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THE EFFECT OF ACOUSTIC ALARMS ON THE BY-CATCH OF HARBOUR PORPOISES IN THE DANISH NORTH SEA GILL NET FISHERY

A PRELIMINARY ANALYSIS

by

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ABSTRACT

The Danish Institute for Fisheries Research conducted an experiment in 1997 to investigate whether acoustic alarms could reduce the unintentional by-catch of harbour porpoises in the Danish bottom set gill net fishery for cod in the North Sea. The experiment was designet as a double-blind experiment with a control group consisting of nets with inactive pingers. All 14 participating vessels had an observer from DIFRES on board during the experiment which was conducted in the period 30 August to 10 October 1997. The double-blind aspect meant that neither the crew nor the observer on board knew which of the pingers were active and which were dummies. The pingers used were proto type pingers developed by Loughborough University, England. Pingers were attached to the nets so that no net was more than c. 70 m from a pinger.

The participating vessels had a total of 168 days at sea during the experiment, fishing a total of 590 stations varying in size from 4 nets to 240 nets. The total effort was 6523 nets with active pingers, 5680 nets with dummy pingers and 3395 nets without pingers. During the experiment alltogether 24 porpoises were caught, including 1 animal caught in nets with active pingers, 13 caught in nets with dummy pingers and 10 caught in nets without pingers.

The frequency of by-catch of porpoises was 0.00015 in nets with active pingers, 0.00229 in nets with dummy pingers and 0.00295 in nets without pingers. The difference in frequency of by-catch between nets with active pingers and nets with dummy pingers is statistically highly significant (p=0.000669). There is no significant difference in by-catch frequency between nets with dummy pingers and nets without pingers (p=0.699).

INTRODUCTION

An investigation of the by-catch of harbour porpoises in the Danish North Sea bottom set gill net fishery in 1992 and 1993 concluded that the total annual by-catch was in the order of 7 000 animals (Vinther 1997).

Research conducted in the USA, UK and the Netherlands suggest that acoustic alarms (pingers), can be very efficient in reducing the by-catch of porpoises. As a contribution to the EU funded BY-CARE project, the Danish Institute for Fisheries Research in 1997 conducted a controlled experiment to test whether the use of pingers could reduce the by-catch of harbour porpoises in the Danish gill net fisheries.

It was considered important in planning the experiment that it was of a magnitude, that would allow an evaluation of whether the expected reductions in by-catch were statistically reliable. It was also important to be able to evaluate whether the use of pingers had any effect on the catch of target species. It was furthermore important that the experiment was conducted in cooperation with the fisheries organisations and interested fishermen, to draw on their experience and to identify as early as possible any potential problems in using pingers during routine fishing operations.

The main objective was to investigate if the use of pingers could reduce the by-catch of harbour porpoises in the Danish North Sea bottom set gill net fishery for cod. As described below, information was also collected on the total fish catches including discard, to allow an evaluation of whether the pingers could be expected to have an effect on the fish catches. However, this paper presents only a preliminary analysis of the effect of the pingers on the by-catch of porpoises.

METHODS

Selection of fishery

The principal criteria for selecting a fishery for the pinger experiment was that it should have as high a by-catch rate as possible, to facilitate determination of a specific reduction. Of the North Sea fisheries where by-catch rate is known, the bottom set gill net fishery for cod in the area 55N30'-57N30' and 2E-6E in the third quarter of the year has the highest rate (Vinther 1995). There are furthermore indications that the wreck fishery has a higher by-catch rate than the other cod gill net fisheries (Vinther, *pers.comm.*).

Gear type and fishing practices

Nets used in this fishery are 1 000 meshes long, typically 21.5-26.5 meshes high and stretched mesh size is 130-170 mm. The head rope is 8 or 10 mm and 70-80 m long given hanging ratios of around 0.5. Nets are tied together into strings of varying length.

In the wreck fishery strings are 2-4 nets long and typically 2-4 string are placed on each wreck. In the fishery on flat bottom/stony grounds strings are typically 20-60 nets long, depending on whether they are set in parallel rows or as a single meandering string.

Fishing depths are typically 20-80 m and soak times in September are 8-15 hours, depending somewhat on water temperature.

