Seafish Technology Implementation Department

Sea Fish Industry Authority[1]
Chelonia Ltd
Cornish Fish Producer's Organisation
Sea Mammal Research Unit

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Trial of acoustic deterrents ('porpoise pingers') for prevention of porpoise (*Phocoena phocoena)* bycatch.

Phase 2 and 3 Endurance and Tangle net Trial

Summary
This study details the practicalities of attachment, deployment and testing of acoustic deterrents (porpoise pingers) within the Celtic sea gill net fishery. The endurance trial was carried out on commercial fishing trips from Newlyn (Cornwall) over the course of one year using four of the commercially available models of pingers. This study concentrates on the deployment characteristics of the currently available models and includes results of Flume tank testing, deployment data an economic appraisal, and feedback given to manufacturers. Fishermen's perspectives on pinger design and operation are also discussed.

Keywords: porpoise pingers, acoustic deterrents, gill net, tangle net, cetacean bycatch.

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Acknowledgments

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Dr Andy Hough of Moody Ltd investigated the feasibility of an accreditation scheme and this work is described in Section 8 and Appendix 1. John Wood of Ruthern Instruments bench tested the power consumption of the pingers.

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1. Introduction

DEFRA (2003) suggested that certain static gear fisheries should use active acoustic deterrents ('porpoise pingers') to deter harbour porpoise bycatch. Up to that point in time there had only been experimental deployment of pingers in the Cornish static net fishery (SMRU, UCC et al. 2001). It was clear that, although deterrence was shown in that study and in North America (Kraus, Read et al. 1995), there remained some serious technical weaknesses in the design of pingers with respect to their use in the Cornwall fishery.

Developments had taken place in pinger design in American and Danish fisheries following the introduction of legislation in these nations (American static net fisheries introduced pingers in 1997 and Danish wreck netters in 2000). In the Mediterranean, pingers were introduced in nets for bluefin tuna (*Thunnus thynnus*) to deter striped dolphins (*Stenella coeruleoalba*).

After the commencement of this study, in 2004 the European Union introduced legislation which will require the fitting of pingers to static nets on vessels of 12m or more in length (Council Regulation (EC) No 812/2004) in Western Approaches and Baltic and North Sea waters, commencing in June 2005.

Cornish vessels use static nets in the Western Approaches. There are approximately 15 vessels of 12 to 25m length and 40 of less than 12m length using static nets operating from Cornish Ports. Gill nets are used for catching hake on a year round basis and tangle nets to catch monkfish, turbot and ray seasonally; from approximately March until September. Thus it was imperative to examine whether pingers could function in this fishery and to improve the designs if required. Operating conditions in these fisheries can be highly demanding, with gear being shot at speeds of up to 7 knots (3.6 ms^{-1}).

2. Objectives

The objectives of the Cornish FIFG project are as follows;

1. To carry out flume tank trials to investigate and minimise negative impact of pinger attachment on nets.

2. Verify the modifications carried out by manufacturers following the first deployment trial (Sea Fish Industry Authority, Cornish Fish Producers' Organisation et al. 2003), which achieved improved endurance for the pingers.

3. To deploy the pingers continuously in commercial conditions for a period of one year.

4. To carry out deployment trials on tangle nets.

5. To devise a method for field-testing pingers to ensure continuing operation.

6. To carry out an economic appraisal of pinger use.

7. Review pinger implementation schemes and results from other parts of the world.

8. To examine the feasibility of devising a pinger accreditation scheme.

3. Project plan

This work was planned to be divided in to 3 phases:

Phase 1: Deployment trial of acoustic deterrents (porpoise pingers) on hake gill net fisheries. This trial consisted of a single deployment of 4 pinger models made by the manufacturers discussed in this document (Sea Fish Industry Authority, Cornish Fish Producers' Organisation et al. 2003). It revealed that in their current form 3 of the 4 models tested would not function satisfactorily in this fishery, and the three manufacturers agreed to make improvements designed to make them more suitable for the fishery. Modelling was also carried out in order to examine the effects of pinger malfunction on deterrence.

Phase 2: Endurance trial of acoustic deterrents in hake gill net fisheries.

Phase 3: Deployment trial of acoustic deterrents in tangle net fisheries.

This report summarises work carried out in the 3 phases and discusses possible alternatives and further work aimed at developing the means to introduce pingers into this fishery.

