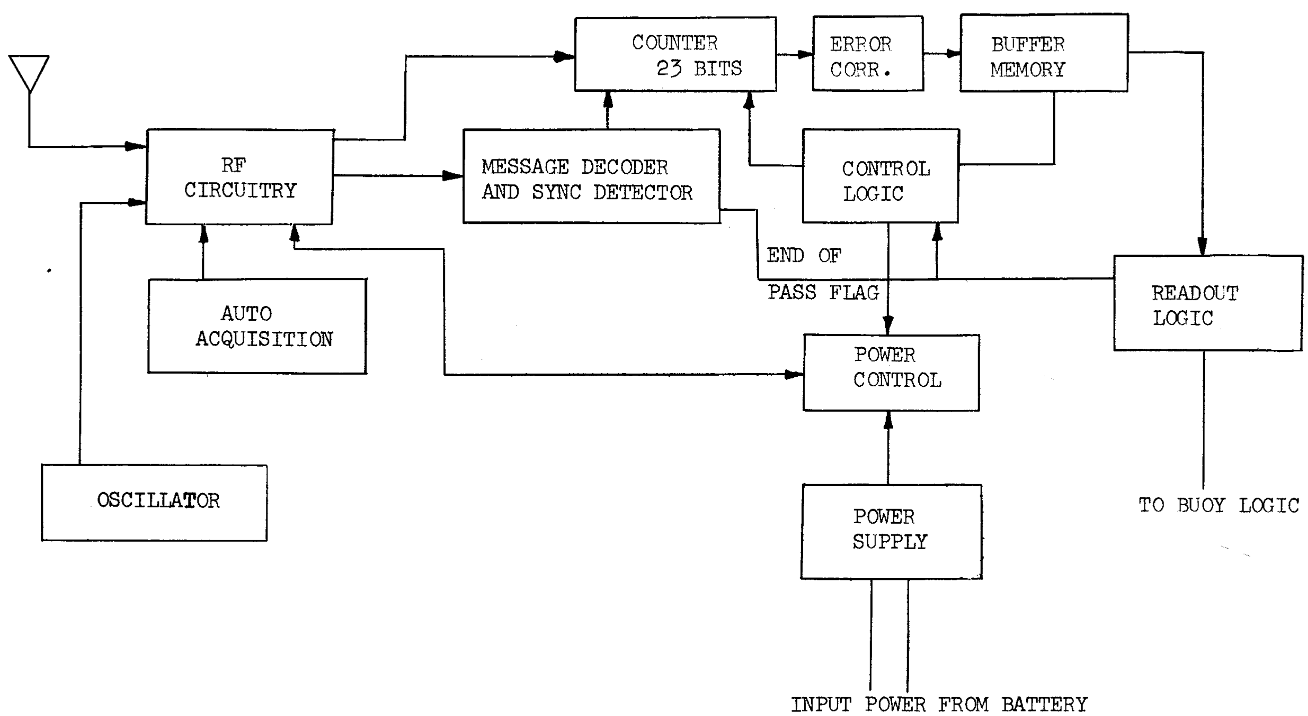

Figure 4. Buoy navigation receiver block diagram