# DEPARTMENT OF ECOLOGY AND BEHAVIORAL BIOLOGY

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# DISCLAIMER

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# VERTEBRATE BEHAVIOR AND ECOLOGY

Progress Report
for Period July 1, 1976 - June 30, 1977

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Project Titles:

Overall Project Title:

VERTEBRATE BEHAVIOR AND ECOLOGY

Subproject Titles:

(1) Engineering Design and Development

(2) Statistical Procedures and Quantitative Methods for Analysis of Ecological and Behavioral Data

(3) Coexistence and Population Dynamics of Selected Vertebrates

(4) Application of Radiotelemetry to Selected Problems in Vertebrate Censusing and Population Study

(5) Fish Response to Alterations in Water Quality Resulting from Power Production

(6) Seasonal Migrations and Habitat Selection of the Pronghorn Antelope

Period Covered in PROGRESS REPORT:

July, 1976 through June, 1977

## Progress Report

### Summary

Progress is summarized under six subprojects, 1) Engineering design and development, 2) Statistical procedures and quantitative methods for analysis of ecological and behavioral data, 3) Coexistence and population dynamics of selected vertebrates, 4) Application of radiotelemetry to selected problems in vertebrate censusing and population study, 5) Fish response to alterations in water quality resulting from power production, and 6) Seasonal migrations and habitat selection of the pronghorn antelope (Antilocapra americana).

During the past year Subproject One, Engineering Design and Development, has centered primarily on fish temperature and pressure tags, and the design of a transmitter optimized to match the characteristics of the water. Temperature tags were optimized for various battery voltages and resistor capacitor combinations. Pressure tags were designed and field tested on salmon in the Snake River. Effort is also being made to continually improve the existing transmitters and receivers.

Our work under Subproject Two, Statistical Procedures and Quantative Methods for Analysis of Ecological and Behavioral Data, has been concerned primarily with updating the software system used for handling telemetry data. Special emphasis has been placed on the program which analyzes vegetation or habitat types within a home range and considers intensity of use of the available habitats. Testing has been done by using previously collected and analyzed telemetry data on snowshoe hares (Lepus americanus) to verify that area and habitat use calculations are accurate to .001 square mile.

Work under Subproject Three on co-existence and population dynamics of gray (Sciurus carolinensis), fox (Sciurus niger), and red squirrels (Tamiasciurus hudsonicus) has been entirely on data analysis and writing. All data tabulation was completed and all of the initial home range and activity pattern analyses have been run on the CDC Cyber 74. Detailed evaluations have been completed on daily and seasonal activity patterns of adult gray squirrels and on movement and dispersal patterns of immature gray squirrels. Interaction between the species has been analyzed for some of the squirrels and we are continuing with these calculations at the present time.

Studies under Subproject Four, Application of Radio Telemetry to Selected Problems in Vertebrate Censusing and Population Studies, continued in Prince William Sound, Alaska, and the Monterey area of California. Our new technique of attaching radio transmitters by placing two posts through the rear webbing and anchoring the transmitter around one of the digits has worked extremely well. We attached radio transmitters to 19 sea otters (Enhydra lutris) in Prince William Sound this summer and monitored their activity and movements from the time of transmitter attachments until July 15. Experiments were also conducted on the various types of immobilizing drugs that might be suitable for sea otters and on the effects of oil contamination on otter behavior and survival. Three animals were exposed to Prudoe Bay crude oil. The design of these experiments and the fate of the animals are discussed in detail. Additional studies must be carried out on larger samples of sea otters to verify the suggested results of our oiling experiments.

The effect of gas super-saturated water on the behavior of migratory salmon (Onchorhynchus tshawytscha) is being investigated through the use of pressure sensing transmitters under Subproject Five, Fish Response to Alterations in Water Quality Resulting from Power Production. This project is a cooperative investigation between the Ecosystems Department of Battelle Northwest Laboratories and the University of Minnesota. Pressure sensitive depth transmitters were used to evaluate travel routes and depths of salmon in the Snake River during spring and fall migrations of 1976 and spring migration of 1977. There is some indication from our data that Chinook salmon avoid harmful gas supersaturation conditions near the water surface by swimming at different depths depending on water condition. The data also indicate that the depth of travel of salmon was significantly different in the spill of the Little Goose Dam than in other areas of the Snake River. Such differences appear to be related to delays in migration upon encountering the dam.

Under Subproject Six, a telemetry study of pronghorn antelope began at the Idaho National Engineering Laboratory site in October 1975 to document seasonal movements of antelope that summer in the area north of the INEL site, to determine their use of the INEL site as winter range, to record specific areas of use near INEL facilities, and to obtain information on migration routes, habitat selection, and summer ranges. This research is a cooperative effort of the INEL, Idaho Department of Fish and Game and the University of Minnesota. A total of 77 antelope have been marked with radios and followed during their migratory movements. Migration movements appear to be related to changing temperatures and changes in the moisture content of vegetation on the range rather than to snowfall as indicated in the literature. Field work on this project has been concluded and efforts are being directed to the analysis of data and preparation of manuscripts.

## SUBPROJECT ONE

## ENGINEERING DESIGN AND DEVELOPMENT

### Temperature Tags

Development has continued on temperature tags. The temperature circuit has been changed to increase voltage stability. The revised circuit (Figure 1) includes resistors $R_{S1}$ and $R_{S2}$ to decrease the variation in pulse rate caused by supply voltage changes. Table 1 indicates the pulse variation due to a decrease in battery voltage. The 2.6 to 3.0 voltage variation is greater than would be expected from lithium batteries. Table 2 shows the variation typical for 1.4 volt mercury batteries. The compensation network $R_{S1}$ and $R_{S2}$ are not used with 1.4 volt transmitters because the stability of the tag at 1.4 volts is greater and secondly, the compensation network decreases the sensitivity of the thermistor. Both of these tables were generated using a fixed value resistor in place of the thermistor. The actual pulse rate or range of greatest sensitivity can be chosen by chosing the thermistor-timing capacitor combination (Figure 2). By varying this combination, the range or sensitivity can be optimized.

The current required by the temperature portion of the tag excluding the transmitter is 0.005 to 0.01 ma depending on temperature. The actual drain of the entire package is determined by the transmitter range requirements. Current drains of 0.3 to 0.7 ma are typical.

Long-term baseline drift is harder to determine and eliminate. We might expect two sources for this error, aging of the timing capacitor, or thermistor aging. We have placed a number of transmitters under long-term test. Two examples are shown in Figure 3. One of the transmitters drifted very little, the other about $1^{\circ}$ C was the worst case. It should be remembered that the short-term drift is very low so that differences in temperature on a short-term basis can be measured very accurately. Increased long-term drift reduction could probably be achieved by preaging the tags before calibration.

### Pressure Tags

The circuit of the pressure tag was changed to reduce the physical size (Figure 4). The current tag uses a voltage-to-current converter on the input instead of the instrumentation amplifier used previously. Although this technique results in reduced physical size and reduced current drain, it is at the expense of temperature and offset drift. Figure 5 illustrates typical drift versus temperature characteristics. Most of this drift is due to amplifier offset drift. Fortunately in most applications the temperature is stable or measureable so that a correction can be made if necessary. Twelve tags were placed on salmon in the Snake River in the fall of 1976 and 30 were placed on salmon in spring 1977. Typical response to depth is shown in Figure 6. In both field applications the tags performed well.

The primary problem in developing an efficient low-cost pressure tag is the transducer. In each of the series of tags we have built, we have used a different transducer. All transducers are a compromise between cost, sensitivity, stability, and resistance to environmental factors. In the last two series of tags we used a stainless steel transducer housing and diaphragm. Although this arrangement provides an environmentally resistant transducer, it is at the expense of sensitivity. For the spring run we increased the resistance of the gauge. This allows a reduction in the current through the bridge without a reduction in sensitivity. Some increase in sensitivity can also be achieved by making the diaphragm thinner. To maintain the sensitivity needed we used a current of 0.22 ma through the bridge (transducer). The present bridge has an element resistance of 1500 ohms. We would like to increase this to 5000 ohms, however, the manufacturer has not been able to ensure the reliability of transducers using 5000 ohm elements. The present tags use two 6.8 K resistors in series with the bridge to limit current through the bridge. With the 1500 ohm bridge elements, this means only about 10 percent of the bridge power is used. Although the voltage could be reduced, this would require additional circuitry. We will continue research efforts toward improving the transducer performance especially in reducing the power required to maintain transducer sensitivity.

## Fish Tags Attenuation in Water

Work has continued in trying to determine the characteristics of transmitters in water of differing conductivities. Theoretical studies and experimental field studies have been conducted. Recently several experimental studies have been done in an attempt to verify theoretical calculations (King, 1974; Lee, 1975; Shen, 1976). Although these studies provide some new insights, none were done at varying antenna depths. In addition, it has generally been supposed that attenuation increases with increasing frequency, however, the theoretical equation given by Shen does not indicate that.

$$k = \omega\{\mu(\varepsilon + j\frac{\sigma}{\omega})\}^{\frac{1}{2}}$$

When we use the values for our frequency and water characteristics, the attenuation is essentially independent of frequency comparing 53 MHz and 164 MHz. The phase factor does change as we would expect. Our experimental data indicates that the loss versus depth is greater at 164 MHz than 53 MHz (Figure 7). Signal strength versus transmitter antenna orientation was also determined with the receiver antenna horizontally polarized and vertically polarized (Figure 8). This data indicates, as do theoretical calculations, that a vertically polarized receiving antenna should be superior to horizontally polarized.

Table 1. Pulse interval variation versus supply voltage (2.8 volt nominal lithium cell).

| | | Battery Voltage | | |
|---|---|---|---|---|
| Thermistor | | 2.6 | 2.8 | 3.0 |
| Resistance | vs= | Pulse | interval | (Milliseconds) |
| 488K | | 656 | 656 | 656 |
| 1.0M | | 1110 | 1109 | 1109 |
| 1.5M | | 1552 | 1548 | 1548 |
| 2.04M | | 2073 | 2067 | 2063 |
| 2.5M | | 2518 | 2510 | 2507 |

Table 2. Pulse interval variation versus supply voltage (1.35 volt nominal mercury cell).

| | | | Battery Voltage | | | |
|---|---|---|---|---|---|---|
| Thermistor | | | 1.2 | 1.3 | 1.4 | 1.5 |
| Resistance | Cap | vs= | Pulse | interval | (Milliseconds) | |
| 470K | .47 | | 158 | 160 | 162 | 165 |
| 680K | .47 | | 210 | 211 | 212 | 214 |
| 1.0Mg | .47 | | 341 | 342 | 343 | 346 |
| 1.5M | .47 | | 472 | 472 | 472 | 474 |
| 2.2M | .47 | | 700 | 700 | 700 | 700 |
| 3.3M | .47 | | 983 | 983 | 983 | 983 |