4. Method

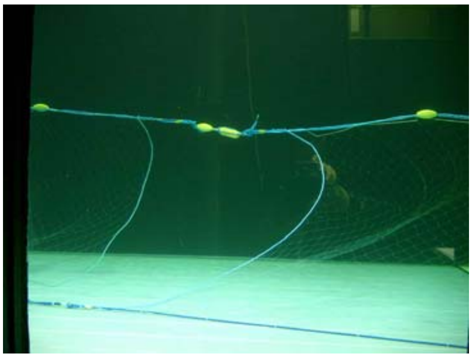
Flume tank and sea trials on 4 types of pinger were carried out in the Seafish flume tank in Hull and FV Ben Loyal from Newlyn. The pingers were also acoustically tested at different stages and logs kept of their function and interaction with the nets used. In addition there was a deployment trial of dummy Fumunda pingers (floaters and standard see below) on a NE coast tangle net fishery during December 2004 and a further tangle net trial on the Ben Loyal during July/August 2005. The chronology is described in Table 1.

4.1 Flume tank trials

Flume tank observations were used to assess the best method for attachment and position in relation to the nets floatation and to assess compatibility with the gill nets being used during the trial. The Seafish flume tank was used to carry out simulations of the effect of pingers on the static nets. It should be noted that static nets do not perform well in the flume tank; the tank is designed for testing model trawls so observations can only be of a general nature.

The nets used were of half the height of a normal net, allowed to stretch diagonally across the tank with a join in the middle of the net where the pinger would be located. Headline height was measured with and without pingers, using the tank's measuring system; it was found that this was not an exactly reproducible measurement, so heights were referred to controls without pingers frequently during the experiments. The comparisons were made in still water and at $0.5ms^{-1}$ (1knot).

Pingers were also tested on tangle gear, during July 2005, using several different methods of attachment. Due to the weight of most pingers in water and the lack of floatation used on tangle gear, pingers were attached to the leadline of the net between the joins to try and minimise the impact on the gear.



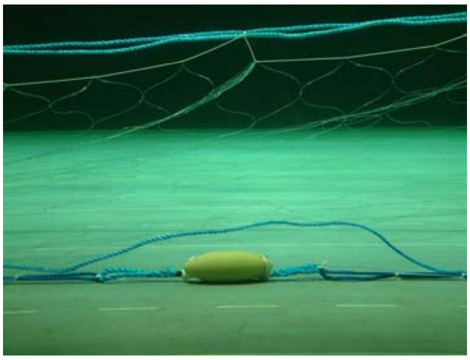


Figure 1 Pingers in flume tank; left AIRMAR Pinger attached next to a float, right AQUAmark pinger attached to tangle net leadline.

Table 1 Chronology of field work

Month	Activity
Phase 1	
Sep-Oct 03	Deployment trial. Actions required to improve pingers discussed with manufacturers. Fully described in Sea Fish Industry Authority, Cornish Fish Producers' Organisation et al. (2003)
Dec 03	Flume tank trials; tests for flotation
April 04	Pre trial acoustic testing to assess functioning and source levels Deployment trial; pingers placed on gear and removed on the same trip. They were tested acoustically post this first trip. This was carried out in order to ensure that modifications made since the phase 1deployment trial enable the pingers to function satisfactorily after 1 trip (trip 1).
Phase 2	
May 04	Start of endurance trial, pingers deployed on gear and Skipper briefed to keep records of fishing effort and pinger function over the following two unaccompanied trips, trips 3 and 4.
June 04	Monitoring trip (trip 5); all pingers tested on gear by observer using a bat detector or by hearing as appropriate. Observations on handling of gear with pingers made.
Jun-August 04	Three unaccompanied trips (with pingers deployed) Trips 6, 7 and 8.
August 04	Monitoring trip (Trip 9) all pingers tested onboard by observer using a bat detector or hearing as appropriate.
Sept 04	Deployment of control pingers on moorings in shallow water
August – Dec 04	Four unaccompanied trips (Trips 10, 11, 12 and 13) with pingers deployed; Skipper keeps fishing effort records and observes handling characteristics.
Dec 04	Monitoring trip (trip 14) all pingers tested onboard by observer using a bat detector or hearing as appropriate and then removed for testing ashore
March 05	Accompanied trip (Trip 15) to redeploy functioning pingers
April-June 05	Eight further unaccompanied trips (Trips 16-23); Skipper keeps records as above
May – June 05	Some pingers removed from the vessel as gill nets are replaced with tangle gear
July 05	Accompanied trip to remove and test remaining pingers.
Sept. 05	Recovery and testing of control pingers
Phase 3	
Dec 04	Test of dummy Fumunda pingers on Yorkshire coast tangle nets
August 05	New pingers (5 of each type; Fumunda, AIRMAR, and AQUAmark) deployed on Cornish tangle gear, (Trips 25-27) monitored by the Skipper and removed at the end of the month.

