TECHNICAL PAPERS

Underwater Listening to the White Porpoise (*Delphinapterus leucas*)

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Recent developments in underwater acoustics have led to considerable speculation on the sounds made by cetaceans. Exclusive of those incidental to breathing or splashing at the sea surface, there is a variety of sounds which several species are known to make habitually while submerged. Published accounts allude to such sounds as heard through the air, but there seems to be no record of what can be heard by listening in the whales' own medium.

To learn more of the extent to which particular cetaceans do make underwater noises and how they sound under natural conditions on underwater listening apparatus, we wished to find an area where a single species was plentiful enough to be observed and listened to for relatively long periods. The white whale or porpoise, *Delphinapterus leucas* (Pallas), suggestively nicknamed "sea canary" (*1, 2*), seemed a promising subject and was known to occur in large numbers in the St. Lawrence estuary. As suggested by Vladykov's recent comprehensive works (*10, 11*) on this species, we found a good concentration in the lower Saguenay River in Quebec. The white porpoises were remarkably numerous, passing up and down the river in groups of various sizes throughout the day, so that we were able to listen to them for hours at a time, while watching them through field binoculars. Furthermore, no other cetaceans were observed there, although the little piked whale, *Balaenoptera acutorostrata* Lacépède, was seen in the St. Lawrence River a few miles away.

Our listening gear (a conventional underwater microphone, or hydrophone, with an amplifier) enabled us to hear over a frequency band between somewhat less than 500 and 10,000 cycles/sec, well within the normal human audible range. Strong currents, shoals, tide rips, and traffic in the St. Lawrence contributed to a noise background sufficiently high to interfere with our hearing. In the lower Saguenay the deep water (over 100 fathoms) and our good fortune in having little wind gave us the quiet essential for good listening, although there were two intervals with strong gusts of wind when the waves drowned out the sounds made by *Delphinapterus* nearby.

We found the water remarkably free of animal noise except when *Delphinapterus* were within range. Whenever we saw them we heard a variety of sounds which would become louder as the porpoises were seen coming around a bend in the river and would die away as they passed out of sight. But for the two occasions of rough water, we never sighted them without hearing them, and rarely heard them without seeing them, except after dark.

The noises which we thus ascribed to *Delphinapterus* were heard as high-pitched resonant whistles and squeals, varied with ticking and clucking sounds slightly reminiscent of a string orchestra tuning up, as well as mewing and occasional chirps. Some of the sounds were bell-like, and a few rather resembled an echo sounder. Occasionally the calls would suggest a crowd of children shouting in the distance. At times there were sharp reports, somewhat like a blow with a split bat or a slap on the water, although nothing could be seen to be striking the water in any way; perhaps this was jaw snapping, as reported for *Tursiops* by McBride (*8*, p. 25; *9*, p. 112). On two occasions we heard trilling, which quite justified the name "sea canary." This description is given with some diffidence in view of the notorious difficulty of adequately describing unfamiliar sounds. We hope to make phonographic recordings at another opportunity.

It is to be emphasized that all these sounds were made under water. We heard them only through the hydrophone, which was at depths of 60 to 90 feet; the porpoises were never nearer than about 200 yards, and often over two miles away. Mostly they passed along the far side of the river in their usual series of short dives (5–10 seconds' submergence, perhaps 50 feet of horizontal progression), but sometimes they would make unusually long dives (up to about half a mile) apparently to avoid us; in either case their calls continued uninterrupted. Axel Olsen and Léopold Boulianne, of Tadoussac, Province of Quebec, who accompanied us, said that they had previously heard whistles when *Delphinapterus* passed directly beneath their canoe, but that they had never heard such a variety of sounds as they now did over the underwater gear. Similarly, the underwater sounds heard by earlier authors (Fisher, *3, 4*; Kane, *6*; Nielsen, *2*; and others, summarized by Vladykov, *10*, pp. 121–124) may be recognized among the list of those we heard, although no single listener seems to have heard them all, perhaps because they were handicapped by listening through the air instead of through the water alone.