Experimental design

The experiment was designed as a double-blind experiment with a control group of nets with inactive pingers, so-called dummies. The double-blind aspect meant that neither the crew nor the observer knew which of the pingers on board were active and which were dummies. To avoid that consistent differences between the participating vessels in fishing practices and preferred areas would have an effect on the results of the experiment, all vessels alternated on a daily basis between fishing with active pingers and dummy pingers on the nets. Thus each vessel was given an active set of pingers as well as a dummy set. Each pinger was given an individual ID-number and each set was colour coded to facilitate identification.

Effort required

The main objective of the experiment was to determine whether the use of pingers could result in a significant reduction in harbour porpoise by-catch, here understood as a statistically significant reduction of at least 50% determined with a probability of 0.95. Analyses of by-catch rates from previous years suggested that a total effort of around 1 000 km of nets fished, equally distributed on the treatment group (nets with active pingers) and the control group (nets with dummies) was necessary. To limit the effect of a seasonal trend in the by-catch rate, the experiment was limited in duration to 4 weeks. Based on information on the typical effort of a vessel engaged in the selected fishery, it was estimated that 12 vessels were required to obtain a total effort of 1 000 km in 4 weeks of fishing.

Selection of participating vessels

The main criteria for selecting the 12 vessels needed were similarity with respect to fishing practice, preferred fishing area and fishing gear. In addition they should fulfill a number of requirements related to carrying an observer during the experiment.

Data collection

All participating vessels had an independent observer on board for the duration of the experiment. The principal tasks of the observer were the attachment and replacement of pingers following specific guidelines and collection of information on gear type, fishing effort, pinger use and by-catch of cetaceans. In addition the observer collected data on the magnitude and species and size distributions of all catches including discard.

The collection of data is centered on a Station, defined here as a number of nets with the same mesh size, set at roughly the same position and depth and with similar seabed conditions. In the wreck fishery, a Station are the nets with the same mesh size set on a wreck.

Pinger

The pinger used was a prototype, LU-1, developed by Loughborough University, England. LU-1 has these technical specifications:

Frequency:	8 different signals between 40 and 120kHz
Source level:	145 dB (re 1 microPa @ 1 m)
Signal length:	300 ms
Signal interval:	random between 5 and 30 s

Length:	145 mm
Diameter:	44 mm
Volume:	0,22 l
Weight (in air):	c. 400 g

LU-1 is equipped with a capacitor switch, which activates the signal emission when the pinger is submerged in water. Before the experiment and after each fishing trip, all active pingers were tested to ensure proper functioning.

Pingers were attached to the nets with a carabinhook on a short strap and a 50 mm wide velcrostrap glued to the mid part of the pinger and strapped around the headrope. The pingers were attached to the tail-ends, *i.e.* the bridles used to tie the nets together into strings. The general rule for inter pinger distance was that no part of a net should be more than one net length (c. 70 m) from a pinger. In general this would mean placing pingers between every other net. However, when strings were set in parallel rows close to each other, only every other row or sometimes only every third row would have pingers attached. On wrecks it would normally be sufficient to have one pinger on each side of the wreck.

In the wreck fishery, where only a few short strings are set on each wreck, it was possible to attach the pingers during shooting. However, in the flat bottom/stony ground fishery strings are normally shot with a higher speed (up to 6 knots), and it is not possible to attach the pingers during shooting. Here the pingers were attached and replaced during hauling when the nets passed the table where the catch was removed, before going through the net cleaner and into the net pounder. Since all pingers were brought ashore for checking between trips, this attachment procedure meant that in the flat bottom/stony ground fishery pingers could not be placed on the nets in the first set on a new trip. These sets without pingers constitute a third group in the experiment.

Data analysis

In this preliminary analysis, only data relevant to the effect of pingers on the by-catch of harbour porpoises are analysed.

The by-catch is here considered as a Bernouille process, where each sampling unit (here the individual nets) is given the value 1, if there was a by-catch in the net, or 0 if there was no by-catch in the net. For each of the three groups in the experiment this results in two figures, that together describes the probability of porpoise by-catch in that group. Using a $\chi 5$-test it is tested whether the three groups have significantly different probabilities of by-catch.

RESULTS

Effort

The experiment was conducted from 31 August to 10 October 1997. A total of 14 fishing vessels participated, and they had a total of 168 days at sea during the experiment. All together 590 stations, varying in size from 4 to 240 nets, were fished. However, the majority of the stations were between 6 and 12 nets (wreck fishery) and between 30 and 60 nets (flat bottom/stony ground fishery).