4.2 Gill net deployment and endurance trials

These commenced in April 2004 with a deployment trial in which the pingers were placed on the gear for one trip, removed and checked to verify modifications carried out by manufacturers. In May 2004 the pingers were redeployed on the vessel and left, with the Skipper commissioned to log information. The Skipper was provided with a pinger log sheet to record the number of shoot/haul cycles completed during the unaccompanied trips, and was asked to make comments as to the performance of the different makes of pinger. The pingers were monitored on the trips as described in Table 1 and removed in December 04 for onshore testing. Three manufacturers' pingers were redeployed during March 2005 (Savewave pingers being discontinued at the six month stage). All pingers were then removed from gill nets for final acoustic tank testing in July 05.

Table 2 Total number of Shoot/Haul cycles during the 15months of the trial.

Make	April- December 2004	March- July 2005	Total Number of Shoot/Haul Cycles
Fumunda	2280	808	3088
AIRMAR	2332	528	2860
AQUAmark	1028	239	1267
Savewave	760		760

Shoot/Haul Cycles = No. of pingers x No. of deployments

Due to the vessel working tangle gear during the summer months a number of gill nets with pingers attached were removed from the vessel during May/June to make space for more tangle gear. The gill nets were worked less intensely during the summer months as effort moves to fishing with tangle nets.

MFV Ben Loyal in Newlyn

Spencer Carter™ hauler

Hauling the gear

Over ending machine

Figure 2 Vessel and deck machinery

4.3 Laboratory testing

Pinger function

Although there had been 2 accompanied monitoring trips during June and August, it had become clear that it was necessary to remove the pingers and take them ashore to ensure consistent testing and diagnose any faults. The pingers were tested, either by bat detector or by hearing, by the observer as they were removed. This was done so that a comparison could be made between the accuracy of onboard testing and the testing done ashore.

During December 2004 the pingers were tested ashore with signal levels recorded using an anechoic tank, broadband hydrophone, and digital oscilloscope sampling at 5MHz. Audible pings were also recorded. Pingers were tested individually and where possible their individual numbers were recorded. Signal levels were recorded using an oscilloscope connected through a hydrophone. Audible volumes were also recorded.

Battery endurance

Laboratory testing of the Fumunda pinger's battery endurance was carried out. This was done by measuring the electricity consumption by the pinger both in standby mode and whilst pinging. This was compared with the charge available from the battery and the life of the battery estimated.

4.4 Manufacturer's feedback

The results of the tests carried out at the 6th month stage of the project was sent to each of the four manufacturers along with any of their pingers which were faulty, in order to allow them to carry out further tests. We requested that they report their findings from any further tests they carried out.

4.5 Tangle net deployment trials

These trials were carried out in order to assess the deployment of pingers on tangle and trammel nets. Whilst net handing systems are similar to gill nets, these nets are much lighter and rely on the headrope for buoyancy; in most cases there are no floats. These nets are sufficiently different from gill nets to warrant separate investigation.

East Yorkshire Coast; tangle net

In order to investigate the deployment of floating pingers developed by Fumunda 20 dummy pingers were deployed (10 of the normal pattern and 10 Floating models) on tangle gear (8 mesh deep 12" mesh using 8mm polypropylene headline and No 4. footrope) off the East Yorkshire coast. Ten pingers of each type on two fleets of nets which were each hauled 10 times. i.e 20×10 = 200 pinger deployments between 14th and 22nd of December.

Cornish (MV Ben Loyal); trammel nets

During July – August 2005 a range of pingers were deployed on trammel nets (2 outer walls at 36" and a single inner wall at 10.5") for 3 trips. Five of each type (AQUAmark, AIRMAR and standard Fumunda) were attached to the footline between the joins of individual nets. Six Fumunda floating pingers were attached to the headrope between the joins of individual nets. The attachment positions were made on the basis of the flume tank observations and judgements concerning the minimisation of entanglements of these relatively heavy pingers. The Skipper was asked to monitor the performance of the pingers during the course of shooting and hauling of these nets.

4.6 Control pinger Trial

During September 04 five of each pinger type were deployed at sea attached to anchors in two (relatively) sheltered locations around St Clements Isle (approx 1.5 miles) from Newlyn in 25 foot of water. The intention to leave the pingers submersed during the course of the trial to test battery longevity. During September 05 the pingers were recovered, though due to the adverse weather conditions during the winter months only one of the two instalments was recovered and tested acoustically. The results are given in Section 5.4.