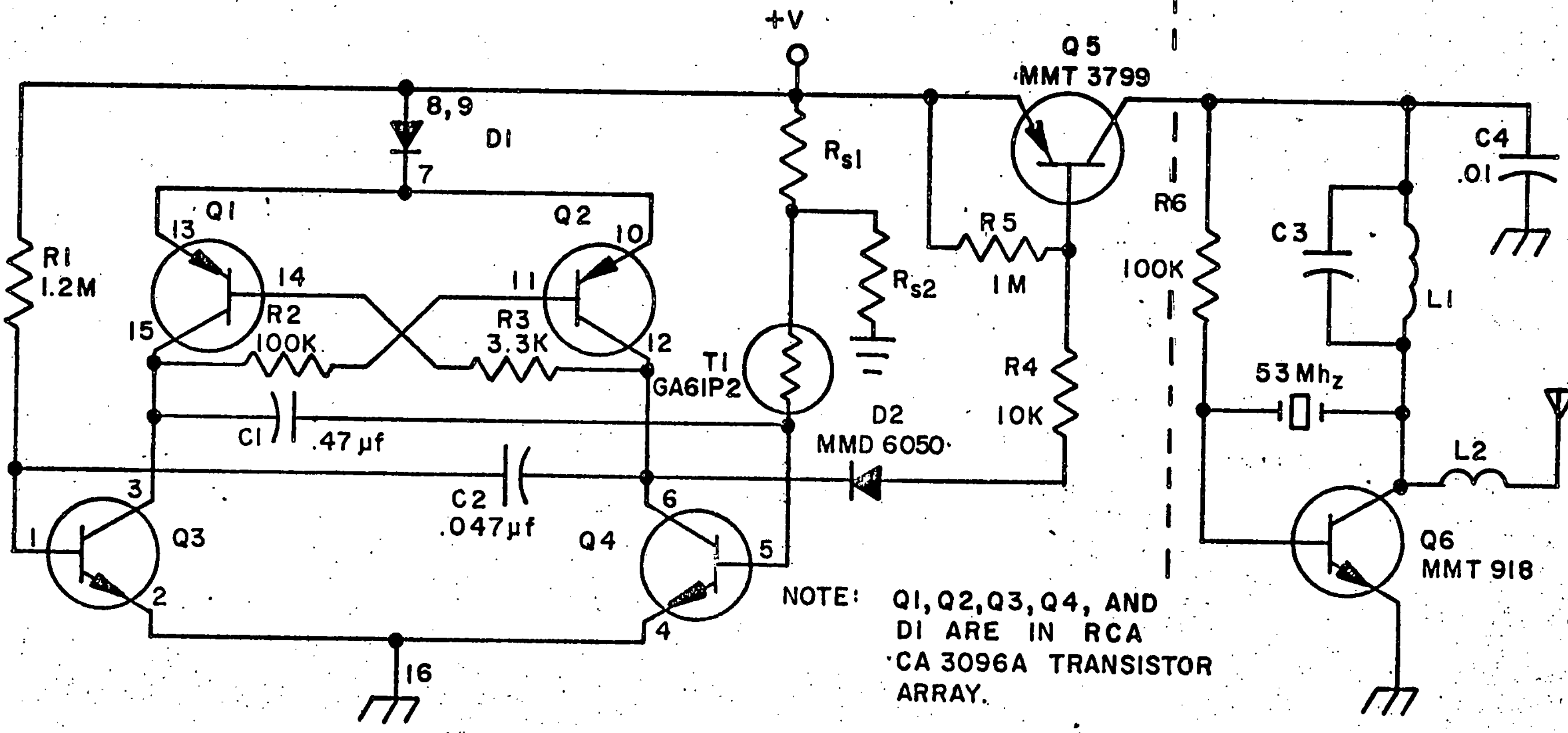



Fig. 1 TEMPERTURE TRANSMITTER

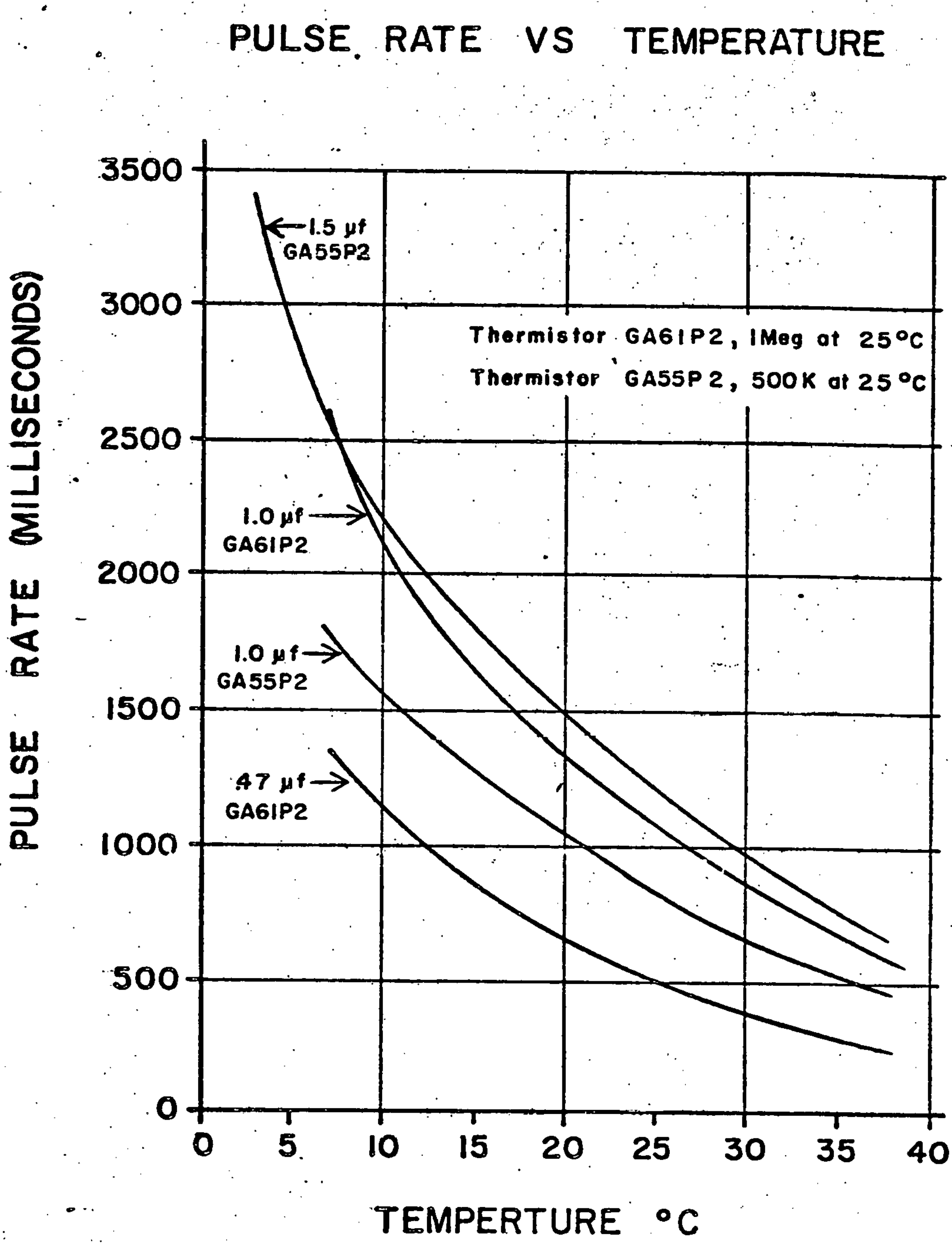
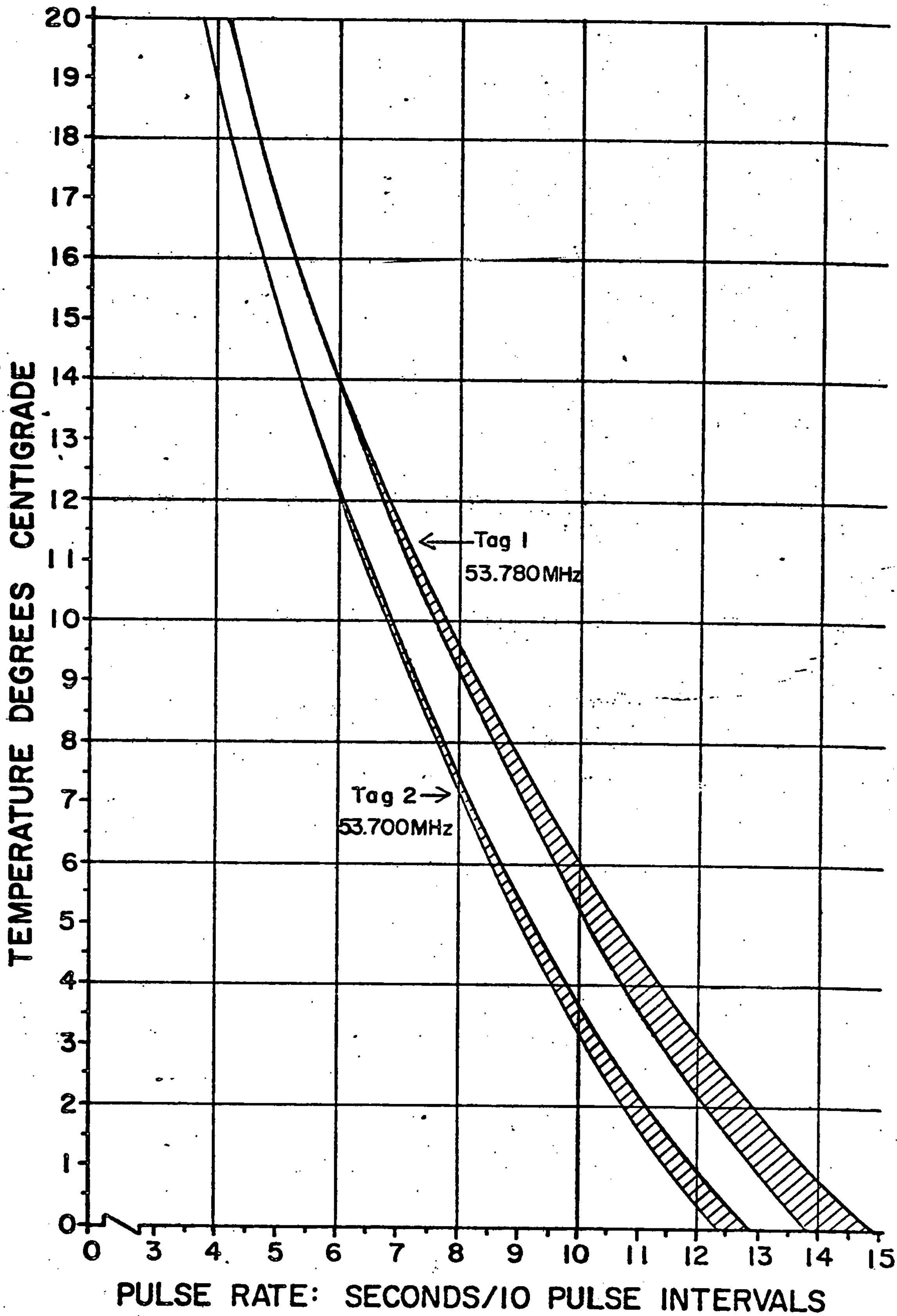
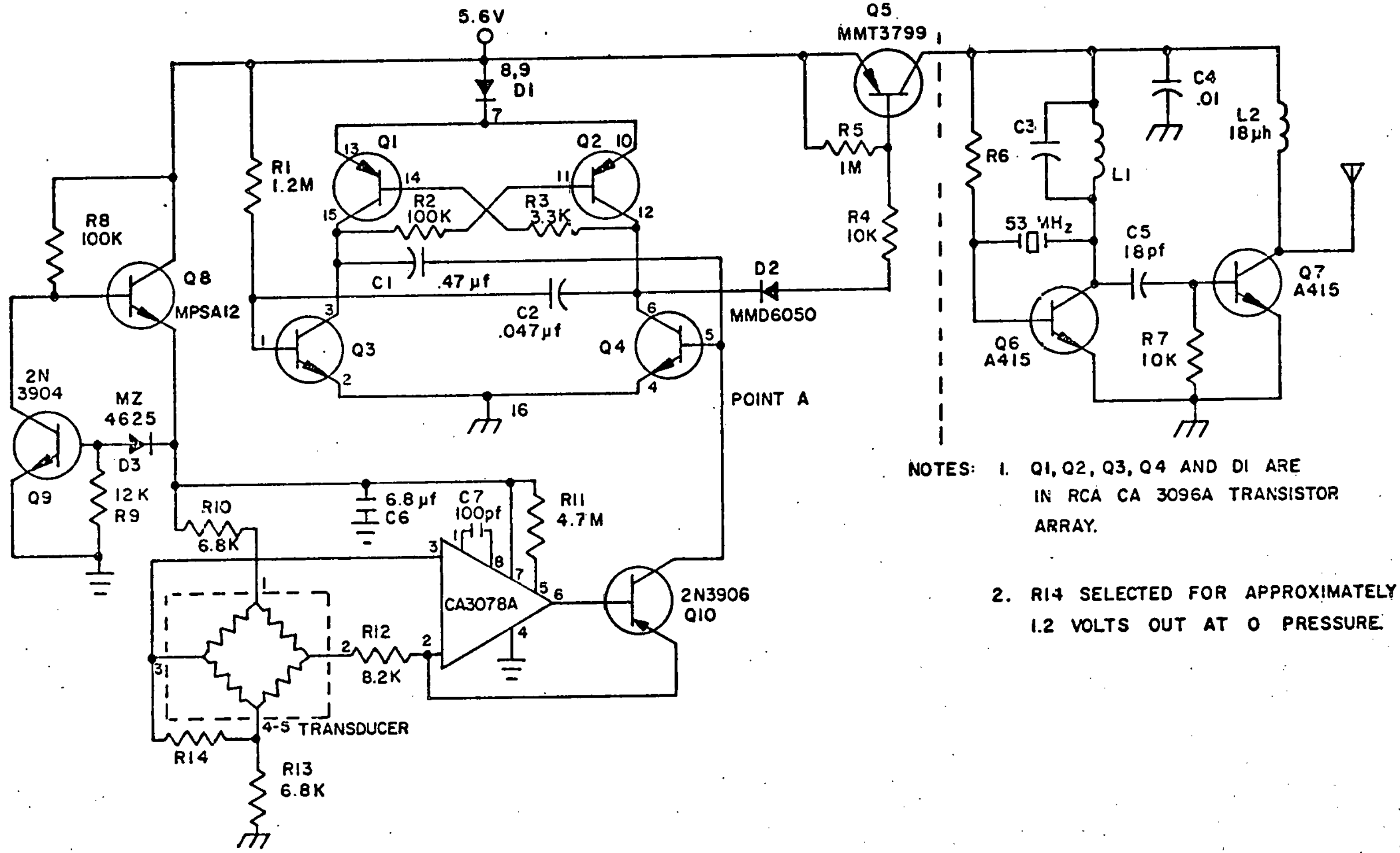



