Testing acoustical methods for detection of odontocete whales

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The problem

Stock sizes of most odontocete species are hard to get. At present, whaling activities are either banned or existing at such a small scale that no usable data are generated for the traditional methods of population estimates. Therefore, sight surveys have now become the dominating inventory method. The detection rate of sight surveys, however, is low (assumed to be 5% in NASS 1989) and not easy to quantify. Sea state, illumination and visibility are obviously influencing detection rate; animal density, diving behaviour and observer experience are also known to be important. Clearly, any measures that serve to increase detection rate will lead to better estimates.

Proposed solution

Since odontocetes are known as vocally active animals, it has often been proposed to detect them by acoustic means. Quite a number of reports describe methods operating in the low audio frequency range (Thomas *et al.*, 1986). Such methods, however, require a silent ship, running at 4 knt or less. For standard transects as in the NASS- surveys, such speeds are not attractive. Further, the ultrasonic sonar pulses of these animals are not utilised by audio equipment. These pulses have recently been found to be very powerful, with source levels in the 220-230 dB re. 1 µPa range (Au *et al.*, 1988). As background noise in the sea is decreasing with frequency, signal to noise ratio should improve at ultrasonic frequencies.

To take advantage of ultrasonic pulses for detection, they have to be converted to audible frequencies. The only online technique available is heterodyning, where a segment of the ultrasonic spectrum is converted down by subtraction from a chosen, fixed frequency. In essence, the process is a filter for the spectrum segment in question. For odontocete whistle signals, this can be an efficient technique, yielding outputs with high signal to noise ratios and therefore large detection ranges. For the broad band sonar pulses, heterodyning is inefficient by filtering out only a small part of the

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energy available. However, since overall signal energy is very high, detection may still be feasible (Møhl, 1990).

Implementation

To explore this possibility we have developed a tow-able acoustic sensor. The sensor - or acoustic fish - is made of a 2.5 m polyethylene tube, 11 cm in diameter, tapering in both ends. A shock absorber (2 m of thin-walled rubber tubing) connects the fish with the towing cable (100 m of 5 mm steel wire, 4 leads). Two hydrophones (sonobuoy surplus type), spaced 1 m apart, are suspended inside the water filled tube in rubber bands. The fish also has a pressure gauge for depth indication. 10 m in front of the fish a number of lead weights can be attached to the wire in order to adjust towing depth to towing speed. The fish is flooded with water at launch. This operation requires the ship to be stopped.

On board, the signals from the hydrophones are fed to a two channel heterodyne converter with pass-band centre frequencies adjustable from 10 to 100 kHz. The bandwidth is 3 kHz, and the dynamic range is 40 dB.

The Simrad SONAR

r/v "Magnus Heinarsson" is equipped with a SimRad SU Survey P661E SONAR, operating at 18kHz. During the cruise we realized that this instrument could be utilised in its passive mode to listen for odontocetes when the ship was making 8 knt. Its working principle is that of a heterodyne converter, but selectivity is introduced at the transducer level, as is directionality.

Findings

Sperm whale (*Physeter macrocephalus*)

A single specimen was spotted at an estimated distance of 5 NM. The ship proceeded at 2 knt towards the point of diving. The acoustic fish was deployed and signals recorded with the heterodyne converter set at 10 kHz. Repetition rate was steady at about 1 pulse every two seconds. A time series of a single pulse is given in Fig. A1, showing double path transmission (probably due to reflection at the surface). The time difference between the two sets can be used to estimate the depth of the source, provided a range estimate is available. The somewhat higher signal amplitude in the delayed path can be interpreted as an indication of the animal's acoustical axis being more aligned with the reflecting point than with the acoustic fish.

Also, the multi-pulsed structure so characteristic of this species is shown. From the interpulse interval of 4 ms, an estimate of 15 m for total body length of the specimen can be made (Adler-Fenchel, 1980). This information reveals the sex, since only males grow to this length. Although this information is no big surprise (only males are observed at these latitudes), it serves to show the kind of information obtainable with the acoustic fish.

In Fig. A2 is shown the simultaneous output from the two transducers in the fish for the first pulse of a click. The time difference shows that the whale was at a bearing 17° off the towing direction. To determine the side, the course of the ship will have to be changed during recording.

When the speed of the ship was increased, propeller noise was driving the hydrophone amplifiers into saturation.

Pilot whale (*Globicephala melas*)
A pod of 6 animals were observed in calm sea. They were heading away from the ship, and before the acoustic fish was deployed and operated, distance was estimated to be 1 NM. Both whistles (Fig. P1) and clicks (Fig. P2) were detected. The best signal to noise ratios were obtained at 20 kHz.

In pursuing the pod, it was again made abundantly clear that the acoustic fish in its present configuration is useless when operated from a ship of this size at speeds more than 2 knt.

White-sided dolphin (*Lagenorhynchus acutus*)
A school of about 10 animals was encountered while the Simrad SONAR was used in its passive mode. The school was initially detected acoustically while the ship was steaming at 8 knt. The course was changed to the direction indicated by the SONAR, and after 6 min, the school was seen surfacing at an estimated distance of 0.5 NM. Thus, the acoustic detection distance was roughly 3 times the visual one.