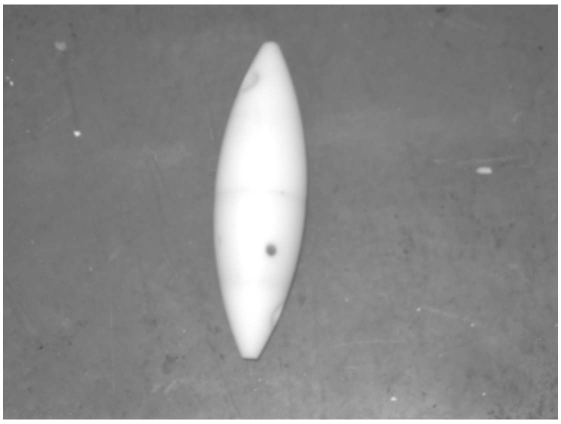
5. Results

The results are described by pinger and gear type. Results from the flume tank observations and gill net trials are described in Sections 5.1 and 5.2 and tangle net deployment trials are described in Section 5.3. Results from the control pinger trial are described in Section 5.4 and field testing and logistics in Section 5.5. In these results 'working' and 'not working' pingers' are those judged to be functioning satisfactorily in the tests. 'Lost pingers' are those whose fate is known while 'Unaccounted' for pingers are those whose fate is unknown; they could have been lost from the gear or with lost gear or simply been removed and mislaid by the crew

5.1 Flume tank and gill net trials

In this section results of the flume tank and gill net endurance trials are describe by pinger type. Included are the acoustic test results at approximately half way (December 2004) and at the end of the trial. Feedback from the manufacturers at the half way stage is described. Developments arising form these trials are described in the Discussion.

5.1.1 Fumunda FMPD 2000



FUMUNDA MARINE PRODUCTS

Pinger Model: *FMPD-2000*
Pinger Range: 100m (approx. 1 pinger on each net)
Type of Signal: Audible 10kHz (every 4 seconds)
Estimated battery life: 1.25 years continuous
Immersion Switch: Optional
Battery: Replaceable lithium cell
Pinger weight in air: 230g

Fumunda Marine Products, 1061 Elkhorn Rd., Watsonville, CA 95076, USA
Tel: +1 831-761-8324 Fax: +1 831-763-1928 Email: contact@fumunda.com
www.fumunda.com

Flume tank trials

Tank trials indicated negligible effects on gill nets from this pinger either in still water or at 0.5ms^{-1}current speed. Two types of Fumunda pingers were flume tank tested with tangle nets. The standard ones, which weigh 63g in water resulted in a decrease of approximately 20% (from 1485 to 1175mm) in headline height at 0.5cm^{-1}current speed. Also a floating version was tested on tangle nets, slightly larger and made from a different material from the smaller version, which very slightly increased the headline height at this current speed.

Attachment: gill nets

At the commencement of the duration trial the pingers were attached to the headline of the gill nets using 1.3mm braided nylon twine (as supplied by the manufacturer). The twine was passed through the attachment holes at the end of the pinger and secured with a locking knot. Each end in turn was then tied, through the lay of the headline rope, adjacent to a net float to aid buoyancy and give the pinger some protection from impact damage. The pinger was tied as tightly as possible to avoid negative impacts on the gear and possible button holing (pingers dropping between the nets meshes). The design of the pinger allowed the pinger to be tied very tightly to the headline and ensured the best attachment of all the four models tested.

Interaction with gear: gill net

When shooting the gear the pingers performed satisfactorily, not causing any problems with button holing or hitching (catching in other nets' meshes). The design of the Fumunda pinger caused little to no problems with handling and comfortably navigated the hauler and over-ending machine. The pinger design, being very similar to a net float, had so little impact on the gear crew noted that at times they did not notice the pingers were on the gear. The pingers continued to operate when stored in the net pounds onboard the vessel although they had immersion switches fitted. This is possibly due to moisture being retained by the nets being enough to activate the pingers. This will obviously have effects on battery life.

Skipper's Comments

The Skipper's comments relating to the Fumunda pingers were "by far the best and least likely to tangle". In conversation with the Skipper he thought they were the only pingers on test completely compatible with the gill nets being used. He was wary about the possible cost implication associated with attaching pingers to his nets though would be happy to use the pingers if costs were reduced to an acceptable level.

Dec 2004; Onboard testing:

50 Fumunda pingers were deployed on gill nets in May 2004. Of the 46 Fumunda pingers removed from the gear in December, 6 were found to be working satisfactorily, whereas 40 pingers when tested gave no signal. Three pingers remained unaccounted for; one pinger had been retained by the Skipper in the wheelhouse.

Dec 2004; Acoustic Tank Testing

Of the 47 pingers retrieved from the Ben Loyal 41 pingers returned no signal when tested. The remaining 6 (including one which had been removed by the Skipper and retained in the wheelhouse) were found to be working adequately (Table 3).