Fig. 2 THERMISTOR - CAPACITOR COMBINATION

(Fig. 3)

ENVELOPE OF LONG TERM CALIBRATION DRIFT.
CALIBRATION CHECKED: 10/5/76, 10/19/76, 11/2/76, 11/17/76, 12/21/76.






NOTES: 1. Q1, Q2, Q3, Q4 AND D1 ARE IN RCA CA 3096A TRANSISTOR ARRAY.

2. R14 SELECTED FOR APPROXIMATELY 1.2 VOLTS OUT AT 0 PRESSURE.

Fig. 4 PRESSURE TAG

TEMPERATURE SENSITIVITY

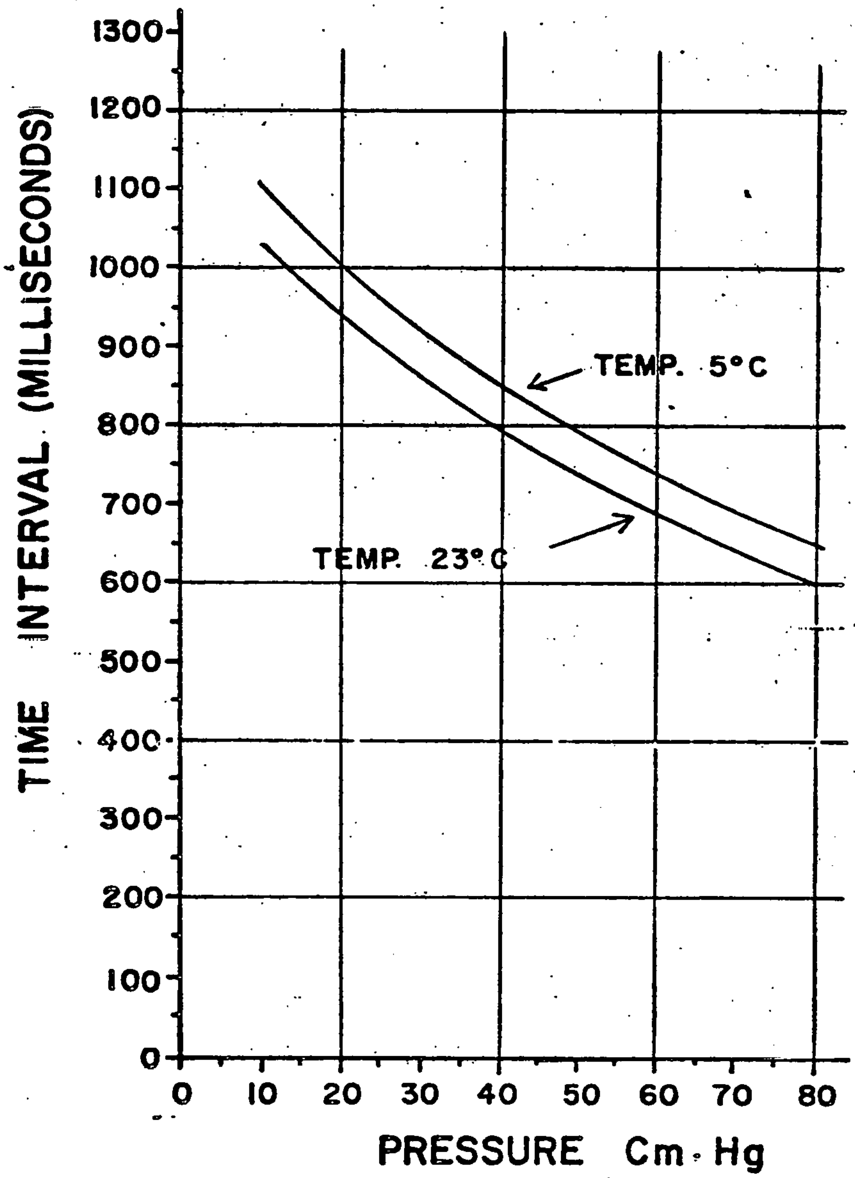
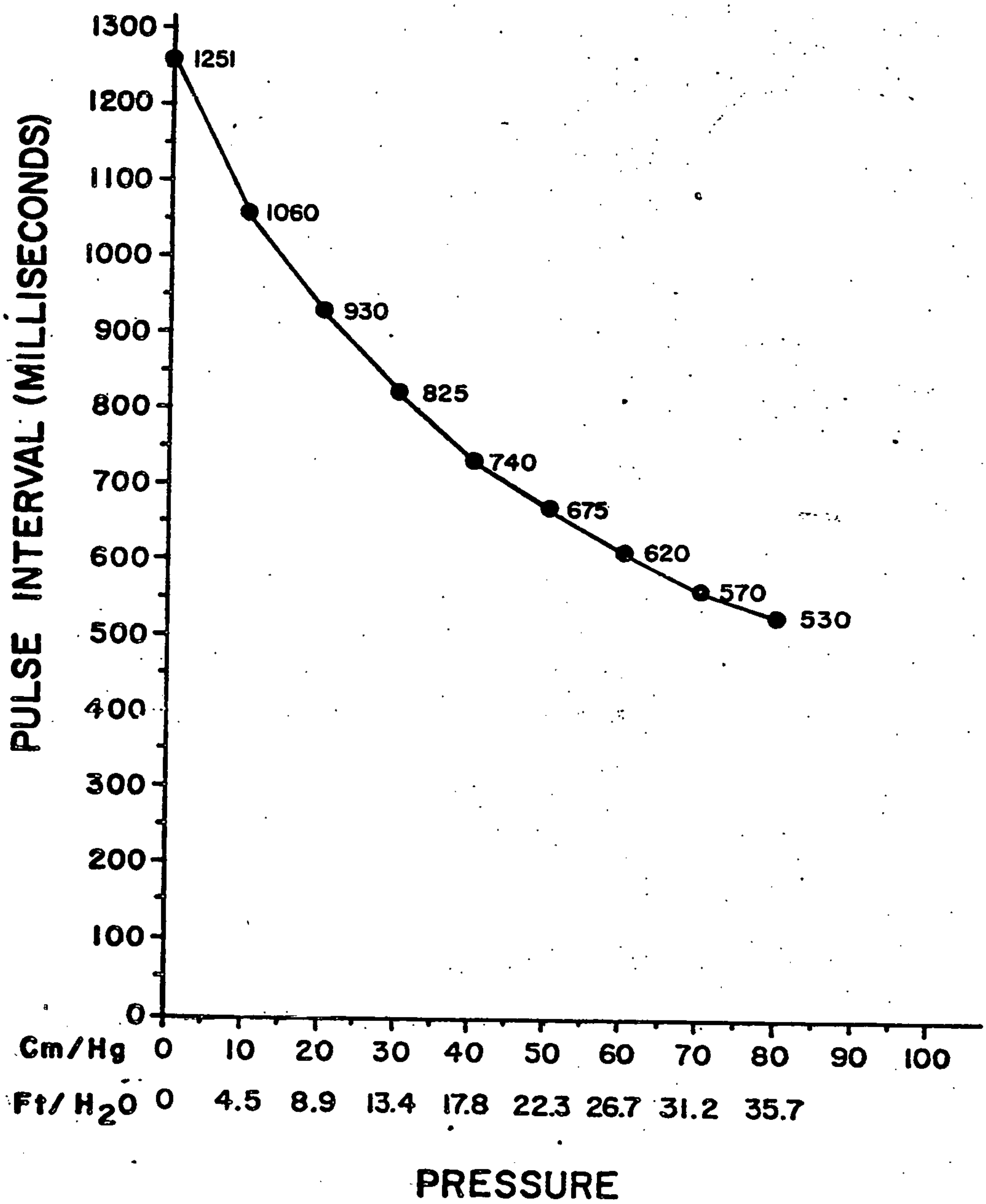
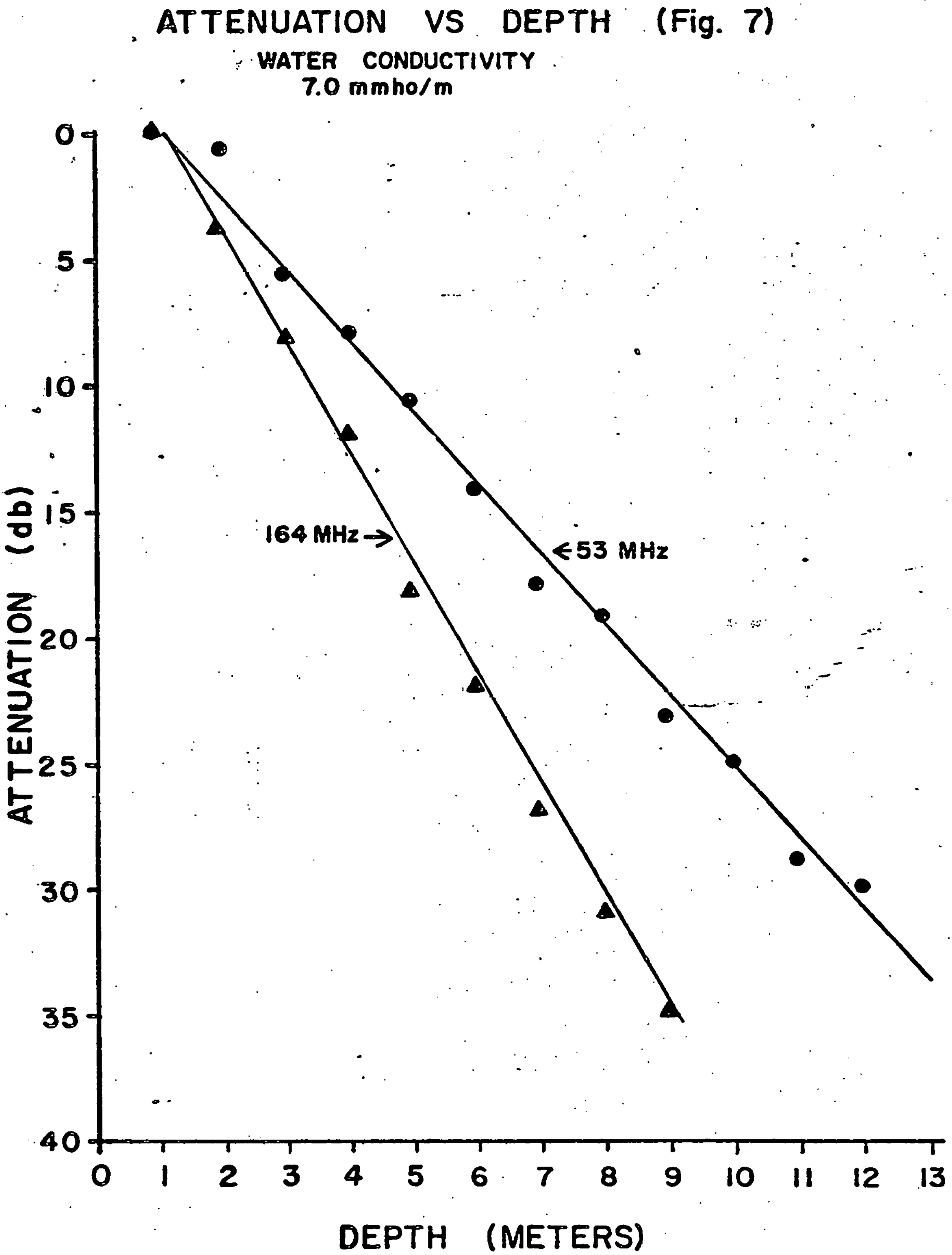



