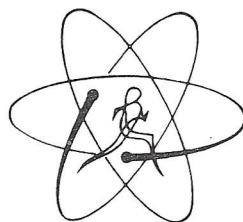


Proceedings of the Fourth International Symposium on Biotelemetry
Garmisch-Partenkirchen, Germany, May 28 - June 2, 1978

BIOTELEMETRY IV

Edited by: H.-J. Klewe, Braunschweig
and
H. P. Kimmich, Nijmegen

184 Figures and 13 Tables



Klewe/Kimmich, Braunschweig · Nijmegen

Biotelemetry IV, pp. 27-30, 1978
Eds.: H.-J. Klewe and H. P. Kimmich

A MULTICHANNEL ULTRASONIC TELEMETRY SYSTEM
FOR PHYSIOLOGICAL AND BEHAVIOUR STUDIES OF BLUEFIN TUNA

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INTRODUCTION

Since feasibility experiments in 1975, a bluefin impoundment fishery has developed in St. Margaret's Bay, N.S., Canada. Bluefin tuna caught in mackerel traps are impounded and fattened over a three month period to provide "sashimi" for the Japanese market. The impoundment of these giant bluefin tuna provides a unique opportunity to study the biology of this important species. Consequently, along with on-going growth, behavioural and biochemical studies in St. Margaret's Bay, experiments using ultrasonic telemetry have been undertaken to monitor parameters of importance to both biological investigation and impoundment procedure.

This paper describes the development of a system to monitor ambient water temperature, body temperature and swimming depth from the impounded tuna. Ambient and body temperature are of interest because, although the ability of tuna to thermoregulate is well-known (1), the relevance of this phenomenon to fish growth is poorly understood. Measurements of swimming depth permit understanding of the Bluefin's utilization of the water column within the impoundment which is a prerequisite for the determination of optimum stocking densities. Because of the necessity of obtaining data continuously from several sensors over a period of several days or more, the system was designed to automatically decode, display and record the required information.

SYSTEM DESCRIPTION

A brief summary of system components is given below.

Transmitters

Since the transmitters must be attached to freely swimming fish, the possibilities for sensor placement are rather limited. The method chosen consisted of using two transmitter packages. One, containing the body temperature sensor, was inserted in a bait fish held on a line. As a

Superheterodyne - type receivers (CR-40, Communication Associates, New York) provided the required selectivity while a simple threshold test on an audio detector output provided the required logic pulse. Disabling of this logic pulse for approximately 100 msec after the receipt of a valid signal provided adequate protection against false outputs due to echos.

Decoding, Display and Recording

Two types of decoder were used:

(i) a digital decoder which measures the interval between the received pulses and passes the information, along with the time of day and receiver identifier, to a digital printer.

(ii) an analog decoder which produces a voltage proportional to the input pulse repetition rate. This voltage is recorded on a strip chart recorder.

Originally it was anticipated that only two transmitters would be used and a two channel digital decoder was constructed. Subsequently when a third channel was required it proved more convenient to add an analog decoder. Because of the usefulness of the analog display for observing trends during the experiment, analog decoders were later implemented for all three transmitters with the digital decoder operating in parallel for two of them.

A brief description of each type of decoder is given below:

Digital Decoder Figure 2 shows the organization of the decoder. A decoding sequence is triggered by INITIATE from the clock. The rate of occurrence of these pulses is switch selectable (10 sec, 30 sec, 1 min or 2 min). Initially Receiver 1 is selected and on the receipt of the first receiver pulse the counter is started counting at a rate of 1 kHz. The next receiver pulse causes the counter to be stopped. The counter thus contains the pulse period of Receiver 1 in milliseconds. This information, with the time of day and a receiver identification, is printed. Then Receiver 2 is selected and the process repeated. The counter is then cleared and the system is idle awaiting another INITIATE pulse.

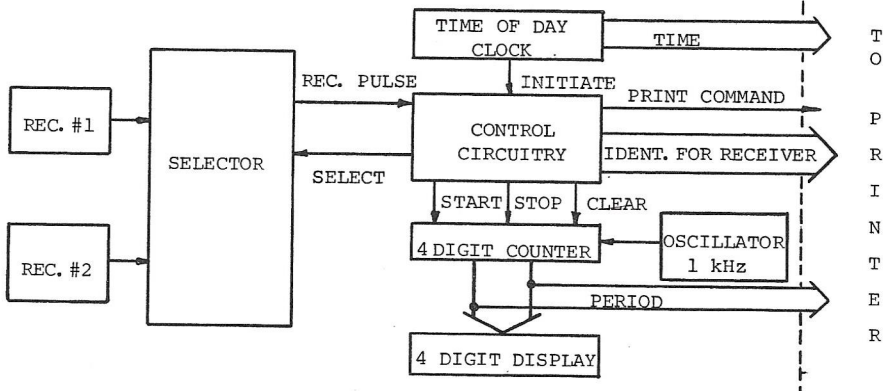


Figure 2: Digital Decoder Organization

Analog Decoder Since the output of the receiver on signal detection is a logic level of fixed amplitude and duration, a voltage proportional to the received signal repetition rate is generated by passing the receiver output through an average value circuit. The time constant of the average value circuit was set at 15 sec. so as to permit an acceptable response to transmitter repetition rate variations. With such an arrangement the average value circuit contains a rather large ripple component and, therefore, this signal is sampled on each received pulse for presentation to the strip chart recorder.

CONCLUSIONS

Results

Several experiments of up to two weeks duration were conducted over the three month period that the fish were impounded. No serious difficulties were experienced and recorded data throughout appeared to be reliable with responses to feeding, daylight etc. being easily observable.

Future Developments

While the system described above produced many useful results, certain requirements which are described below for future experiments have been identified.

Sensors Swimming speed and heartbeat are two additional sensors for which there is an immediate need. A swimming speed sensor based on a propellor interrupting an LED photo diode combination has been developed and successfully tested. The heartbeat sensor is more difficult because of the transmitter attachment method which must be used but we are optimistic that it will be possible to detect heart sounds with an internal transmitter placement.

Multichannel Transmission With the increasing number of sensors the use of a different transmission frequency for each sensor becomes unwieldy because of the number of receivers required. Therefore, we have developed a multiple parameter coding scheme which permits the use of several sensors with a single transmission frequency. A microprocessor decoder for this type of transmission has also been developed.

Computer Readable Output The present methods of data presentation (printed numbers or strip chart recordings) are useful for observation of an experiment in progress but are very unwieldy for analysis. Therefore output will be produced, in computer readable form, on magnetic tape cassettes.

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