Table 3 Acoustic testing results from Fumunda pingers

Date Removed	Numbers of pingers				
	Accounted for	Working	Not working	Lost	Unaccounted for
Dec 04	47	6	41	0	3
May/June 05	25	21	4		
July 05	21	14	7		
Tot. May-Jul 05	46	35	11	0	4

Battery levels were tested and were found to be low in all the non functioning pingers. When tested with a new battery, the pingers functioned satisfactorily.

For the continuation of the endurance trial new batteries were inserted into all (47) pingers and 3 new pingers added to bring the complement back up to the original 50 deployed.

Reattachment March 05

The 50 Fumunda pingers were reattached to gill nets during an accompanied trip in March 2005. Eight further unaccompanied and one accompanied trips were carried out between March and June 05. During May/June 05, 25 of the gill nets with Fumunda pingers attached were removed from the vessel to create space for tangle nets. These 25 pingers were removed when the nets were transported to the store and took no further part in the trial.

Final Testing July 05

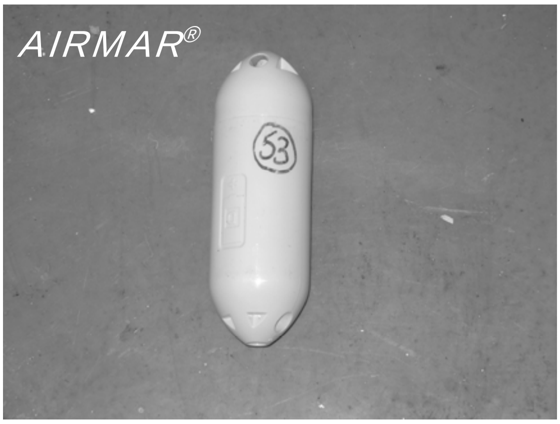
The vessel was again accompanied by a Seafish observer, the objective of this trip was to remove, for onshore testing, all remaining pingers attached to gill nets. A further 21 Fumunda pingers were removed during this trip. Pingers were once again tested ashore and the results are shown in Table 3.

Of the 50 pingers deployed during March 05, 35 of the pingers were operative, 11 Fumunda pingers returned no signal. Of these 11 pingers, 2 had taken on water and no longer operated, the other 9 worked satisfactorily when tested with a new battery. Of the 53 pingers deployed over the course of the project 7 remain unaccounted for; it is assumed that they were lost with lost gillnets or worked loose from the net.

Manufacturer's feedback

The battery life problems encountered with this model was a result of a signal enhancer incorporated within the pinger, in order to try to increase the pingers audible range, being too heavy a drain on the battery, thus reducing battery life to less than 6 months. This device is to be removed on subsequent models and should increase the life expectancy of the battery (see Section 9.1.1)

5.1.2 AIRMAR Gillnet Pinger



AIRMAR TECHNOLOGY CORPORATION

Pinger Model: *Gillnet Pinger*
Pinger Range: 100m (approx. 1 pinger on each net)
Type of Signal: Audible 10kHz (every 4 seconds)
Estimated battery life: 1 year continuous
Immersion Switch: No
Battery: Replaceable 'D' cell
Pinger weight in air: 400g

AIRMAR Europe, Pilehøj Vænge 8E, 3460 Birkerød, DENMARK
Tel: +45 45 81 04 18 Email: sales@airmareurope.com
AIRMAR Technology Corporation, 35 Meadowbank Drive, Milford, NH 03055, USA
www.airmar.com

Flume Tank observations

Flume tank observations were used to assess the best method for attachment and position in relation to the floatation and to assess compatibility with the gill nets being used during the trial.

The weight of this pinger in water was assessed at 190g. The AIRMAR pingers were the least buoyant tested. When attached to a sample gill net alongside a float the headline height was reduced by 33% (800mm). This reduction in headline height was all but negated when the net was subjected to a current with a velocity of 0.5ms^{-1}.

On tangle nets the AIRMAR pinger caused the net to sink to the bottom of the tank both with and without current. This could be negated by the addition of 2x 80g floats.

Pinger Attachment

At the commencement of the duration trial the pingers were attached to the headline of the gill nets using 1.3mm braided nylon twine. The twine was doubled over, to avoid knot slippage, and passed through the attachment holes a number of times to try and minimise compression of the shell material as seen in Phase 1 one of the trial. The twine was then passed through the hole at the end of the pinger. Each end in turn was then tied, through the lay of the headline rope, adjacent to a net float to aid buoyancy and give the pinger some protection from impact damage. The pinger was tied as tightly as possible to avoid negative impacts on the gear and possible button holing. The design of the AIRMAR pingers with holes for attachment at the tips made attachment to the headline as easy as possible. For comparison with other pingers see discussion.