The experiment included a total of 6523 nets with active pingers, 5680 nets with dummy pingers and

3395 nets without pingers.

By-catch of porpoises

During the experiment a total of 24 porpoises were caught on 15 stations. Two stations had 5 porpoises each, 1 station had 2 porpoises and 12 stations had 1 porpoise each. There was 1 animal caught in nets with active pingers, 13 caught in nets with dummy pingers and 10 caught in nets without pingers (Table 1). No net caught more than one porpoise.

Table 1. Number of nets with and without by-catch of harbour porpoises.

	Number of nets with porpoises	Number of nets without porpoises
Nets with active pingers	1	6522
Nets with dummy pingers	13	5667
Nets without pingers	10	3385

Effect of pingers

The frequency of by-catch of porpoise is 0.00015 in nets with active pingers, 0.00229 in nets with dummy pingers and 0.00295 in nets without pingers.

The difference in by-catch frequency between nets with active pingers and nets with dummy pingers is highly significant (p-value: 0.000669).

There is no significant difference in by-catch frequency between nets with dummy pingers and nets without pingers (p-value: 0.699).

If nets with dummy pingers and nets without pingers are pooled into one control group, the difference in by-catch frequency between nets with active pingers and the pooled control group is highly significant (p-value: 0.000204).

DISCUSSION

The results of the experiment carried out in the the Danish North Sea bottom set gill net fishery for cod in 1997 are in agreement with pingers trials conducted in other areas (Kraus & Brault 1997; Kraus *et al.* 1997; Gearin *et al*. 1996). Comparing the by-catch frequencies in nets with active pingers and nets with dummy pingers, the high-frequency pingers signals have almost completely eliminated the by-catch of harbour porpoises, and the difference is statistically highly significant. There is no significant difference in by-catch frequency between nets with dummy pingers and nets without pingers, suggesting, as expected, that the physical presence of the pingers on the head rope has no effect on the by-catch. It is the alarm signals themselves that cause the reduction in by-catch.

Whether the effect is indirect, *e.g.* through the deterrence of prey animals, or directly on the porpoises cannot be determined from the experiment reported here. However, studies on free living harbour porpoises conducted in Loch Duich, Scotland, in 1996 show that alarm signals similar to those of LU-1 result in an immediate escape reaction of the exposed animals (Goodson *et al.* 1997). This is in agreement with studies conducted on free living porpoises in Washington State, USA, (Laake *et al.* 1997), on free living Hector=s dolphins in New Zealand (Stone *et al.* 1997) and on porpoises in captivity (Kastelein *et al.* 1997). In all three studies, a direct effect was found on the animals. It is thus very probable, that the reduced by-catch reported in the present study is a result of the direct effect of the high-frequency sounds on the porpoises= behaviour.

It can thus be concluded, that the use of high frequency acoustic alarm signals can significantly reduce the by-catch of harbour porpoises in the Danish North Sea bottom set gill net fishery for cod, at least in the short term. This is an important conclusion in relation to the ability to extrapolate the results to other fisheries. However, whether the use of pingers will be effective in the longer term will depend on whether the porpoises will habituate to the alarm signals. In general, it would be expected that the degree of habituation will depend on a number of factors like the signals= frequencies, source level, wave form and predictability as well as on the behaviour of the porpoises, but very little is known about this. The experiment presented here cannot provide answers in this respect, as it is not known *e.g.* how often the individual porpoises in the area covered by the experiment were exposed to the alarm signals. Furthermore, LU-1 is designed to reduce the problem of habituation, by using 8 different signals with signal interval varying randomly between 5 and 30 seconds. There is thus a need to carry out research in order to obtain the necessary information on the habituation of porpoises to different alarm signals, to be able to evaluate what signals will be most efficient in the long term. Such research is at present being conducted at Odense University in cooperation with the Fjord & Beltcentre, Kerteminde, where three porpoises are held in captivity for research purposes.

It is also important to note that extensive use of pingers will create areas, which the porpoises are excluded from using for feeding, migration and other purposes. The effect of this on the porpoise populations will depend on a number of factors like the geographical distribution of pinger use, the effective distance of the pingers as well as on the availability of alternative areas that the porpoises can use, but it will not necessarily be without cost to the porpoise populations. Research on the effective distance of the LU-1 is being conducted by DIFRES as part of the EU-funded project EPIC, using porpoises temporarily held in pound nets. DIFRES has also initiated a study of the potential geographical extent of pinger signal coverage given pinger use is made mandatory in the Danish North Sea gill net fisheries. In addition DIFRES has initiated a study on how local abundance of porpoises varies in relation to, among other things, bottom topography, fishing activities and season. These studies will help providing the basis for assessing the potential effects of extensive pinger use on the affected porpoise populations.

