AQUATIC MAMMALS - PINNIPEDIA AND CETACEA*

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A feature of telemetry as applied to marine mammals is the contrast between its potential and its accomplishment. For over a decade, attachment of telemetric and recording packages to free-living animals has been attempted. Notable success has been achieved but twice; time-depth recording on the Weddell seal by Kooyman of Scripps and telemetric tracking of small whales by Evans of the Naval Undersea Research and Development Center. This summary will indicate some of the problems involved and some of the desirable parameters for measurement.

The possibility of telemetry in the marine environment will not become reality, on a large scale, until problems of non-acoustic data-transmission within that environment are solved. Marine mammals are highly vocal themselves and can hear sounds far beyond man's capabilities: at least to 60,000 cycles for each of the three species for which audiograms are complete (possibly even to 150,000 depending upon power output). Thus, we shun sonic transmittal of data underwater and turn to electromagnetic transmission in air as the animal breaks water. This avenue, as Evans' work has shown, involves an attached telemetric package. Other approaches are in design and development stages and are based upon the recording instrument package technique used by Kooyman. A recording instrument package which stores data on tape and which is retrieved by recapture of the animal is under development and testing by this writer. A more sophisticated and considerably larger package which stores data on film is also under current development by another worker.

A major initial problem is that marine mammals are extraordinarily difficult with regard to instrument attachment; basically, they strongly resist such rude treatment and there are few "handles" on their gracefully streamlined bodies. It is essential that the behavioral biologist and the engineer educate one another over a long time span so as to come up with a design which not merely works electronically, a relatively simple chore, but which is acceptable to the beast, often far more difficult. However, marine mammals have one notable advantage; they are large and the buoyancy of the hydrosphere makes package

* Supported by contracts to the Johns Hopkins University from the Office of Naval Research (Oceanic Biology Program).

size and weight not so great a problem as for birds. The smallest marine mammal, seal or whale, is about 400% larger than the largest flying bird when both are mature.

This summary will not treat the problems of reception (by boat, aircraft, land station, or satellite), but will be restricted to the package itself. Package design. Packaging is the greatest single problem in marine mammal telemetry. If size is not so critical, other problems are: rugged construction (a 3-ton elephant seal may chose to lie on his package on a rocky substrate), pressure (some marine mammals dive to over a mile and all dive in excess of 100 meters, probably), neutral buoyancy (slightly negative is better for flotation and retrieval), and shape as a hydrofoil. EM transmission means that antenna placement and orientation are critical. This is not so difficult for porpoises which break water in consistent and predictable fashion, but it is an unresolved problem for those, such as pinnipeds, which lie in every conceivable position out of water. The total package, including antenna, must be designed so as to interfere very little with basic behavior or such instrumentation becomes self-defeating.

Data storage. Implicit in all packages is data storage, if only briefly. There are three principle ways to do this: 1) by various electronic means, 2) digitally on film or tape, and 3) continuously on film or tape so that sounds made by the animal, for instance, are recorded as analogues. Photographic and tape-recording techniques involve components of relatively large size. The miniaturization of these components is as yet unsolved satisfactorily. For instance, a tape recorder in the form of a minicasette which could operate for a day and record sounds of from 100 to 10,000 cycles flat would solve many of the problems we now face.

Desired data. These fall into four categories: 1) track of animal's movements, 2) behavioral/physiological correlates, 3) navigational/orientation correlates, and 4) hydrological and oceanographic data. It is important that these data be recorded so that they may be correlated. The purpose of telemetry is the recording of natural phenomena with relation to the environment in which the animal swims. Multivariate analysis is essential. The various components falling into these categories are listed below:

1. Track. 11-meter beacons have been used for detection of range and bearing and for the detection of initiation and ' completion of dives. These beacons also act as homing beacons for package retrieval. The range varies with power and with receiver altitude. Ten miles is a minimum; 100 miles would be achieved by aircraft pickup. Satellites use doppler and can track over much larger distances than these.

2. Temperature. Both water and animal temperature are desirable. Marine mammals are closely keyed to their environmental temperature and studies of thermoregulation require knowledge of both external and internal temperatures. External temperature can be picked up by thermistors or thermocouples, but attachment of these detectors remains

a problem. Internal temperature requires either a deep probe or an EM endosonde which transmits to the recording instrument package. If such an endosonde is placed in the stomach, feeding behavior can be detected by a sudden drop in temperature. 3. Heart rate. Various methods are available including animal-borne pressure changes, acoustic detection, and alterations in a magnetic induction field. Data can be transmitted internally or externally.

4. Swimming speed and/or pitch angle. Marine mammals swim at speeds of possibly up to 25-30 knots, but mostly under 10 knots. A deflected-wand strain guage, protected by a cowling, is one method. Speed can also be detected by.doppler shifts. Pitch angle involves the use of a pendulum-potentiometer, but package orientation and attachment on the animal are obviously critical.

5. Acoustic output. Since marine mammals are highly dependent upon sound for orientation, food-finding and communication, it would be ideal to be able to record from a telemetered animal. A major, unresolved problem is how to record from the subject rather than from a nearby member of the same species screaming in its ear. In other words, the problem is one of body-coupling of sounds. It also would be ideal to record sounds as analogues which are subject to spectrographic analyses. This is not so easy as the recording of sounds as events or with regard to their spectral content. It is the requirement for analogue that determines the size, shape and complexity of the entire package, in many instances.

6. Environmental components. Light level and spectral content, water temperature, and salinity are the essential parameters for correlation with marine mammal behavior. Bottom topography is no less essential, but may be derived if tracking is accomplished and need not be a part of the package.

7. Real time. Though the package shuts off, in many cases, when the animal breaks surface and used this time for transmittal, continuous real time (0000-2400 GMT) is an obvious datum. The setting of an oscillator accomplishes this and establishes a continuous check on tape speed, etc.

The telemetry of marine mammals thus may reveal features of their behavior. The value of the data is not only intrinsic, but also relates to the management of a resourse of worldwide value.