Interaction with the gear: gill nets

When shooting the gear for the first time the pingers performed satisfactorily, not causing any problems with button holing or hitching, catching in other nets' meshes. When hauling the nets, the pingers, although successfully navigating the hauler, caused slight problems when passing through the over-ending machine. The reason the nets are over-ended is to remove any twists in the net and separate the headline from the leadline (footline). Due to the pingers weight the over-ending machine had difficulty coping with the pinger when there was more than half a turn in the net. This resulted in the crewmember having to reset the machine, thus slowing down the hauling process. The weight of the pingers also meant that it was quite hazardous to the crew member in charge of the over-ending machine, as in order to spread the net evenly around the net pound he would find himself at times standing directly below the machine. With the possibility of being struck as the pinger is "spat" out of the over-ending machine. The Skipper noted on one of the unaccompanied trips that an AIRMAR pinger hit one of the crewmembers whilst he was over-ending.

Skipper's Comments

The Skipper's comments relating to the AIRMAR pingers were that "I can hear them in my bunk, prefer the ones the human ear cannot hear" and "The pingers are too heavy, a crewmember got hit as one came out of the over-ending machine".

In conversation with the Skipper he thought they were too bulky and emphasised the problems encountered by the crew when over-ending.

December 2004: Onboard testing

Fifty AIRMAR gill net pingers were deployed in May 2004. Of the 44 AIRMAR pingers taken off the gear 34 were found to be working satisfactorily, whereas 10 pingers when tested gave no signal. Six pingers remained unaccounted for, this loss could be due to attachment problems, nets being "snagged" on obstructions on the bottom or nets being towed away by trawlers.

December 2004: Acoustic Tank Testing

Of the 44 pingers retrieved from the Ben Loyal 31 pingers returned a satisfactory signal when tested. The remaining 13 pingers did not return a signal when tested. All pingers were then unscrewed so that the batteries and internal workings could be tested.

Table 4 Acoustic testing results from AIRMAR pingers

Date Removed	Numbers of pingers				
	Accounted for	Working	Not working	Lost	Unaccounted for
Dec 04	44	31	13	0	6
May/June 05	12	10	2		
July 05	16	8	8		
Tot. May-Jul 05	28	18	10	0	3

When the batteries of the inoperative pingers were examined it was found that on all 13 batteries the positive terminals had been compressed hence causing a loss of contact. It appeared that this was probably the result of impacts undergone by the pingers whilst being deployed on the net. The 13 inoperative pingers were then tested with a new battery. Seven of the 13 pingers returned a satisfactory signal the remaining 6 returned no signal. On further investigation of the 6 pingers it was found that although the circuitry of these pingers was live the transducer was either disconnected or broken. (These 6 pingers were returned to the manufacturer for further testing.)

Reattachment March 05

The 31 working AIRMAR pingers were reattached during an accompanied trip in March 2005. Batteries were not changed; this is different from the approach taken with the Fumunda pinger. Eight further unaccompanied and one accompanied trips were carried between March and June 05. During May/June 05, 12 gill nets with AIRMAR pingers attached were removed from the vessel to create space for tangle nets. These pingers were removed when the nets were transported to the store and took no further part in the trial.

Final Testing July 05

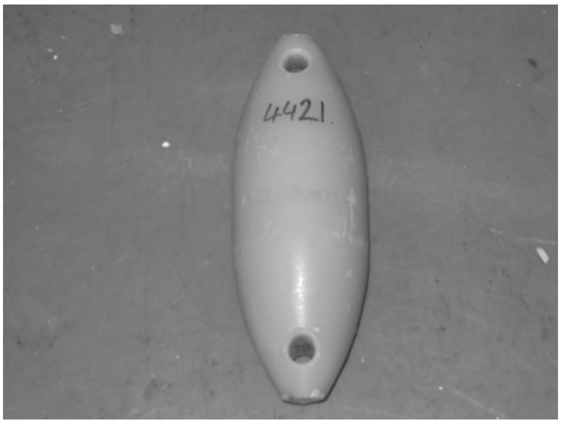
The vessel was again accompanied by a Seafish observer. The objective of this trip was to remove, for onshore testing, all remaining pingers attached to gill nets. A further 16 AIRMAR pingers were removed during this trip.

Pingers were once again tested ashore by using an acoustic tank. The results are shown in Table 4. Of the 31 pingers deployed during March 05, 18 of the pingers were operative when tested, 10 pingers returned no signal. Of these 28 pingers accounted for, on examination, all batteries, including working pingers, had some form of compression to the positive end. Of the 10 pingers which returned no signal 7 produced a satisfactory signal when tested with a new battery the other 3 returned no signal.

