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Design of an Interactive Acoustic Deterrent to prevent by-catch of cetaceans in pelagic trawl fisheries

by
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Abstract

Incidental catches of cetaceans have been reported in several EU pelagic trawl fisheries and are felt to have a significant impact on cetacean populations. Dolphins have been observed deliberately entering trawls to feed, generally exiting the trawl without being caught. However, entrapment can occur and when it does it can effect many animals at once. Efforts have been made to eradicate the problem by adapting passive acoustic deterrents ("Pingers"), originally developed for use on static gears, but with only limited success due largely to the acoustic noise generated by the vessels and gear used in the fisheries as well as the large size of pelagic trawls. As part of research under an EU funded project, a more intelligent acoustic deterrent system has been designed as a simpler solution to the problem of cetacean by-catch in pelagic fisheries. The interactive unit developed has the benefit of being silent until the detection of echo-location activity from dolphins. When this is detected the unit is triggered and instantaneously outputs a sound based on the wide band signals, which have been shown to be very effective at displacing harbour porpoises in the vicinity of gillnets. This serves two purposes, firstly to mask the echolocation returns to the animal, thus preventing foraging, and secondly warn off dolphins thus preventing them entering the trawl to begin with. Studies have been carried out into associated trawl noise, and as a consequence of these preliminary experiments, the unit has been developed to cope with the many noise sources present within a trawl net. The interactive unit has to apply advanced recognition algorithms to the signals received to discriminate between background noise / boat sonar activity and true echo-location activity from dolphins before firing. Initial tests to prove the units ability to distinguish echo location activity from noise have been conducted on captive animals in the dolphinarium, at Kolmarden Wild Animal Park, Sweden. Full interactive experiments with wild dolphins in the Shannon Estuary are planned, followed by extensive trials onboard commercial fishing vessels during the albacore tuna fishing season in late summer.

Introduction

Annual strandings of large numbers of dead dolphins have been noted during winter months on French Atlantic and English Channel coasts since the late 1980s (Collet and Mison 1996). Forensic pathology suggests that a large proportion of these animals have died in fishing operations, and pelagic trawlers have been implicated in many cases (Kuiken, Simpson et al. 1994), (Bennett, Jepson et al. 2000).

Whereas much effort has been put into devising methods of minimising cetacean by-catch in gillnet fisheries, notably harbour porpoises in bottom set nets, there has been very little published work so far on minimising cetacean by-catch in pelagic trawl fisheries.

Several attempts have been made in European pelagic trawl fleets to minimise cetacean by-catch. De Haan, et al., (1998) describe preliminary work where the reactions of captive animals to excluder devices and acoustic signals were studied, and where a prototype excluder panel was designed. Northridge (2002) reported on ongoing rigid grid trials in the UK bass pair trawl fishery, where the effectiveness of the device remains to be ascertained. Ongoing work in the Dutch fleet operating in Mauritania has yet to be published but involves both acoustic deterrents and exclusion devices (de Haan, pers comm.).

In the pair pelagic Albacore tuna fishery, which is prosecuted by French and Irish vessels and there has been recorded evidence of by-catch, acoustic methods are considered one of the few realistic mitigation measures. This is because the target species and commercial by-catch species are relatively similar in size to associated cetacean by-catch species. Thus systems based on size selection such as grids or specialised net panels are potentially much more difficult to utilise in this particular fishery.

Commissioned by BIM, a prototype pelagic acoustic deterrent (AQ528) was developed by Aquatech Subsea Ltd and tested onboard Irish commercial tuna trawlers in 2002, 2003 and 2004. In order to prevent habituation to the device and save on battery power, this prototype unit comprised a control unit in the wheelhouse of the vessel which communicated via a "through" water acoustic link to an underwater pod generating aversive broadband signals (Figure 1). Table 1 summarise the results from these trials.

Table 1 Summary of observed cetacean by-catch from hauls with and without the prototype AQ528 pinger 2002-2004

	TOTAL NO OF OBSERVED HAULS	NO OF HAULS WITH AQ528 PINGER	CETACEAN BY-CATCH	NO. OF HAULS WITH BY-CATCH
2002	*Present*	33	2	1
	Absent	79	14	4
2003	*Present*	18	0	0
	Absent	37	1	1
2004	*Present*	16	2	1
	Absent	20	5	1
TOTAL	*Present*	67	4	2
	Absent	136	20	6

Relatively low levels of cetacean by-catch occurrence make it difficult to assess the success of the AQ524 system. The results are by no means definitive, but suggest this device provided a technically feasible strategy. Acoustic testing of this device indicate a source level of 165 dB re 1 μPa at 1m at the transducer resonance. This design value is some 20 dB higher than the 145 dB SL of the AQUAmark200 gillnet deterrent devices to take account the noisier environment these devices were designed to work in with associated gear and vessel noise. However, it became clear, during the course of the sea trials, that the set-up requiring manual activation was impractical from a commercial perspective.