Following the preliminary analysis presented in this paper, more detailed analyses of the data collected will be conducted. These analyses will include whether the pingers have had an effect on the catches of the target species and whether there are any consistent differences between the three groups of nets with respect to factors like the geographical distribution of the effort, bottom topography, soak time and

water currents. With the experimental design employed in this study, especially the double-blind aspect combined with the alternating use of active and dummy pingers from day to day, it is not expected that there will be any significant differences between the three groups that could affect the general conclusion of this paper, *i.e.* that the use of high frequency acoustic alarm signals can significantly reduce the by-catch of harbour porpoises in the Danish North Sea bottom set gill net fishery for cod.

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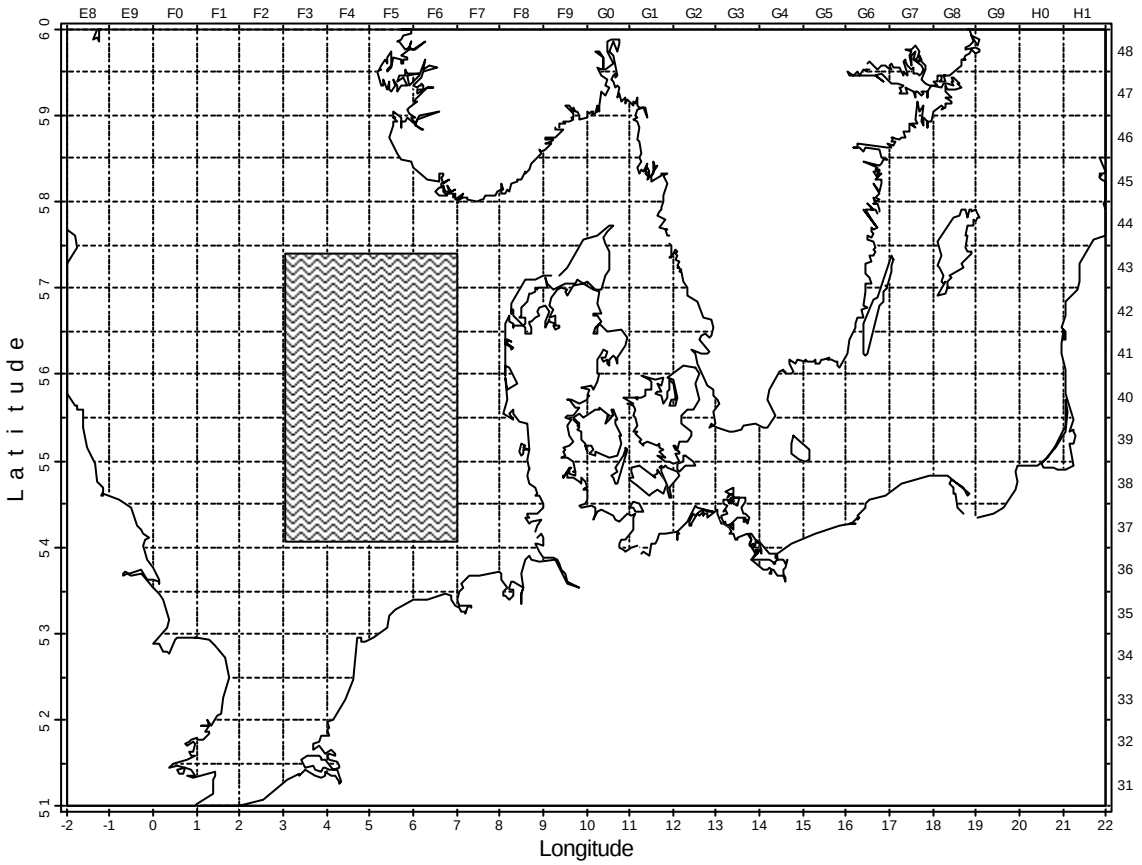

Fig. 1. The North Sea and adjacent waters with approximate area where the pinger experiment was conducted.