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Reduction of harbour porpoise (*Phocoena phocoena*) bycatch by iron-oxide gillnets

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Abstract

Reduction of harbour porpoise bycatch by use of high-density iron-oxide (IO) gillnets was tested in sea trials in the Danish North Sea bottom set gillnet fishery in September–October 2000. The trials were conducted as a controlled experiment with conventional gillnets as the control group. Eight porpoises were caught in the control nets and none in the IO nets, a highly significant reduction ($P < 0.01$). Of the four fish species analysed only catch rates of cod (*Gadus morhua*) were significantly ($P < 0.01$) different between the two net types, with CPUE in the IO nets being ca. 70% of the CPUE in the control nets. Subsequent investigations in seawater tanks revealed that the difference in acoustic target strength of the two net types was not significant and that the nets behaved similarly under various water flow conditions. Based on laboratory tests of twine samples and analyses of catch composition we conclude that it is the mechanical properties of the IO nets, primarily the measured increase in stiffness, that are the main reasons for the differences in catch rates for cod and for porpoises between IO and conventional nets.

Keywords: Acoustic detectability; Bycatch reduction; Echo-location; High-density gillnets; *Phocoena phocoena*; Target strength

1. Introduction

The documentation of high bycatches of small odontocete cetaceans in various gillnet fisheries in the last two decades has led to the development of different types of acoustic alarms (pingers) whose function is to deter animals from nets, thereby reducing bycatch. A number of trials in commercial fisheries have shown that pingers can indeed reduce bycatch considerably (Kraus et al., 1997; Larsen, 1999; Gearin et al., 2000; IWC, 2000; Barlow and Cameron, 2003). However, pingers are active electronic devices, and as such they have a number of disadvantages, including the need for a continuous source of energy and sensitivity to physical impacts. In addition, concern has been expressed about the effects of widespread pinger deployment on target as well as non-target species and potential habituation by cetaceans to the alarm signals (IWC, 2000; Cox et al., 2001). Despite this, large sums have gone into developing and testing pingers, and pingers are now routinely used in a number of fisheries, e.g. in the California drift gillnet fishery and in bottom set gillnet fisheries along the US east coast and in the North Sea (Rossman, 2000; Larsen et al., 2002; Barlow and Cameron, 2003).

Comparatively little effort has been invested in modifying the acoustic properties of conventional nets, to increase their detectability to echo-locating odontocetes. A number of trials were conducted in the 1980s, but they were largely unsuccessful. Either they failed to take the acoustic capabilities of the odontocetes in question into account or enhancement of acoustic detectability had severe side effects, namely reduced catches of the fish target species (Perrin et al., 1994). Increased acoustic detectability has a number of advantages relative to pingers, of which the most important are: (a) habituation is irrelevant; (b) no noise pollution; and (c) no need for an energy source. However, reducing bycatch by increasing the detectability of nets rests heavily on the unproven assumption that odontocetes are entangled because they fail to detect the nets. There can be several possible reasons for an animal failing to detect nets: (i) the animals do not use their sonar to scan for obstacles sufficiently often (or fail to pay attention, even though emitting sonar signals); (ii) animals orient themselves so the net is out of the sound beam (e.g. when bottom feeding vertically) and drift

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sideways into the net; (iii) echoes from the nets are masked by echoes from free swimming or entangled prey in and around the net; or (iv) the net itself is not detectable by the odontocetes at a sufficiently large distance to avoid entanglement. In the two former cases enhancing the detectability alone will not reduce bycatch whereas it could have a beneficial effect in the two latter situations. It is also possible that porpoises are well aware of the nets but do not perceive them as a hazard, in which case increasing detectability of the nets may not reduce bycatch. Studies of detection distances for porpoises and delphinids suggest that they are capable of detecting regular gillnetting (Au, 1994; Kastelein et al., 2000; Villadsgaard et al., 2007), although the detection distance can be quite short, particularly for porpoises, depending on factors such as ambient noise level and angle of incidence, as well as the net itself and attached material (floats and lead-lines). If odontocetes are entangled because they don't perceive the nets as a hazard it could be because the echo from the nets is not sufficiently strong, in which case enhancing the detectability again could reduce bycatch. It seems from the above that there are good reasons to develop and test nets with increased acoustic reflectivity, and that controlled experiments with such nets could help in the choice between the competing theories on why odontocetes become entangled in gillnets.