Fig. 5 CALIBRATION DRIFT VS TEMPERATURE

TAG RESPONSE VS PRESSURE (Fig. 6)

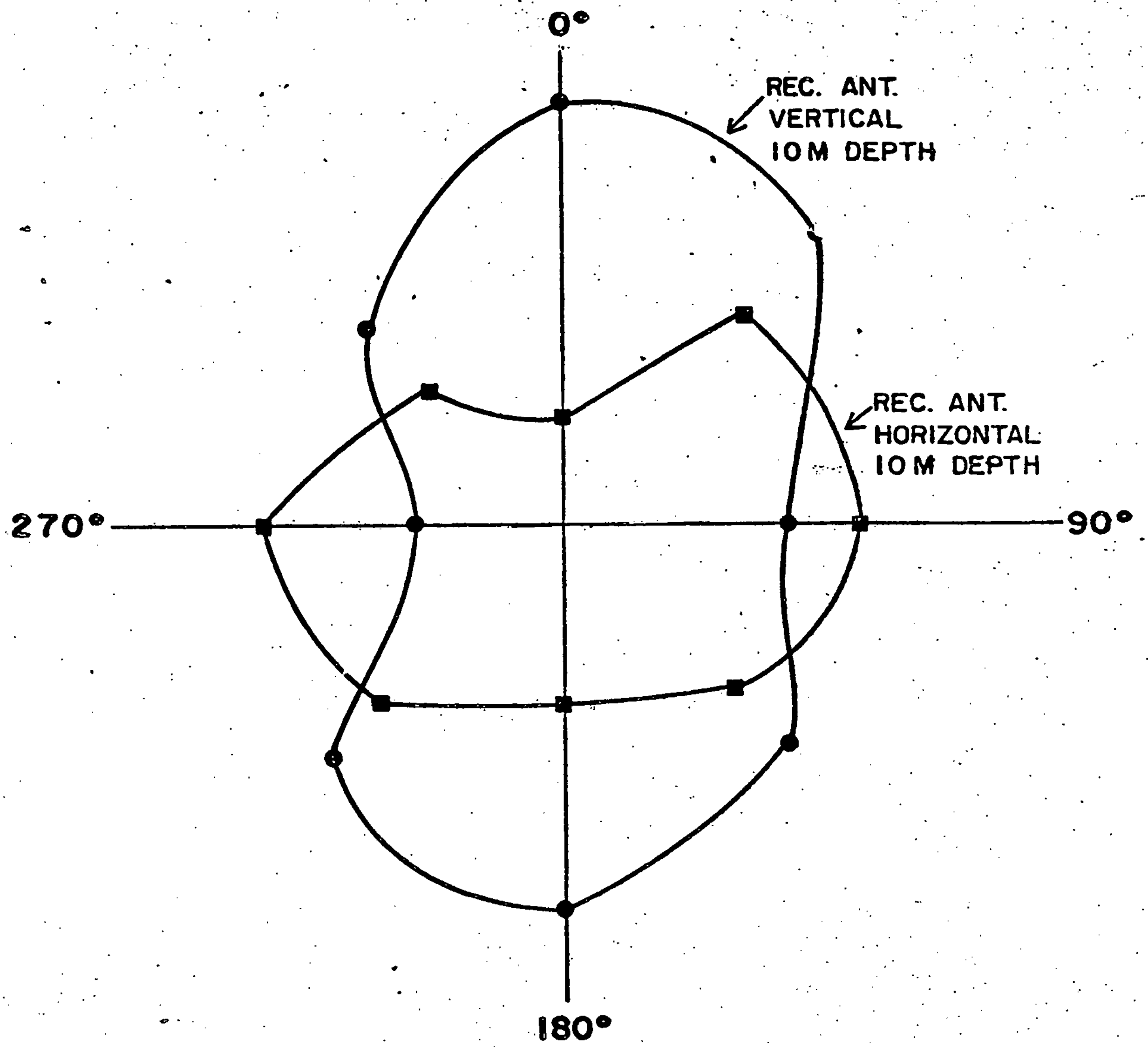




ATTENUATION VS DEPTH (Fig. 7)
WATER CONDUCTIVITY
7.0 mmho/m
ATTENUATION (db)
0
5
10
15
20
25
30
35
40
164 MHz
53 MHz
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DEPTH (METERS)

DIRECTIONAL PATTERN OF FISH TAG & RELATIVE SIGNAL STRENGTH OF VERTICAL & HORIZONAL RECEIVING ANTENNA (TAG HORIZONTAL) (Fig. 8)

(0°- TRANSMITTER ANTENNA POINTED TOWARD RECEIVER ANTENNA)



Literature Cited

King, R.W.P., K.M. Lee, S.R. Mishra and G.S. Smith. 1974. Insulated linear antenna: theory and experiment. Journal of Applied Physics 45(4): 1688-1697.

Lee, Kuan-Min and Glenn S. Smith. 1975. Measured properties of base and insulated antennas in sand. IEEE Transactions on Antennas and Propagation AP-23(5):664-670.

Shen, L.C., R.W.P. King and R.M. Sorbello. 1976. Measured field of a directional antenna submerged in a lake. IEEE Transactions on Antennas and Propagation AP-24(6):891-894.

## SUBPROJECT TWO

## STATISTICAL PROCEDURES AND QUANTITATIVE METHODS FOR ANALYSIS OF ECOLOGICAL AND BEHAVIORAL DATA

During the past year we have been working on performance testing of the Cedar Creek tracking system and adding improvements to the software system of the Nova 2/10. Several errors were found in the software system which we contracted for during the last granting period, and these were corrected. Also, problems with hardware were encountered and memory circuits were sent to the factory for correction.

It was found that timing conflicts existed in the Nova 2/10 operating system. Essentially, the computer was not sampling the analogue to digital conversion output at the proper times so the signals used in bearing calculations and activity determination were out of synchrony with the rotating towers. This problem has been corrected via modifications in the software system.

A second problem was found when we tried to work with the definition of "group lists" of animals as defined in the original program. This definition did not give the desired flexibility in changing animals within the group to be tracked and essentially meant that all groups had to be typed into the console of the Nova 2/10 each time the system was restarted. Thus, adding new animals was extremely cumbersome and required considerable time at the console. The software has been rewritten to provide for more flexibility in that additional animals can be added and old animals removed without disturbing those animals where no change is desired.

Some additional minor problems were found and corrected such as: (a) developing a software package which allows modification of the software and source tapes of the Nova 2/10 on the University Cyber 74 batch processor and time-share facilities; (b) increasing the speed of loading process for the Nova 2/10 by generating binary tapes which require no operator intervention on the console and thus can be loaded directly into the memory; and (c) generally speeding up the entire Cedar Creek tracking system software operation by combining the 35 programs furnished us by our contractor into 5 programs.

The results of the performance testing thus far are very encouraging and the gain control and analogue to digital conversion interface is functioning exceptionally well at the present time. We feel that eventually the data collected on activity should be superior to that collected on our old film record in that it will be more sensitive to changes. Thus, a broader interpretation of various activities will be possible. We have found the tapes produced by the Nova 2/10 compatable with the Cyber 74 and the University computer system so that direct reading is possible. We feel that most of the debugging and revision of the Cedar Creek tracking system is complete and we anticipate another three- to four-month period for testing and verification of output.

Another area which has occupied a considerable amount of our time is the software library dealing with analysis of vegetation data. The vegetation map of the Cedar Creek area was digitized some time ago, and the digitizer output is now in the process of being corrected. This has been a very time consuming process because of the number of vegetation polygons involved and the number of errors found. We had to develope a computer program which points to errors in polygons but the process of correction requires individual attention to each error. At the present time 3/4 of the digitized map is corrected and we are continuing to correct the remaining vegetation polygons. We have made some preliminary runs on snowshoe hares and found that the habitat calculations are correct to about 0.001 of a square mile. In this work we have also found it necessary to modify the existing home range programs to produce data files compatable with the vegetation use program. We anticipate that this vegetation analysis package will be completely ready for use by October 31, 1977 and plan then to look at vegetation useage on the data collected from previous Cedar Creek work.

It is our intention to make this software system as versatile as possible for the analysis of telemetry data. We hope that wide use will be made of the programs by ERDA research projects and by other investigations throughout the scientific community.

## SUBPROJECT THREE

## COEXISTENCE AND POPULATION DYNAMICS OF SELECTED VERTEBRATES

Work on this subproject has been entirely on data analysis and writing. All data tabulation was completed and all of the initial home range and activity pattern analyses have been run on the CDC Cyber 74. One M.S. (J. Gull) and one Ph.D. (M. Bland) thesis were completed this year and copies are being submitted with this progress report. Interaction between the species has been analyzed for some of the squirrels and we are continuing with these calculations at the present time.