Thus the option of automatic activation was deemed worthy of investigation and under the EU funded NECESSITY project, BIM sub-contracted Aquatech Subsea Ltd subsequently, to develop a device that would automatically respond to the presence of cetaceans in pelagic trawls. The new Pelagic Trawl Interactive Pinger being developed emits a wide band deterrent signal in response to echo locating animals. The system distinguishes cetacean noises from other acoustic emissions associated with fishing gear or fish finding equipment by recording and analysing click interval and click length. The recording feature of the new system will also assist in assessing the effectiveness of the device in pelagic trawls.

Development of the Interactive deterrent device

Development of the Interactive Device began in April 2004. It was recognised at an early stage that two basic parameters needed to be established before construction of the device could begin. These were:

- Frequencies of echo location clicks in Dolphins / other cetaceans to be included in design

- Ability to recognise click trains as click trains and not random noise

Frequencies of Clicks

The first of these two points is easy to determine. Dolphins principally use echo location clicks in the region of 2kHz up to 150kHz. This can be narrowed down to a more general band of interest, being 30kHz up to 150kHz,so the interactive pinger must detect clicks in this range.

Click Recognition

An integral part of the interactive pinger will be that of intelligence to recognise click trains over noise. The following parameters loosely govern click trains in most circumstances.

- The duration of the clicks will be anything from 100μs up to 500μs

- The inter-click interval can be from 2ms up to 250ms (where clicks make up a train)

- SPL of clicks range from 150dB up to 230dB re 1μPa @ 1m, but are directional

It was also established when designing the interactive pinger that the ability to mask any noise sources is fundamental to the correct operation of the unit. Taking cognisance of these factors, the first phase of development involved extensive underwater recordings of the background noise associated with tuna and mackerel pelagic nets classified as "specific trawl noise, as well as general noise generated by the vessel such as fish finding equipment and sonar fitted to pelagic trawlers. Both standard gillnet pingers (AQUAmark 200) and the original prototype device (AQ524) developed were also tested to establish firstly whether the listening system used was receiving high frequency noises, and secondly to establish if their respective signals could be heard above the gear and vessel noise. This first trial was carried out with two 24m/1000hp pelagic trawlers based in the south west of Ireland in June 2004, which were representative of Irish vessels that participate in typical Irish pelagic fisheries.

The noise sources were recorded using a purpose built listening system contained in an AQ524 pinger housing (Figure 2) mounted on the trawl at various locations. The noises recorded were subsequently analysed with a view to assessing the feasibility of designing an interactive device capable of working in such a noisy environment. The higher frequency range (i.e. above 60kHz), is the area the device is most likely to be listening for cetacean clicks, but the signal levels were found to be only 14dB down on the lower frequency response, so it can be concluded that no high frequency noise sources greater than 94dB occurred. This is based on background noise levels plus the 14dB's difference in the response at higher frequencies.

The lower frequency noise sources (primarily the boat's sonar) had a computed source level of 141dB. Estimating the separation of the boat to the listening unit, the source level of the sonar at the source was computed. This distance was estimated to be 70m, as the boats were approximately 100m apart, and the listening unit was on the net approximately 50m behind the boat. The signal loss at 28kHz at this range is 29dB, which gives the source of the sonar to be 170dB. This level is in the expected region for boats sonar, and from this the response of the listening system was reasonably well estimated and thus could be used as the basis for design of the in built listening system for the interactive device.

The signals found during the trials that could not be dealt with using filtering, as they were within the range of typical cetacean clicks, were the net sounder operating at 50kHz, and the harmonics of the sonar. These noises must be filtered out by intelligence built into the interactive pinger software, as they would interfere directly with any click detection. In conclusion, the trial was deemed a success and the data collected formed the basis of designing the new device

Verification Trials

Following the background noise work, a prototype of the interactive unit was constructed and presented at a workshop held in Boulgne-sur-mer in February 2005.

At this stage further verification of the unit was required and thus trials were carried out at a dolphinarium at the Kolmarden wild animal park in Sweden with bottlenose dolphins (*Tersiops truncates)* in March 2005 (Figure 3).

This trial aimed to check that the interactive unit would respond correctly to the echolocation of cetaceans, and to gather extensive data on click train activity by the dolphins. It was not necessary to deploy a deterrent signal during the trial as data analysis software displayed the signal deployment threshold i.e. the point at which a deterrent signal would have been deployed without actually firing the device. The instrumentation used for the trials consisted of the AQ636 interactive pinger that was under test, as well as a hydrophone and sound recorder operating at a sample rate of 312500Hz. Using the two together the sensitivity of the receiver was roughly computed as well as determining whether the Interactive unit had any reception errors.

The results showed conclusively that the unit logged clicks reliably. Extensive data on click trains were also gathered, and although these may have been available via other sources, statistics such as click length at the outset were thought to be unique to this system, so testing of it was essential. The data recorded was found to concur with the findings of other studies' of click trains.