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Since fish noises predominate in other regions, it seems strange that none were identified here, except for those caused by their biting and pulling at the hydrophone. It is possible that some of the sounds might be of fish origin, but it is significant that only the bites were detected in the absence of *Delphinapterus*.

Particularly striking is the great variety of *Delphinapterus* sounds and their rapid and apparently continuous succession. This loquaciousness contrasts markedly with most terrestrial herd mammals and compares with such chatterboxes as monkeys and men. Among the Cetacea it would appear not to be limited to *Delphinapterus*, as is indicated by the continuity of related but less varied sounds heard by one of us in the presence of different porpoises in the open Atlantic, as well as those on phonograph records at the Woods Hole Oceanographic Institution which are believed to be of porpoises. The considerable difference between the sounds we heard in the presence of *Delphinapterus* and the less spectacular ones associated with *Delphinus* (Kullenberg, 7; Fraser, 5), *Tursiops* (McBride, 8, p. 19; 9, pp. 112–113), and other pelagic forms encourages us to hope that these underwater calls may be sufficiently characteristic to be helpful in distinguishing cetaceans at sea. Such listening probably will have to be carried into the supersonic range.

Only toothed whales (Odontoceti) have figured in the reports so far encountered. It would be of interest to learn of any authenticated instances of hearing underwater sounds from baleen whales. Among these, our experience with listening apparatus is limited to the solitary individuals of *Balaenoptera acuto-rostrata* mentioned earlier; we distinguished no underwater sounds even when a whale was within 300 yards.

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Colorimetric Estimation of Succinic Dehydrogenase by Triphenyltetrazolium Chloride[1]

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Methylene blue or other redox dyes are extensively used as indicators of dehydrogenases. Enzyme activities are frequently defined by the anaerobic decolorization time of a redox dye, but photometric estimation of the decolorization can be carried out in special Thunberg tubes only if the reaction mixture is not very turbid (*3*). It was found in our laboratory that triphenyltetrazolium chloride is a suitable indicator of the succinic dehydrogenase activity of tissue homogenates. The advantages of this technique are that the system does not require anaerobic conditions and that the enzyme activity can be followed quantitatively by colorimetric measurements.

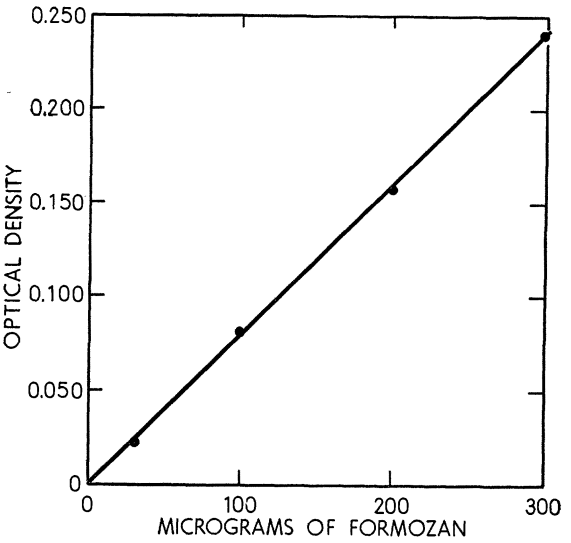

FIG. 1. Straight line relationship between the amount of reduced tetrazolium salt (formozan) and optical density (log I_0/I_x).

Tissue homogenates in the presence of succinate in a buffered (pH 7.4) medium reduce the colorless tetrazolium salt to a red water-insoluble formozan. The formozan (*2*) can be easily dissolved in acetone, which, by precipitating tissue proteins, leaves a clear supernatant ready for colorimetric measurement. Under given conditions, in the absence of succinate the tissue homogenates tested do not reduce the tetrazolium salt except under strongly alkaline conditions.

If this principle is applied, the colorimetric determination of succinic dehydrogenase can be carried out according to the following procedure: Into 15-ml calibrated centrifuge tubes are pipetted 0.5 ml of 0.1 M phosphate buffer (pH 7.4), 0.5 ml of 0.2 M sodium succinate, 1.0 ml of 10% tissue homogenate (*i.e.* 0.1 to 1.0 ml of homogen-

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