The effects of season and various weather parameters on circadian and circannual activity patterns of the eastern gray squirrel have been evaluated in detail (Bland, M.E. 1977. Ph.D. thesis.). In brief, seasonal variations existed in 1) the amount of time per day squirrels were active, 2) the time of onset and cessation of activity, and 3) the size of home range. Squirrels were most active in the fall and spring and least active in the winter. Two peaks in activity (morning and evening) with a mid-day resting period were characteristic of the summer activity pattern. During the winter one brief period of activity occurred during the warm mid-day hours (Figure 3-1).

In the fall, the time of onset of activity was consistent and occurred 20-30 minutes before sunrise. Cessation of activity was also regular and took place 20-30 minutes after sunset. Times of onset and cessation of activity were irregular during the winter and summer with onset usually occurring after sunrise and cessation before sunset. An example of the data leading to these conclusions is presented in Figure 3-2.

Home range size was smallest in winter and largest in late spring and late summer. Male and female range sizes were similar in fall and winter but in the spring and summer, ranges of males exceeded those of females (Figure 3-3). During winter, one night nest location was used per given two week period and daytime activity was restricted to the area around the den site. In spring, summer, and fall each squirrel used between two and three nest locations per two week period and squirrels traveled considerable distance from the den site. Hardwood and cedar forests were heavily utilized by the squirrels with approximately 53 percent of the locations occurring in hardwood forests and 38 percent in cedar forests.

Correlations between the amount of time per day squirrels were active and various abiotic and biotic factors were made. Snow cover and/or extremely cold temperatures during the winter and early spring curtailed movement, and rainy weather in summer decreased activity. The availability of acorns in the autumn and the appearance of food in the spring increased movement.

Detailed analyses have also been completed on movements and dispersal patterns of immature gray squirrels (Gull, J. 1977. M.S. thesis.). Eleven juveniles and three adult females were monitored from the time the juveniles emerged from their dens until their dispersal.

Examination of home range dynamics revealed that juvenile range increased from 0.45 in early summer to 4.00 ha in late summer (Figure 3-4). Range shrinkage occurred in late fall. The adult females displayed larger ranges prior to their offsprings' emergence and again after their dispersal. Range overlap between juveniles and their mothers decreased from 91 percent just after emergence to 53 percent just prior to dispersal. Individual variation contribured a wide range of values for range size and overlap.

Intensively used portions of the range fell in oak and mixed deciduous uplands, associated with locations of dens. An average of 65 percent of the total locations fell in a 0.2 ha portion of the range.

Spacing of family groups suggested that some sort of "territoriality" was maintained until the juveniles dispersed. Though range overlap occurred among families, it was predominantly the result of juvenile incursions. Intensively used areas were not shared between members of different family groups.

Intensively used areas were shared by mothers and offspring. As the juveniles matured, less simultaneous occupancy of these areas was noted. Denning with the mother did not end abruptly, but continued sporadically until dispersal. Some nights of independent denning were followed by a brief meeting with the mother upon arousal.

Major and minor movements outside the main home range were recorded for both juveniles and adult females. All directions and a variety of habitat types were explored (Figure 3-5). Adult females exhibited more directional tendencies than juveniles during the excursions.

Two types of dispersal movements were detected. Three juveniles dispersed short distances and gradually shifted their centers of activity to the new area. Long-distance dispersal was recorded for three male and one female juvenile and an adult female. These movements exceeded 1 km and generally occurred in one morning.

We are continuing our analyses and writing up of the data collected under this subproject, but are not including it as a separate subproject in our current research proposal. The only funds required for completion of this work will be related to publication charges and costs of reprints.

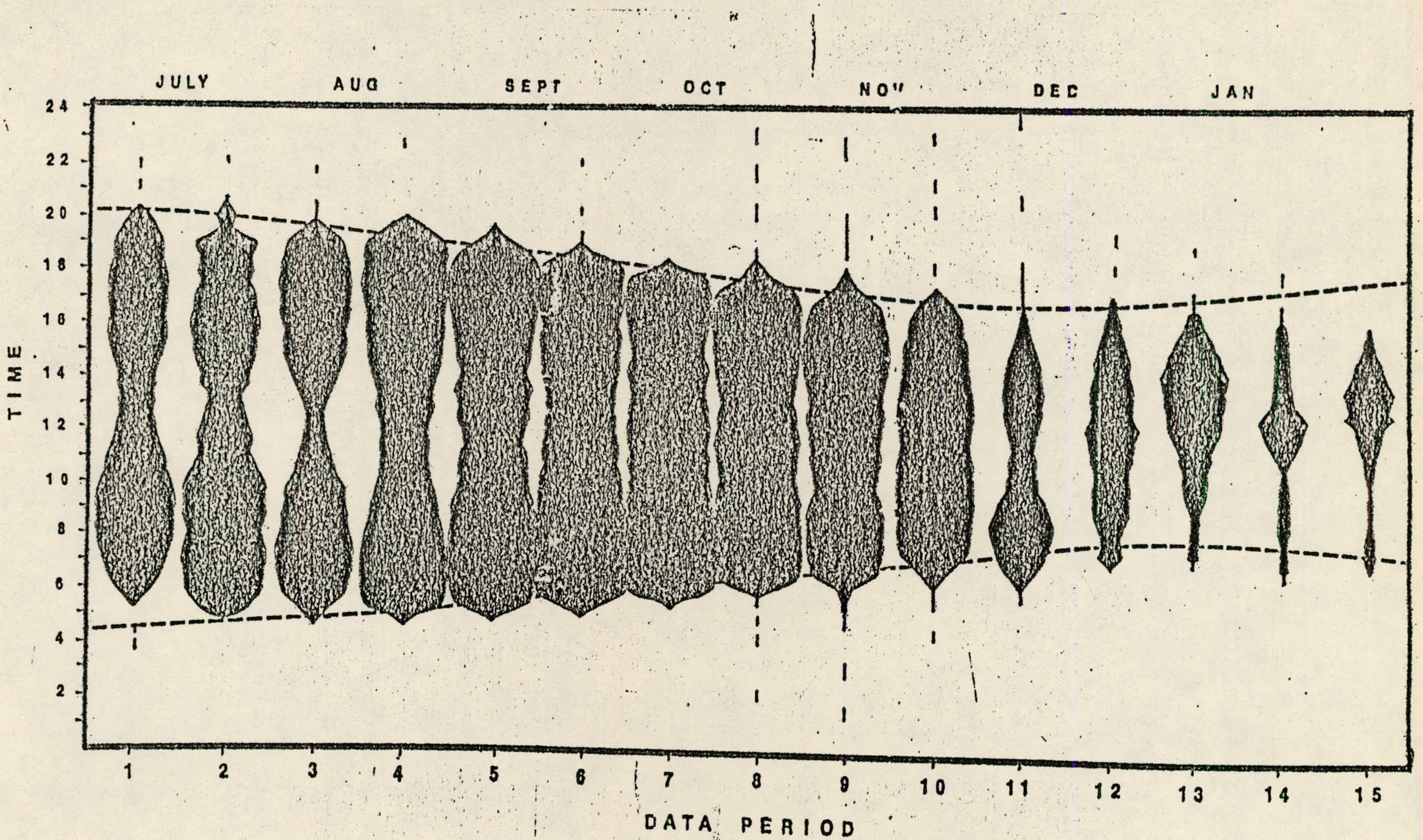



Figure 3-1. Squirrel seasonal activity patterns from July 1, 1971 to September 15, 1972 (average for 4-8 squirrels). Full width of each period indicates 100 percent activity. ------ = sunrise and sunset.

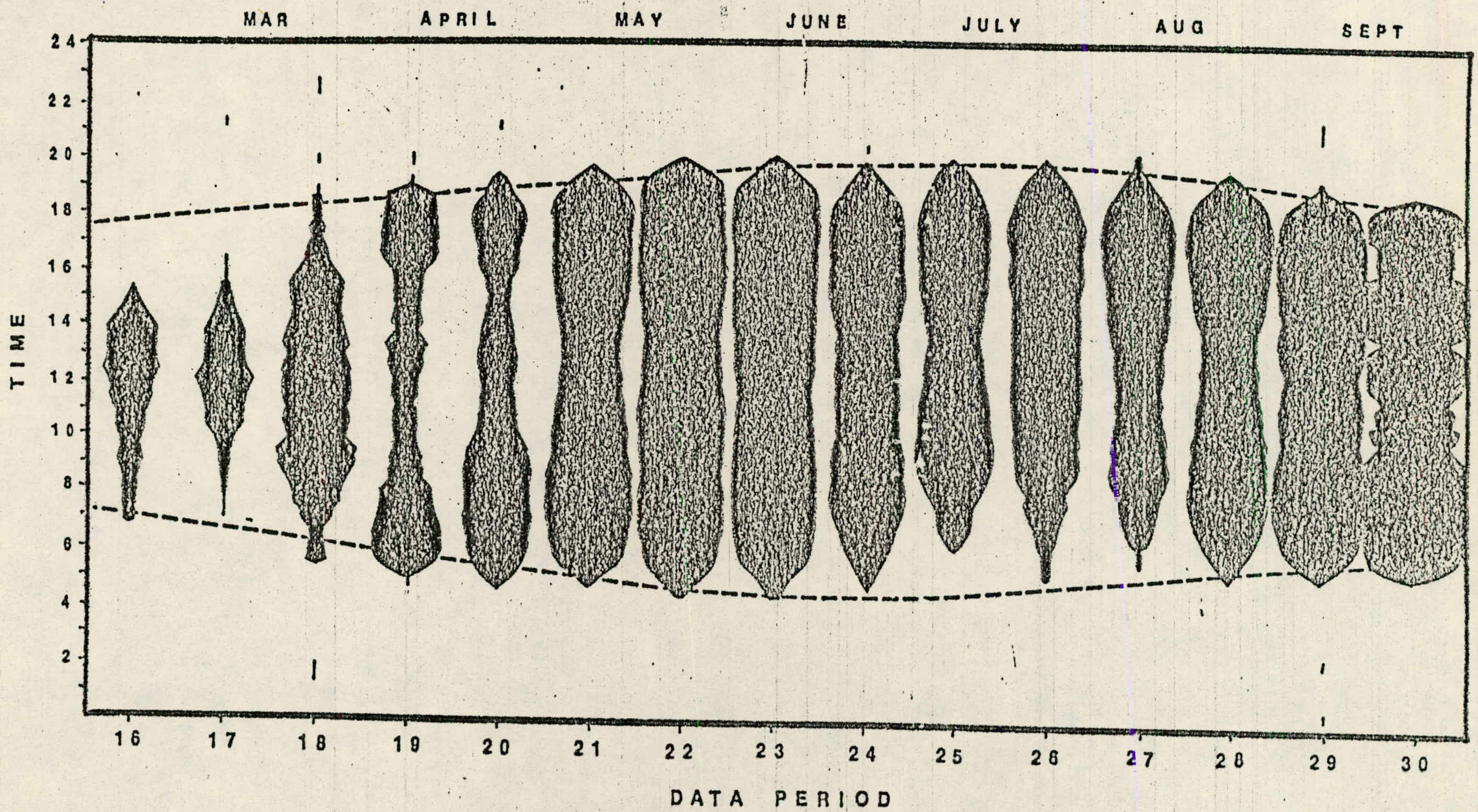



Figure 3-1. Continued.