Manufacturer's feedback

Efforts have been made to reduce the denting of the battery terminal using some kind of pad. However, difficulties arose because of the differing size of D call batteries from different suppliers. The manufacturer also intends to alter the shape of the pinger to make it easier to attach to the net.

5.1.3 AQUAtec AQUA*mark* 100



AQUATEC GROUP Ltd.

Pinger Model: *AQUAmark 100*
Pinger Range: 200m (approx. 1 pinger every other net)
Type of Signal: Ultrasonic 35-160kHz (5-30sec random)
Estimated battery life: 1-2 years continuous
Immersion Switch: Yes
Battery: Non-replaceable 'D' cell. Return to manufacturer
Pinger weight in air: 410g
Aquatec Group Ltd., High Street, Hartley Wintney, RG27 8NY, UK
Tel: +44(0)1252 843072 Fax: +44(0)1252 843074 www.netpinger.net

Flume tank tests

The weight in water of this pinger was assessed as 140g. On gill nets there was some reduction in headline height in still water, but this effect was all but negated when subjected to a current speed of $0.5ms^{-1}$. On tangle nets the pinger caused the headline to sink both in still water and at $0.5ms^{-1}$. This effect could be negated by one or two 85g floats.

Pinger Attachment

At the commencement of the duration trial the pingers were attached to the headline of the gill nets using 1.3mm braided nylon twine. The twine was doubled over, to avoid knot slippage, and passed through the attachment holes at the end of the pinger. Each end in turn was then tied, through the lay of the headline rope, adjacent to a net float to aid buoyancy and give the pinger some protection from impact damage. The pinger was tied as tightly as possible to avoid negative impacts on the gear and possible button holing. The design of the AQUAmark pinger caused slight problems with this method of attachment as the attachment holes are inset from the ends of the pinger. Potentially the ends of the pingers are vulnerable to hitching on the netting.

Other methods of attachment were tried, and it was thought that it might be possible to attach the pinger at the joints of the net inline with the headline. This method was tried using a tension test to ascertain the level of strain the pinger could withstand. When tested the pinger parted at the attachment point under a strain of 1200kgf. A single length of 8mm polypropylene as used on the headline of gill nets withstood a strain in excess of 7000kgf without parting. To avoid excessive damage to the pingers this method was not employed.

Interaction with the gear: gill nets

When shooting the gear for the first time the pingers performed satisfactorily, not causing any problems with button holing or hitching catching in other nets' meshes. When hauling the nets the pingers, although successfully navigating the hauler, caused slight problems when passing through the over-ending machine. Due to the pinger weight the over-ending machine had difficulty coping with the pinger when the nets were twisted by more than half a turn. This resulted in the crewmember having to reset the machine, thus slowing down the hauling process. The weight of the pingers also meant that it was quite hazardous to the crew member in charge of the over-ending machine, as in order to spread the net evenly around the net pound he would find himself at times standing directly below the machine. This means that there was the possibility of being struck as the pinger if "spat" out of the over-ending machine. The Skipper noted on one of the unaccompanied trips that a pinger of similar weight characteristics hit a crewmember.

Skipper's Comments

The Skipper's comments relating to the AQUAmark pingers were that they were "too heavy". In conversation with the Skipper he thought they were too bulky and reemphasised the problems encountered by the crew when over-ending.

Onboard testing; December 04

Twenty-five pingers were attached at 100m intervals rather than the recommended 200m so that the maximum number of pinger could be tested with the length of nets being used by the vessel. Of the 23 AQUAmark pingers taken off the gear 19 were found to be working satisfactorily, whereas 4 pingers when tested gave no signal. One pinger remained unaccounted for and one pinger had definitely been lost over the side. The pingers were tested as the nets were being boarded using a bat detector.

December 04; Acoustic Tank Testing

Of the 23 pingers retrieved from the Ben Loyal 15 pingers returned a satisfactory signal when tested. Audible volumes were also recorded using a bat detector and signal strength using the Aqua Mark tester. The remaining 8 did not return a signal when tested. The differences between the onboard and shore testing of pingers may be a result of the high levels of background noises onboard the vessel when testing individual pingers using the bat detector.

Table 5 Acoustic testing results from AQUA*mark* pingers

Date Removed	Numbers of pingers				
	Accounted for	Working	Not working	Lost	Unaccounted for
Dec 04	24	15	8	1	1
May/June 05	8	5	3		
July 05	6	4	2		
Tot. May-Jul 05	15	9	5	0	1

Using the AQUAmark tester it was possible to get a reading of the battery levels for the working pingers. Three pingers had a battery reading greater than 80%, 11 had battery readings of between 60-80% and one had a reading of 1-20%. Of the 8 pingers that returned no signal 1 showed signs of corrosion on one end contact, another had rust on one contact and a third had slight chips on one end. The remaining 5 had no visible signs of damage. The faulty pingers were returned to the manufacturer for further testing.

