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MONITORING FEEDING OF GREAT WHALES BY INGESTED ACOUSTIC TEMPERATURE TRANSMITTER

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This is rather exactly the 25th anniversary of the publication of the first (1) and second (2) articles on internal monitoring radio transmitters (though there had been earlier student reports and news releases); thus it is appropriate now to indicate a new and current application of the same original technique to the study of a species that is difficult to observe.

The first endoradiosonde (radio pill) transmitted temperature and pressure (1) and was tested on and used with human subjects. After swallowing one, its position in or beyond the stomach could be determined by swallowing a sip of cool water and noting presence or absence of a temperature change (3). In the case of dolphins, a swallowed transmitter in the first compartment of their stomach was reported to show a 2°C temperature drop as subsequent fish were swallowed (4). The present application uses the same technique to follow the feeding activities of great whales, except an acoustic rather than a radio transmitter is used to increase transmission range; high frequency sounds do not disturb mysticete whales. Since much of the time they are out of sight below the surface, they are among the most difficult animals to study.

The transmitter (Fig. 1) uses a thermistor-controlled complementary pair multivibrator in which both transistors are on together

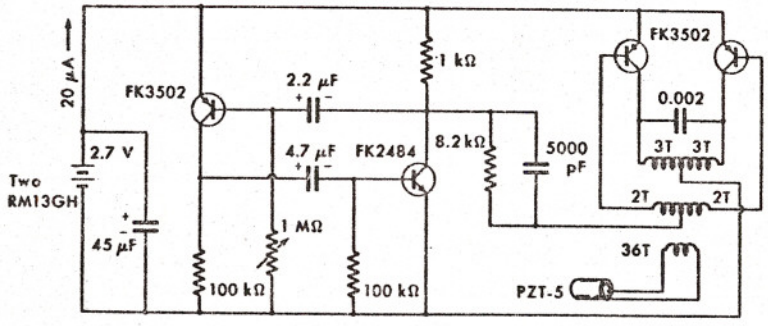

Fig. 1. Temperature controls the frequency at which ultrasonic pulses are produced for propagation through animal and ocean. If connected as shown, the collector and base coils must be wound in opposite directions to maintain oscillation.

and then off together to gate on and off the output oscillator. This is very good for generating short impulses separated by longer intervals but one can do the same with an ordinary multivibrator by replacing one collector resistor with another transistor driven at the opposite collector resistor. Our tests showed 20 msec pulses about once per second are noticeable and conserve battery power. Further circuit details are in (3). The radiating PZT-5 piezoelectric cylinder was mechanically resonant at 80 kHz. Balance was so that the unit orients transducer down in case there is a gas bubble at the top of the stomach; acoustic impedance is not elsewhere poorly matched.

Whales generally swallow food whole. The 1937 description of the dolphin stomach by Pernkopf is convenient (Fig. 2). In toothed

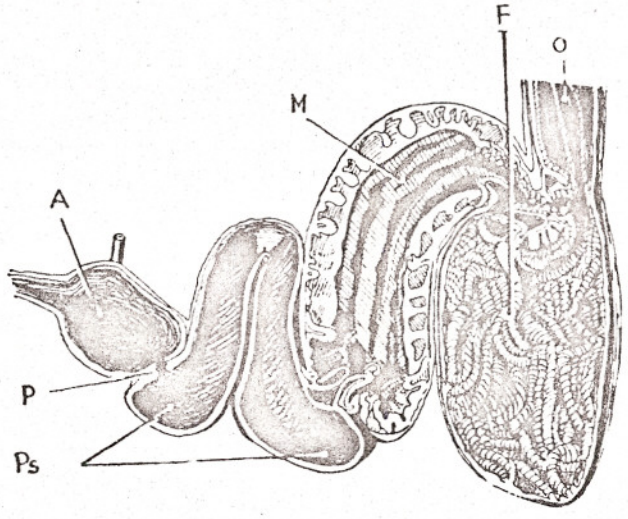

Fig. 2. Section of stomach of a bottlenose dolphin: O is oesophagus; F is forestomach; M is main stomach; Ps is pyloric stomach; P is pylorus, and A is ampulla of duodenum.

whales, the first compartment of the stomach is largest while in baleen whales the second compartment (of 3) is larger. One can throw a fish, with transmitter, into the mouth of a surface-feeding humpback whale (Fig. 3). We have observed humpback whales occasionaly to defecate (not regurgitate) an intact bird (Cassin Auklet) which is about 15 cm in diameter (and very unlucky!) thus reducing worry about an impacted transmitter.

Similar monitoring (of heartbeat, temperature, etc.) can be done from the stomach of seals. With phocid seals a small transmitter will pass while a large one is readily regurgitated.