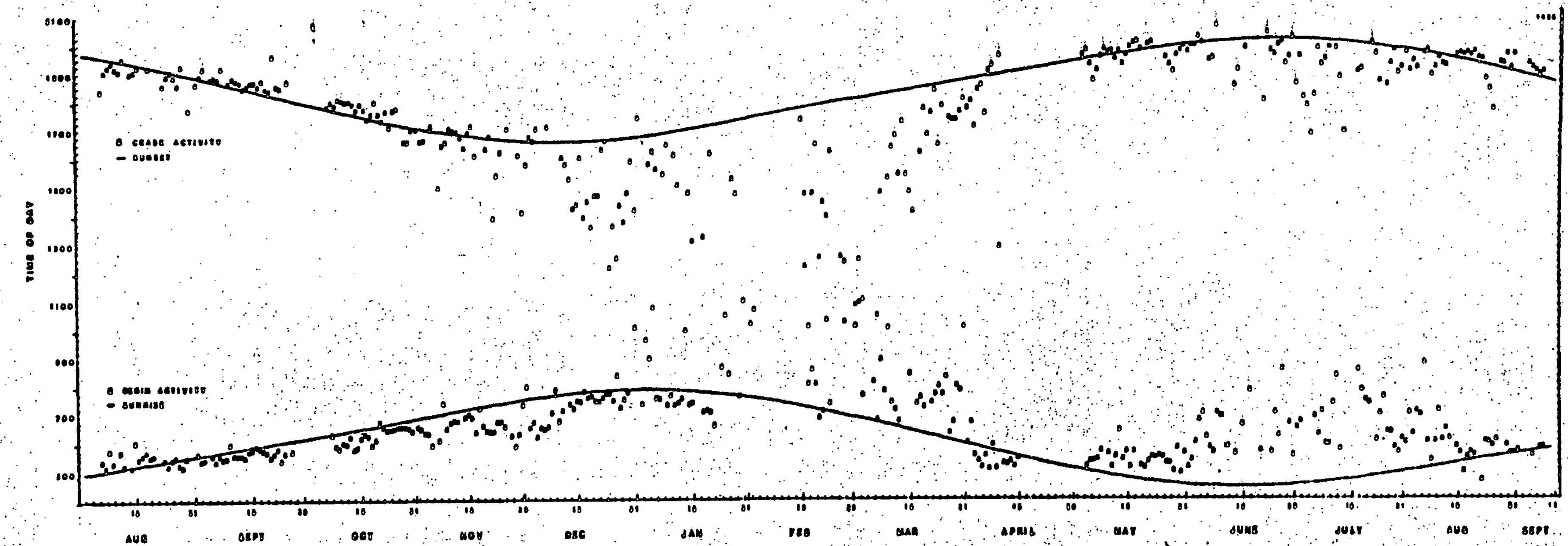



Figure 3-2. Onset and cessation times of squirrel 1426 from August 4, 1971 until September 10, 1972. □ = onset, ■ = cessation, —— = sunrise and sunset.

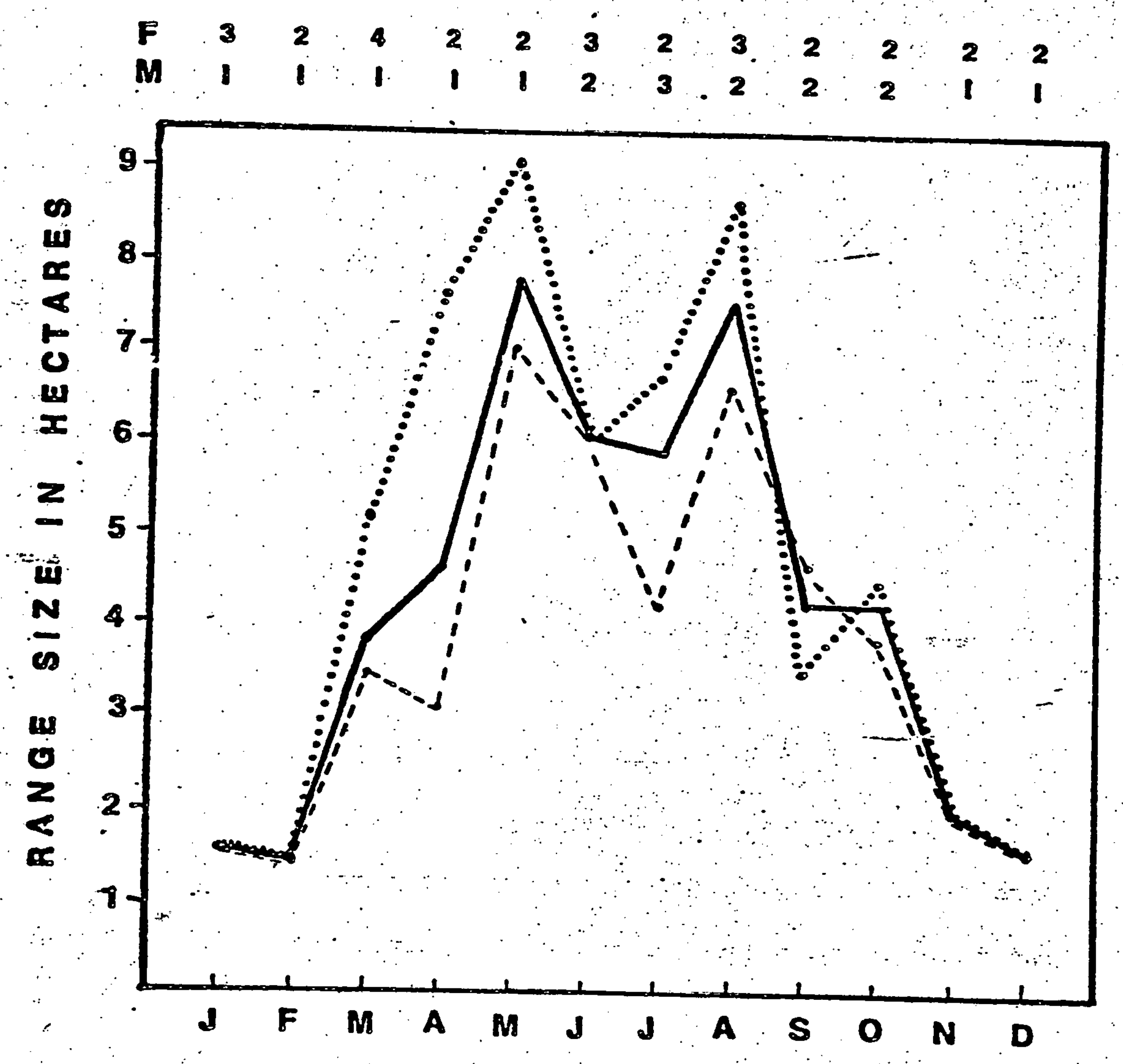



Figure 3-3. Range size of males and females throughout the year. ..... = males, ----- = females, ______ = average.

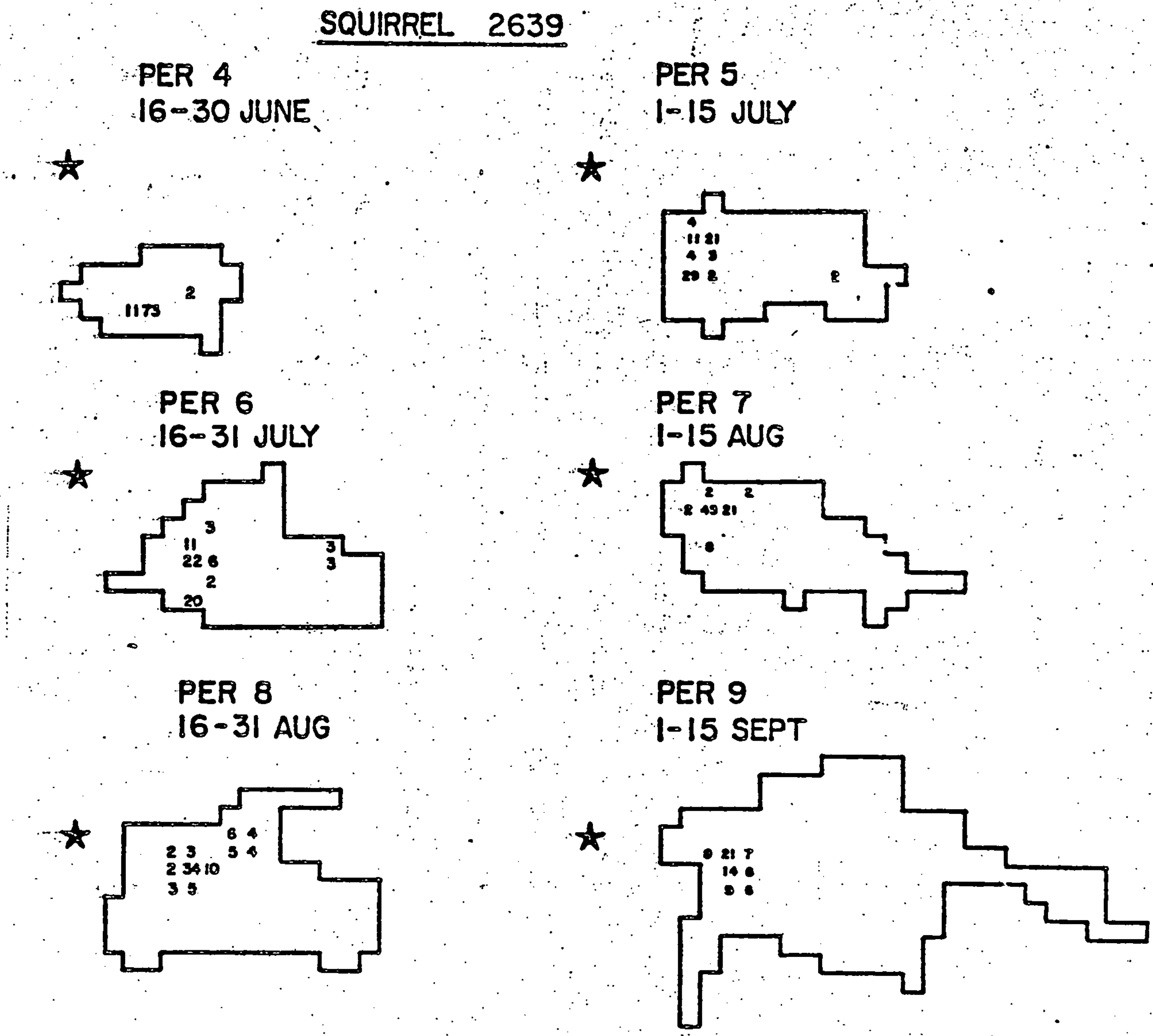



Figure 3-4. Home range expansion of juvenile male 2639, from Periods 4-9 (16 June-15 September). Star denotes location of Bioelectronics Laboratory. Numbers in grid squares are percentages of fixes.