The SONAR recordings show both whistles (Fig. L1) and clicks (Fig. L2). The former contain rather little usable information, since the selectivity of the SONAR slices out the energy only in its passband of less than 1 kHz (centred at 18 kHz). Since delphinids are known to whistle over a range of about an octave, only the parts that happen to sweep through the "window" of the SONAR are detectable. Consequently, nothing can be said about duration, frequency span, or general sonic activity from such records. But since the whistles have high detectability and low directionality they obviously can be used for detection purposes.

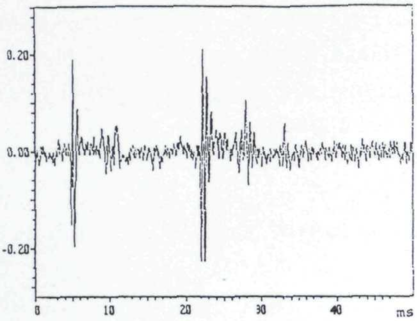
Click trains obtained with the SONAR accurately portrait pulse repetition, and relative intensity at the transducer (Fig. L2).

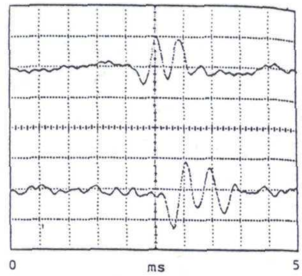
However, the received sequences are fairly short. This is consistent with an assumption about high directionality of the source. The inverse of the repetition rate is believed to indicate roughly the two-way transmission time to the target of interest. The rate in Fig. L2 accordingly suggests a target about 50 m from the animal, possibly the ship.

When the acoustic fish was deployed, signals of the same type as obtained with the SONAR were recorded. However, the greater bandwidth of the heterodyne system resulted in more diversity in whistle structures.

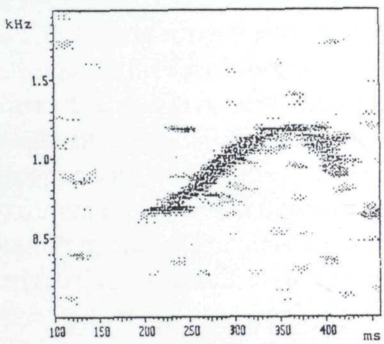
Conclusions

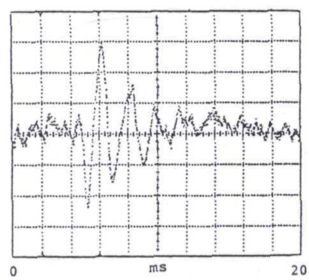
Although exposure to odontocete species during the cruise was conspicuously low, it sufficed to demonstrate the viability of the basic idea of utilising the ultrasonic part of the acoustic spectrum for detection. Clicks were detected by the acoustic fish from all



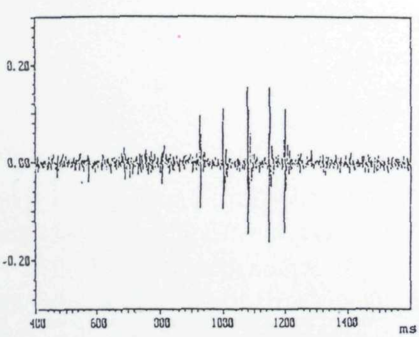


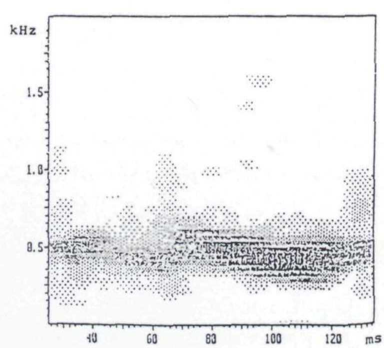
A1 Sperm whale A2





P1 Long-finned pilot whale P2





L1 Atlantic white-sided dolphin L2

3 species, as were whistles from the pilots and the lags.

There is a need for modification of the acoustic fish: it has to be made insensitive to low frequency overloading by propeller noise. Several schemes are possible, including tuning of the transducers to ultrasonic frequencies. This is in part the solution used in the SONAR.

The primary acoustic detection with the SONAR of the lags is particularly encouraging. It suggests a practical method for adding an acoustic survey capability at no cost for ships already equipped with this instrument. The method can be used both during dedicated transect cruises as well as during other activities. If a SONAR is not installed and an acoustic survey capability is wanted, an improved version of the acoustic fish may be worth considering.

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Úrtak

Meðan *Magnus Heinason* var á kanningarferð á Føroya Banka í juni 1992, varð eitt einfalt lurtitól til at upptaka stuttbylgjuljóð (“ a simple, 2-hydrophones, ultrasonic sensitive detector”) sleipað aftaná skipinum. Hetta varð roynt fyri at kanna eftir, um tólið kundi nýtast til at leita eftir tannhvali. Royndin eydnaðist hampiliga væl, tá ið siglt varð við lítlari ferð. Harafturat vísti astikið í skipinum seg at vera rættuliga gott til at leita við, tá ið tað bert varð nýtt sum móttakari.

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