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Echolocation in Harbour seals: Maybe they can do it after all

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where β_c is the critical angle, fits the shape of the melon. For the open nasal plug condition, echolocation "clicks" from the larynx propagate up the nasal duct into the premaxillary sac, which acts as a "bubble" transducer for the search sonar. The source of the whistle-like communicative phonations is identified as lip-modulations excited by exhaust air expelled from the premaxillary sac into the vestibular sac. Experimental confirmation, drawn in part from the bioacoustic literature on Odontocetes, is proffered in support of the principal qualitative features of this new model.

3:50

LL10. Echolocation in Harbour seals: Maybe they can do it after all. Deane Renouf (Department of Psychology/Marine Sciences Research Laboratory, Memorial University of Newfoundland, St. John's, Newfoundland, A1B 3X9, Canada)

Though there is indirect evidence to indicate that various species of seals are capable of some form of echolocation, all previous attempts at an experimental demonstration of sonar capacities have met with negative results. I have obtained the following circumstantial evidence that Harbour seals can echolocate: (1) During three breeding seasons I have observed apparently healthy blind adult harbour seals including females which have successfully raised pups. (2) When visual cues are reduced, harbour seals make click vocalizations similar to those of animals which are known to echolocate. (3) They are able to find live fish in total darkness, producing clicks while doing so. (4) One seal trained to retrieve a ring which he first had to find in a 10-m-diam tank performed as well in the dark as in daylight, but clicked only when he could not use vision. I obtained a more rigorous demonstration of Harbour seal sonar when I was able to train an animal to discriminate between two visually identical rings which differed in acoustic impedance. When the acoustical properties of the rings were made equal, the animal was no longer able to distinguish between them. Very faint single or doublet clicks were recorded during the animal's performance, and it is suggested that quiet distinct signals may have been appropriate in an enclosed tank when the objects to be discriminated were suspended close to the enclosure's walls. The reasons why the training procedures used in this demonstration were successful are discussed, and the limitations of the conclusions which can be drawn from such results are outlined.

4:05

LL11. Incidental evidence for echolocation in polar pinnipeds. Jeanette A. Thomas, Frank T. Awbrey, and Sheldon R. Fisher (Hubbs Sea World Research Institute, 1700 South Shore Road, San Diego, CA 92109)

Efforts to experimentally demonstrate echolocation in California sea lions, *Zalophus californianus* [W. Evans and R. Haugen, Bull. So. Cal. Acad. Sci. **62**, 165–175 (1963); R. J. Schusterman, Psych. Rec. **16**, 129–136 (1966)] and in grey seals, *Halichoerus grypus* [B. Scronce and S. Ridgway, in *Animal Sonar Systems*, pp. 991–993 (1980)] have been unsuccessful. However, similar studies on polar pinnipeds have not been conducted previously. No studies have investigated the potential for ultrasonic vocalizations in pinnipeds. Echolocation in polar pinnipeds has been suggested because of their highly developed vocal abilities and their need to find food and navigate during the dark austral winter [G. Kooyman, Ant. Res. Ser. **11**, 227–261 (1968); J. Thomas and V. Kuechle, J. Acoust. Soc. Am. **72**, 1730–1738 (1982)]. This presentation will summarize observations and evidence that indicates the presence of echolocation in polar pinnipeds and report the production of ultrasonic vocalizations by a captive leopard seal (*Hydrurga leptonyx*). Clicks, buzzes, and frequency-modulated chirps were produced with peak frequencies from 4 to 164 kHz, but generally between 50 and 60 kHz. This study demonstrates the importance of investigating ultrasonic vocalizations in all pinnipeds and implies that polar pinnipeds may be the best test group for echolocation.

4:20

LL12. Seal blindfolded discrimination: Echolocation not proven in *Halichoerus grypus*. B. L. Scronce and S. H. Ridgway (Code 514, Naval Ocean Systems Center, San Diego, CA 92152)

A four-year-old female gray seal from Iceland was trained to wear an opaque elastic band that blocked vision. Echolocation capability was evaluated in two experiments: (1) The seal was required to retrieve an air-filled plastic ring 20 cm in diameter placed at random in a 5×1 m section of a 10-m redwood tank. (2) The seal was required to detect the flat surface of a 25-cm styrofoam disk as opposed to the edge of the same disk ($-$ 30 dB target strength), placed randomly on either side of a divider. Without the blindfold, the seal's ring retrieval rate was 100% with a latency of 3.8 s. In 427 blindfolded trials there were 99% correct responses, but latency increased to 6.5 s. Head scanning movements were observed on about half the blindfolded trials and click trains were recorded on about 10% of the trials observed. In the second experiment, the blindfolded seal approached the divider and made a choice about target location (right or left) at least 1.5 m away. Correct responses in a session never exceeded 65% and averaged 46% on 617 trials. Without the blindfold, the seal's performance was almost 100%. The gray seal makes sound underwater but does not appear to use the clicks for echolocation in any way similar to the demonstrated capabilities of dolphins.

THURSDAY AFTERNOON, 10 NOVEMBER 1983 SENATE/COMMITTEE ROOMS, 1:00 P.M.

Session MM. Underwater Acoustics V: Signal Processing I (Précis-Poster Session)

Arthur B. Baggeroer, Chairman
Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

Chairman's Introduction—1:00

Invited Papers

1:05

MM1. Broadband signal selection and generation for channel sounding. T. G. Birdsall (University of Michigan, 262 Cooley Bldg., Ann Arbor, MI 48109)

Two classes of signals and applications are considered. The T class, for deep water work where ray paths are an appropriate model, requires a processed output waveform that is a short pulse with zero amplitude beyond a