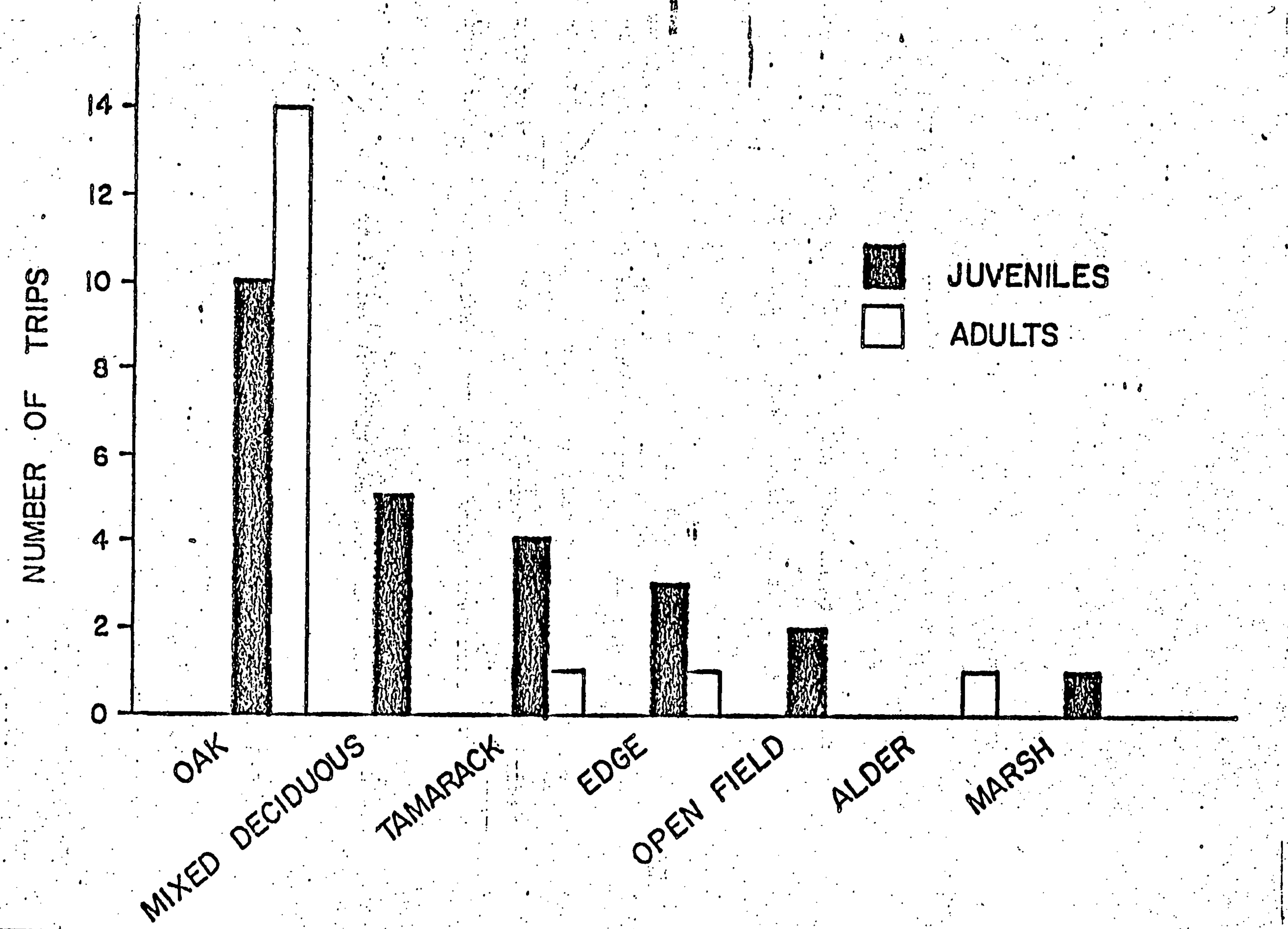



Figure 3-5. Habitat designation of the last known location obtained during a range extension or dispersal movement.

# SUBPROJECT FOUR

## APPLICATION OF RADIO TELEMETRY TO SELECTED PROBLEMS IN VERTEBRATE CENSUSING AND POPULATION STUDY

The original proposal of this subproject set forth general plans for research on sea otter populations at Amchitka Island and in other areas of Alaska and along the California coast. This research program called for the use of telemetry to obtain information on census methods and selected population problems. Emphasis was placed on the sensitivity of otter populations to environmental disturbances. We were in particular concerned about the influence of oil contamination which is likely to increase as oil shipping begins from the terminus of the Alaska pipeline at Valdez in Prince William Sound, Alaska. We feel that it is important that a long-term research program be initiated to: 1. Develop population monitoring techniques and procedures to shed light on population regulatory factors, 2. Begin data collection to evaluate possible influences of environmental changes and disturbances, and 3. Conduct experiments which will yield information relative to the influence of various contaminents on sea otter populations.

The following report summarizes our work on this subproject for the period July 1, 1976 to June 30, 1977 in the Monterey Area of California and Prince William Sound, Alaska.

### Attachment of Transmitters

As indicated in our previous progress report, early studies were directed toward developing a satisfactory transmitter attachment procedure. We tried neck collars and ankle transmitters with varying degrees of success. During the summer of 1975 we were able to instrument four animals, two with neck collars and two with ankle transmitters. Mortality was known to have resulted from both attachment procedures. The neck attachment seemed quite satisfactory; however, fitting was critical and we concluded that immobilization was necessary to assure a proper transmitter fit. Because of the complications in working out appropriate drugs and dosage levels, we have not pursued this attachment procedure at this time but have decided to look for alternative methods. During the summer of 1976 we continued tests on ankle transmitter attachment. From this work we found similar problems to the neck attachment. Fitting was a critical matter and if the ankle transmitter was too tight, swelling occured and eventually the animal died. Thus, it was clear alternate transmitter attachment procedures would be required.

In consultation with our electronic engineers, it was decided that we would proceed with attachment procedures similar to that used on some of our Antarctic seal studies. That is, we would attach a small transmitter to a marker tag placed through the webbing of the rear flipper. This procedure worked well and studies using this method were initiated in California in July, 1976.

California Studies

Our plan in the summer of 1976 was to coordinate studies with the California state agencies, the U.S. Fish and Wildlife Service, and two university investigations, one from University of California, Los Angeles and the other from University of California, Santa Cruz. The latter two projects were concerned with activity patterns and physiological studies, respectively. We arrived in the Monterey area in mid-July and set about catching otters for instrumentation. Initially we planned to work in the vicinity of San Simeon, as the Fish and Wildlife Service had plans for the establishment of a marine laboratory in this area and wished to begin long-term studies nearby.

We were unable to capture otters in this area and, therefore, moved north to the vicinity of Monterey. On 23 July we captured two otters and instrumented them with small transmitters attached to metal marking tags placed in the webbing of the rear flipper. Preliminary observations of behavior indicated the animals tolerated this attachment procedure well. They initially chewed on the transmitter briefly but, when seemingly unsuccessful, proceeded to largely ignore the area of attachment. On July 25, we captured another otter and instrumented it in a similar manner.

Cooperative studies with other investigators complicated the evaluation of the effects of transmitter attachment. Experiments with physiological measurements and placing the otters in captivity for a short period of time complicated separation of transmitter effects from other influences. Of the three otters captured and instrumented, one eventually died of pheumonia, which we feel was not related to the attachment procedure.

The two remaining otters were monitored for activity patterns, and behavioral observations were made to correlate automatic recording of activity with visual observation. Table 1 indicates the type of data obtained from automatic recording of dive patterns. Although these data are rather meager, they indicate the type of information available and lead to the monitoring system currently in use in Alaska. Accumulation of data of this nature will allow further assessment of census techniques.

We remained in the field in California until mid-August. Our attachment procedures indicated that the animals tolerated the attachment well but that infection at the site of puncture was a problem. A contributing factor in the infection was the continual rubbing of the post which extended through the rear flipper webbing. It was concluded that a more firm and stable attachment would be necessary. Thus, we have proceeded with a two post attachment through the rear webbing with anchoring the transmitter around one of the digits. This process is being examined in Alaska this summer.

Our results in California last summer gave us further appreciation for the problems of working in the area. Clearly, there is a problem with the public being so ever-present. Working in the Monterey area attracts considerable attention and causes, we feel, modification of normal activity patterns and movements. Divers and boaters are constantly in the area and otters are attracted to the general public by their food offerings. In addition, the procedure used for capturing otters in California may select animals which are in some way impaired. This method utilizes the diver-help trap. A scuba diver swims under an otter laying on the surface, pushes the device over the animal, and thus captures it. Healthy animals seem to be less likely to be captured than animals that have some physical disability simply because they are more alert. We feel certain that the otter that died was sick or injured prior to capture. The stress of capture no doubt initiated the mortality; however, the fact that it was in poor condition when captured undoubtedly speeded the process. Also, there is similar evidence from other researchers. Thus, we are proceeding more cautiously with our studies in California and trying to assure that the probability of success is high prior to entering the field.

The Fish and Wildlife Service has made arrangements for the acquisition of laboratory space at San Simeon. This laboratory space should be ready for occupancy in the fall of 1977 and we plan to make this area the center of our work. Also, the capture procedures which we suffered through last year will have to be modified. It is clear that the tanglenets which were used in Alaska would be desirable in California. The only reason for not using tanglenets was that early in their development some mortality occurred from their use. We have not encountered such problems in Alaska and it seems that when more data are available, it will be possible to obtain permission for their use in California. We will request this permission in our next permit application which will be submitted in December, 1977.

Alaska Studies

In May, 1976, we again began working with Mr. Ancel Johnson, U.S. Fish and Wildlife Service, in Prince William Sound, Alaska. We were somewhat hampered because of the delay encountered in issuing our federal permit under the Marine Mammal Protection Act. We applied on February 13, 1976 thinking this allowed sufficient time for issuance of a permit by mid-May. However, delays were encountered because of the decision processes which were necessary in order to accommodate our request for studies of oil contamination. Finally, in July, 1976, our permit was issued to continue work on the telemetry portion of our studies but withholding permission for the oil contamination studies. As indicated in the renewal proposal, this problem has subsequently been solved and we plan to initiate oil contamination studies this coming summer (July, 1977). Thus, our work in Prince William Sound during the summer of 1976 was somewhat curtailed.

We entered the field in Prince William Sound, Alaska in mid-May 1977 and terminated our work on 15 July. Table 4-2 lists the animals handled and their eventual fate. In summary, 18 male otters and 1 female otter were instrumented with radio transmitters and released at the point of capture in Sheep Bay from May 19 to June 15. The transmitters weighed approximately 25 grams and were attached as described above. We monitored these animals remotely for activity patterns from an automatic recording station placed in a mountain meadow about 360 feet above sea level. This recording station used a solar panel to help alleviate a battery charging problem. Preliminary tests indicate that the panel, which is approximately .50 x .75 meter in size. kept the batteries fairly well-charged even in the cloudy weather in Prince William Sound. Only twice during the season did we need to bring the batteries out for additional charging. We have estimated that 3 hours of sun per day on the average would take care of the current drain which the system requires. Thus, it looks like this development will be of considerable use in many other projects where monitoring is desired, but the remotemess of areas makes frequent visits difficult. In addition to the activity data collected, we periodically checked the animals' positions using a boat, and once we used an aircraft to locate 2 otters which we were no longer receiving in Sheep Bay. During this flight we located the 1 male otter that had moved out, but were unable to locate the female.

Beginning on July 1 we set the nets again to capture otters for oil and immobilizing experiments. Permission to use immobilizing drugs had only recently been obtained through a request sent to the Director, Fish and Wildlife Service, Washington, D.C. in early June. Between the period of July 1 and July 8 we captured 6 male otters which were used in these experiments. In this group we had 2 mortalities, one caused by the oil experiment and the other from trauma because of captivity. Autopsies were performed and samples of fur and tissue were taken for further analysis.

The oil experiments consisted of exposing three animals to crude oil. This oil is the same oil that will be flowing through the pipeline to the terminus at Valdez, Alaska. One experiment consisted of spraying 25 milliliters of oil in the upper back region of a male otter and releasing it with a transmitter in Sheep Bay. The other experiment consisted of exposing 2 male animals to oil on the surface of the water in an 18 foot diameter swimming pool. The pool was divided in half so that one half of the pool had oil on the surface and the other half was clean. A wooden partition extending into the water approximately 12 inches separated the oiled surface from the clean surface. Of these two animals, one animal that was exposed was not cleaned and died within 24 hours. The other otter was cleaned with a detergent and after its fur was thoroughly dried and it was held for approximately 24 hours. It was then released back into Sheep Bay with a transmitter on July 7. There was some difficulty with this transmitter, as it became intermittant after about 3 days, but all indications were that it was still living when we left the area on 15 July.