In the late 1990s a private manufacturer developed a high-density monofilament, where a metal compound is added as filler in the polymer to increase the acoustic reflectivity and thus the detectability for echo-locating odontocetes. Nets made from such monofilaments were tested in the Bay of Fundy, Canada, in 1998 and 2000 showing reduction in bycatches of harbour porpoise (*Phocoena phocoena*) when compared to control nets. The sea trials also demonstrated unaltered catches of four primary target species. These results were ascribed to different target strengths between the acoustically modified monofilaments and the control nets of standard monofilament (Trippel et al., 2003). However, Cox and Read (2004) reported that the effect was more likely caused by a difference in stiffness of the nets, therefore the mechanism of bycatch reduction in this experiment is not clear.

In the North Sea, the documentation of high bycatches of harbour porpoises in the Danish bottom-set gillnet fisheries (Vinther, 1999; Vinther and Larsen, 2004) led to the formation of the Danish action plan to reduce bycatches of porpoises in the North Sea (Ministry of Environment and Energy, 1998). The action plan recommends pingers as one of the principal mitigations measures, but also recommends that alternative measures be investigated. The high-density gillnets described above appeared to be an interesting alternative to pingers, and a trial was conducted in the commercial fishery for cod during the autumn of 2000. The objective of the trial was to determine if the high-density nets had a lower bycatch of porpoises than the conventional nets used in this fishery. Following this trial the mechanism of reduction of bycatch was further explored during the autumn of 2001 by observing the nets under controlled conditions in a flume tank, and by measuring the acoustic target strength of the nets. The results of the sea trial as well as the subsequent studies are presented here.

2. Materials and methods

2.1. Sea trials

The sea trial was designed as a controlled experiment to compare conventional gillnets with the IO gillnets. To simplify interpretation of results, the IO nets were to be manufactured to the same specifications as the control nets regarding twine size, stiffness, colour, and mesh size. The only expected differences between the nets would be in acoustic reflectivity and in specific gravity. The higher specific gravity was attained by the addition of 20% IO to the polymer from which the net twines were made. The difference in specific gravity was to be compensated by an equivalent increase in the number of floats attached to the IO nets. However, when the IO nets arrived from the manufacturer they differed also from the control nets in colour and in stiffness/flexibility. It was decided to continue with the trials despite knowing that the interpretation of the results would be compromised.

The specifications of the two types of nets used in the trials are given in Table 1. As a measure of twine stiffness we used the E-module, an international standard for stiffness. In this case we used the E-module for longitudinal stiffness (E-alpha), calculated from the relationship between elongation and applied force. This parameter proved to be substantially different between the two net types as seen in Table 1.

The fishing gear used in the trials consisted of strings (each containing ca. 50 individual gillnets of 60 m length tied together) of either control or IO nets. The design required that comparative hauls included approximately equal numbers of control and IO nets fished within a restricted area in time and space in order to minimize as far as practically possible the natural variation in species availability between hauls.

A commercial fishing vessel typical of the Danish North Sea gillnet fleet was chartered to conduct the experimental fishing. The RI324 ("Ingrid Frich" of Hvide Sande), a 45.39 GRT vessel, was used for all sea trials to eliminate between-vessel variation in the experiment. An independent observer was on board the vessel for the duration of the experiment. The principal tasks of the observer were collection of information on gear type, fishing effort and bycatch of cetaceans. In addition the observer measured total weight and size distributions by species for each net string. This was done for all catches including discards.

Table 1
Specifications for the two types of nets used in the trials

	Control nets	IO nets
Twine size	0.59 mm	0.58 mm
Float distance	2.46 m	2.16 m
Hanging ratio	0.4	0.4
Twine colour	Silvery green	Reddish brown
E-module	784 MPa	2617 MPa
Mesh size	156 mm	156 mm
Acoustic reflectivity[a]	–	+13 dB relative to control nets
Specific gravity[a]	–	+11% relative to control nets

[a] According to manufacturer.