Some details of range considerations have been given (3). It became clear during World War II that the attenuation of sound in

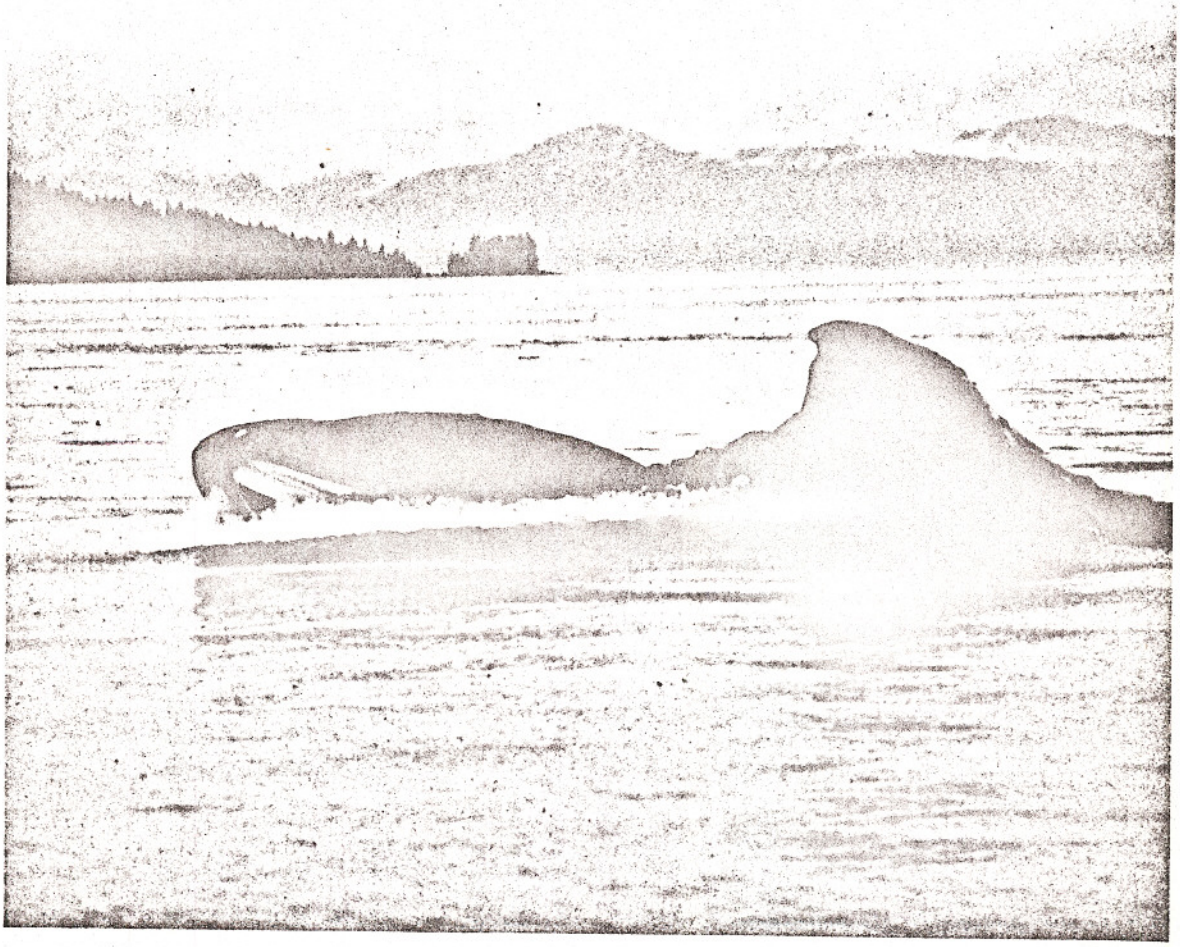

Fig. 3. A humpback whale lunging to the left with open mouth through a concentration of euphausiid "shrimp." The upper row of dark baleen plates is seen projecting from the roof of the mouth out toward the camera. The expandable throat grooves and the lower jaw are to the right.

seawater was approximately 20 times that in freshwater. Molecular relaxation of sodium chloride was suspected but R.W. Leonard showed in 1949 that small amounts of magnesium sulfate caused the excess attenuation. The absorption coefficient of water varies approximately with frequency squared while for tissue it is more nearly proportional to frequency (5). A half meter of blubber is roughly equivalent to 3m of sea water in the present case.

Feeding patterns of humpback whales at Frederick Sound, Alaska vary and are not only simple grazing. In the Summers of 1979, 1980 and 1981 the percentage of feeding done at the surface was approximately 9%, 68%, and 1% respectively. These whales often approach

small boats, making it possible to throw a transmitter into the mouth while they are surface-feeding and thus allowing telemetry of their swallowing under water. The whales are not disturbed by such transmitters.

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