In addition to the oiled animals, two other animals were used for experiments with immobilizing drugs. These experiments did not result in any mortalities, and these animals were released without transmitters but with flipper tags back at the area where they were captured. These data are now being summarized and we plan publications in the near future on the three segments of this investigation, oiling, immobilization, and activity patterns.

Table 4-1. Estimation of probability of sighting for Sea Otters in Monterey using radio telemetry data to determine activity patterns and assumed probabilities of sighting.

| hours | P(not in capture area at hour) | P(resting at hour) | P(active at hour) | P(diving at hour) |
|---|---|---|---|---|
| 0-6 | $^{27}/101 = .27$ | $^{56}/101 = .55$ | $^{15}/101 = .15$ | $^{3}/101 = .03$ |
| 6-12 | $^{36}/108 = .33$ | $^{30}/108 = .28$ | $^{30}/108 = .28$ | $^{12}/108 = .11$ |
| 12-18 | $^{76}/128 = .59$ | $^{13}/128 = .10$ | $^{39}/128 = .30$ | $^{6}/128 = 0$ |
| 18-24 | $^{94}/153 = .61$ | $^{40}/153 = .26$ | $^{18}/153 = .12$ | $^{1}/153 = .01$ |
| average over all hours | $^{223}/490 = .48$ | $^{139}/490 = .28$ | $^{102}/490 = .21$ | $^{16}/490 = .03$ |
| average over 6-18 hours | $^{112}/236 = .47$ | $^{43}/236 = .18$ | $^{69}/236 = .29$ | $^{12}/236 = .05$ |

Table 4-2. OTTERS CAPTURED AND TAGGED IN SHEEP BAY, ALASKA: MAY-JULY 1977

| Date | Tag | Color | Sex | Weight(lbs.) | Transmitter Frequency | Remarks |
|---|---|---|---|---|---|---|
| 19 May | 45 | Blue | Male | - | 296 | |
| 19 May | 46 | Blue | Male | - | 709 | |
| 26 May | 47 | Blue | Male | - | 310 | Tagged #4107 in 1976 - tag removed in 1977 |
| 26 May | 48 | Blue | Male | - | None | |
| 26 May | 49 | Blue | Male | - | 511 | |
| 26 May | 44 | Blue | Male | - | 209 | |
| 26 May | 43 | Blue | Male | - | 603 | |
| 26 May | 42 | Blue | Male | - | 194 | |
| 8 June | 41 | Blue | Male | 37 | 809 | |
| 8 June | 40 | Blue | Male | 45 | 451 | |
| 8 June | 39 | Blue | Male | 37 | 793 | |
| 11 June | 38 | Blue | Male | 67 | 746 | |
| 11 June | 37 | Blue | Male | 75 | 726 | |
| 14 June | 36 | Blue | Male | 53 | 351 | |
| 14 June | 35 | Blue | Female | 36 | 476 | |
| 15 June | 34 | Blue | Male | 43 | 286 | |
| 15 June | 33 | Blue | Male | - | 908 | |
| 15 June | 32 | Blue | Male | 65 | 467 | |

| Date | Tag | Color | Sex | Weight(lbs) | Transmitter Frequency | Remarks |
|---|---|---|---|---|---|---|
| 15 June | 31 | Blue | Male | 55 | 523 | |
| 15 June | 375 | Yellow | Male | 70 | 495 | |
| 1 July | - | - | Male | 65 | None | Oiled - Not cleaned. Died 5 July. |
| 1 July | - | - | Male | 31 | None | Died 5 July. |
| 2 July | 376 | Yellow | Male | (taken) 74 (released) 63 | 750 | Drugged - Released. |
| 2 July | 385 | Yellow | Male | (taken) 62 (released) 60 | 475 | Oiled - Cleaned - Released. |
| 4 July | 383 | Yellow | Male | 43 | 694 | Oiled - Released. |
| 8 July | 387 | Yellow | Male | 46 | 727 | Drugged - Released. |

## SUBPROJECT FIVE

## FISH RESPONSE TO ALTERATIONS IN WATER QUALITY RESULTING FROM POWER PRODUCTION

Beginning in Spring 1976, pressure sensitive depth transmitters, developed by the University of Minnesota Bioelectronics Laboratory, were used to evaluate travel routes and depths of migratory chinook salmon in the Snake River (Tester and Siniff, 1976 Progress Report). Technological advances during the summer of 1976 made possible the use of depth transmitters in Fall 1976 and Spring 1977 which were one-half the volume and twice as precise as those used in Spring 1976.

In Fall 1976, 10 internally radio tagged and 10 control tagged chinook salmon were released below Little Goose Dam. As occurred in Spring 1976, no internally tagged salmon recrossed Little Goose Dam. Only two controls recrossed Little Goose and we believe that the combination of poor fish condition, high water temperatures, internal tagging, and general handling caused high mortality among the Fall 1976 fish. The lack of success of internally tagged salmon in migrating through the river led to a decision to use only external tags in Spring 1977.

In Spring 1977, 30 externally radio tagged and 24 control tagged salmon were monitored. Control and radio tagged salmon in Spring 1977 achieved equivalent success in passing Little Goose Dam as those fish released in Spring 1976.

Depths of Spring 1977 and Fall 1976 salmon were significantly shallower than Spring 1976 fish. During Spring 1976, river run-off and spilling of excess water over hydroelectric dams resulted in 130 percent gas supersaturation of the Snake River. During Fall 1976 and Spring 1977, there was no run-off and river gas saturation values were about 106 percent.

It is possible that chinook salmon avoid harmful gas supersaturation conditions near the water surface. Such a contention is supported by the fact that Spring 1976, Fall 1976, and Spring 1977 fish spent 6 percent, 44 percent, and 28 percent of their time, respectively, above 2.0 m deep, which marks the lower limit of the critical gas saturation zone. However, mean depth of fish in each season was significantly below the critical zone.

Depth of travel of salmon was significantly different in the spill of the Little Goose Dam than in other areas of the river. Such differences appear to be related to delays in migration upon encountering the dam. The precise nature of this relationship is now being determined from the available data.

# SUBPROJECT SIX

## SEASONAL MIGRATIONS AND HABITAT SELECTION OF THE PRONGHORN ANTELOPE

A radio telemetry study of pronghorn antelope seasonal movements began at the Idaho National Engineering Laboratory Site in October 1975. The purpose of the study is: to document the seasonal movements of antelope that summer in three mountain valleys north of the INEL Site; to determine their use of the INEL Site as winter range; to record their specific use of the areas near the INEL facilities; and to obtain information on migration routes, habitat selection, and summer ranges.

Some antelope are found on the INEL Site during spring and summer. In late fall large numbers of antelope migrate from mountain valleys in Idaho and Montana to areas near or on the north end of the INEL Site.

Migration data will be useful in the Idaho Department of Fish and Game and federal agencies which make decisions affecting the management of this species. Since these populations are subject to off-site hunting, data on the timing and routes of migration, habitat selection, and the location of summering areas are required. Detrimental land use decisions, such as sagebrush spraying or construction of fences, may be avoided if the movements and ecology of these antelope are known.

This research is a cooperative effort of the Energy Research and Development Administration, Idaho Department of Fish and Game, and the University of Minnesota. The project will continue until September 1977.

### METHODS

Radio-collars were placed on 54 antelope during winter 1975-76 and 24 newborn fawn antelope during spring 1976. The antelope were herded into a corral trap with a helicopter. Captured antelope were sexed and aged, blood samples were taken (see attached preprint by Seal and Hoskinson), and ear tags attached. Selected animals were fitted with radio-collars operating in the 161-162 MHz range. Each radio transmits on a different frequency and each collar is color-coded, allowing for tracking and observation of individual antelope. In addition, each collar has a plastic laminated tag requesting the collar be returned. Embedded in this tag are TLD's which were measured for radiation exposure when recovered. Newborn fawns were captured by hand and radio-collared near their birth sites. Ground tracking of the radioed antelope utilizes a vehicle with a double Yagi antenna system mounted on a mast. Aerial tracking is done from a Piper Super Cub.

Temperature is being monitored on the INEL Site using the existing weather stations. Snow depths were measured at 18 locations on and near the INEL Site. These data will be analyzed to determine the effect of environmental conditions on pronghorn movements.

RESULTS

On December 4, 1975, 20 antelope were radioed in the Little Lost Valley near Howe, Idaho (5 km off-site). Twenty more were ear-tagged and 47 were released unmarked. Nineteen antelope were radioed in the Birch Creek Valley (8 km off-site) on December 7, 1975, and 40 others were ear-tagged. Fifteen antelope were radioed in Crooked Creek Valley (13 km off-site) on January 10, 1976; 46 others were ear-tagged, and 13 released unmarked. In late May and early June, 1976, 24 newborn pronghorn fawns were hand-captured and fitted with small, expandable radio-collars in the north end of Birch Creek Valley about 55 km north of the INEL Site. Two were fawns of a radio-collared doe.

Two pronghorns from the Little Lost and one each from Birch Creek and Crooked Creek died shortly after being radioed, possibly from trap-related injuries. Two of the radioed fawns died shortly after being collared, one preyed on by coyotes and the other probably from starvation due to physiological problems. Two other fawns lost their collars but are not assumed dead. Two adults were probably poached in the Little Lost. One radio-collar disappeared for 45 days and was then found by a rancher. The second antelope was found up in a canyon where it had been hauled by trappers as bait. One other broke her neck on an antelope-proof fence. Two Birch Creek antelope died during winter but no indication of the cause of death was evident. Two adult males were suspected of being poached in spring when on their territories, one in spring 1976 and the other in spring 1977.

Start of spring migration in 1977 was about a month earlier than in 1976 due to milder weather. Most spring migrations were upvalley to areas near the valley summits. But some antelope migrated in spring 1976 up a different valley than they wintered in during winter 1975-76, and then wintered in that second valley during winter 1976-77. Winter use of the INEL Site was restricted to the north end of the Site, which was used by some antelope from all wintering areas.

Summer ranges were located from 4 to 98 km from the winter ranges, and were upvalley away from the INEL Site in all but two instances. These two doe antelope migrated onto the desert, one passing through the Site and summering south of the Site, the other summering northeast of the Site.

Fawn antelope captured near their birth sites were followed through early winter before their radios expired during and after fall migration.

Fall 1976 migration occurred without snowfall, contradictory to previously published studies, but appeared related to decreasing temperature and decreases in moisture content of vegetation on the summer range. This migration response to drying vegetation on the summer range during fall has not been suggested previously for pronghorns, but is common among African ungulates.

Although the radio-collars have been operating for 18-19 months and most have expired, some still are transmitting a weak signal and attempts to track them during summer 1977 will continue. All other field work has been concluded and efforts are directed to preparation of papers to be submitted for publication. These will include a paper, Pronghorn antelope migrations in southeastern Idaho, which is completed in rough draft form, and Summer movements and fall migration of pronghorn antelope fawns.

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# EFFORT REPORT

| | Percent Effort Devoted to Project |
|---|---|
| Dr. J.R. Tester, Principal Investigator | |
| October 15, 1976 through July 15, 1977 | 31% |
| July 16, 1977 through October 14, 1977 | 42% |
| Dr. D.B. Siniff, Principal Investigator | |
| October 15, 1976 through July 15, 1977 | 10% |
| July 16, 1977 through October 14, 1977 | 37% |
| Mr. V.B. Kuechle | |
| October 15, 1976 through July 15, 1977 | 17% |
| July 16, 1977 through October 14, 1977 | 17% |