Initial Field Testing

The next phase in the development of the interactive system involved field tests in the Shannon Estuary in Ireland with wild bottlenose dolphins completed in July 2005. These trials were undertaken by BIM, Galway and Mayo Institute of Technology (GMIT) and the Irish Whale and Dolphin Group (IWDG), with technical backup provided by Aquatec Subsea.

Using two interactive and two of the previous AQ524 model continuous pelagic trawl pingers, it was planned to test the response of dolphins to these devices using fixed arrays and boat based sampling. Both acoustic and visual methods (observers) were used to assess response. One such method of acoustically monitoring small cetaceans is the T-POD. This tool is now becoming widely used to monitor offshore windfarm sites, and has recently been used to detect patterns of habitat use and to complement visual survey methods. In order to provide non-biased results, the pingers were randomly set to on or off mode with observers unaware of the settings. Temporal and spatial replicates were carried out in order to provide the most effective experimental design. A risk assessment was built into this trial, which consisted of objective criteria to assess whether the impact on dolphins during the trials should warranty cancellation.

Preliminary indications from these trials confirmed that the deterrent noises produced by the devices were correct in that when placed into the water with dolphins present, the animals immediately headed away at high speed indicating a negative response to the sound of the pinger. This response was observed in subsequent replicate experiments. Several technical problems, however, were encountered with the design of the interactive device particularly in respect of the saltwater switch on the unit, which plugs into the terminal of the base of the pinger as well as several bugs in the software when the device did not record it had activated. These difficulties are currently being addressed before further testing onboard commercial trawlers during the 2005 Albacore tuna season in combination with T-Pods. The intelligent features of the new device will be used extensively during these trials to analyse deterrent signal deployments and recordings of dolphins in relation to the presence or absence of cetacean by-catch in the landings. These trials will also be used to test the effectiveness of the unit under noisy conditions and also importantly that the false triggering rate is kept to a minimum. Depending on the results, the interactive devices may then be deployed in the mackerel fisheries and later in the year in the bass fisheries in the English Channel.

A follow up study has also been preliminarily planned with common dolphins (*Delphinus delphis*), which are the principal cetacean by-catch species from the Irish pelagic tuna fishery. Pods of these dolphins frequently occur in the Galway Bay area, off the Clare coast in the West of Ireland in August and September each year and also off the south coast of Ireland in January-March. It is planned to carry out a boat-based exercise similar to the Shannon trial, to assess the response of the common dolphins to the interactive device.

Conclusions

- The work carried out to date has indicated that modified acoustic deterrent devices are potentially a means to reduce cetacean by-catch in certain pelagic fisheries, where the target species and commercial by-catch species are relatively similar in size to associated cetacean by-catch species.

- Devices must be loud enough to be heard by animals over the background noise of the vessel and fishing gear.

- The interactive approach is technically a much more desirable option than a continuous device in terms of extended battery life, reduced chances of habituation by animals and reduced noise pollution in the marine environment. The interactive device does require extensive testing in a commercial fishing environment.

- The interactive device must have in built intelligence to recognise click trains from cetaceans over background noise from vessels and fishing gear.

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Figure 1a Remotely controlled acoustic deterrent   Figure 1b - Acoustic through-water link

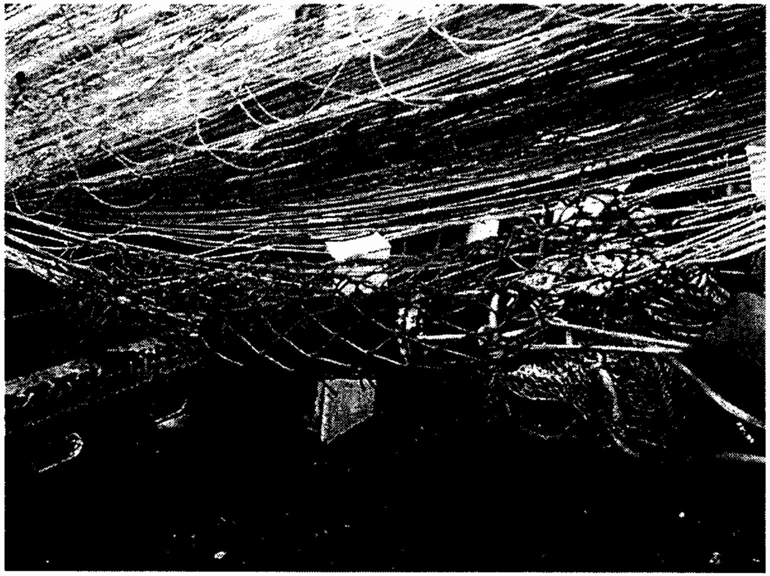

Figure 2 Listening Device mounted on a pelagic trawl

Figure 3 Interactive Device being deployed during the trials in Kolmarden