March 05; Reattachment

The 15 working AQUAmark pingers were reattached during an accompanied trip in March 2005. Eight further unaccompanied and one accompanied trips were carried between March and June 05. During May/June 05, 8 gill nets with AQUAmark pingers attached were removed from the vessel to create space for tangle nets. These 8 pingers were removed when the nets were transported to the store and took no further part in the trial.

July 05; Final Testing

The vessel was again accompanied by a Seafish observer the objective of this trip was to remove, for onshore testing, all remaining pingers attached to gill nets. A further 6 AQUAmark pingers were removed during this trip.

Pingers were once again tested ashore using an acoustic tank. The results are shown in Table 5. Of the 15 pingers deployed during March 05, 9 of the pingers were operative when tested, 5 pingers returned no signal and one pinger was unaccounted for.

Manufacturer's feedback

The faults in the 8 pingers returned to this manufacturer were a direct result of the moulding process carried out to make these pingers. These pingers were constructed in two stages, firstly the circuitry is attached to a pre moulded section of the pinger, and then a second moulding process forms the actual shape of the pinger. The problems with the faulty pingers occurred along the joins between the pre and final mould. The manufacturers consider that they have solved this problem by forming the pinger during a single moulding process. Further developments are expected with the use of epoxy instead of polyurethane for the material of the pinger (see Discussion Section 9.1.3).

5.1.4 Savewave Gillnet pinger

SAVEWAVE INTERNATIONAL
Pinger Model: Endurance Saver
Pinger Range: 200m (approx. 1 pinger every other net)
Type of Signal: Ultrasonic 5-160kHz (4-16sec random)
Estimated battery life: 1 year continuous
Immersion Switch: Yes
Battery: Non-replaceable lithium cell. Return to manufacturer
Pinger weight in air: 400g

SaveWave International, P.O. Box 81, NL-2600 AB Delft, The Netherlands
Tel: +31 15 257 8958 Fax: +31 15 262 2875 Email: info@savewave.net www.savewave.net

Flume tank tests

The weight in water of the Savewave (NB these were pingers that had been used on the phase 1 deployment trial) was assessed at 50g.

When attached with or without additional floatation (85g) the pinger caused only a minor difference to the shape of the gill net at 0.5ms^{-1}current velocity. The pinger did not remain upright on the headline as expected, but had a tendency to lie on its side. This may be due to the method of attachment as the pinger was tied as tightly as possible to the headline of the net. A looser method of attachment was tested in phase one of the project but was found to be incompatible with the working operations of the vessel. The effect on floatation of tangle nets was minimal either in still water or with 0.5ms^{-1}of current.

Further investigation by the manufacturers indicated that the polystyrene floats had become saturated with water and this resulted in the pinger having less buoyancy than expected. The manufacturer is taking steps to rectify this fault.

Pinger Attachment

At the commencement of the endurance trial the pingers were attached using a similar method as those described using 1.3mm braided nylon twine.

Interaction with the gear: gill nets

When shooting the gear for the first time the pingers performed satisfactorily, although successfully navigating the hauler, they were noticeably causing the machinery to work slightly harder in order to push them under the third wheel.

By June (Trip 5) of the 20 pingers remaining on the vessel 12 showed signs of having problems with the casing opening and the inner lip being forced out. All of the Savewave pingers had been removed from the vessel partly because they were in poor condition and partly because the nets they were on were removed for repair. To give the pingers the optimum shoot/haul cycles, it was agreed with the Skipper that the 10 best Savewave pingers should be reattached to the gear and monitored during the following trips by the Skipper and reviewed on the next accompanied trip.

Skipper’s Comments

The Skipper’s comments relating to the Savewave pingers were that they were “catching in the gear and don’t go well through the hauler” and were “too big and clumsy”.

In conversation with the Skipper he thought they did not work well with the gear due to their size and shape and thought the smaller float shaped pingers were more suited for the gear they used. The crew also commented that they were causing problems when travelling through the over-ending machine by snagging the net and not allowing the headline and footline to be separated.

Dec 2004; Onboard testing:

Of the 9 Savewave pingers taken off the gear 7 were found to be returning a signal when tested onboard, whereas 2 pingers when tested gave no signal. One pinger remained unaccounted for. The pingers were tested as the nets were being boarded using a bat detector.

Dec 04; Acoustic Tank Testing

Of the 9 pingers retrieved from the Ben Loyal none of the pingers returned a signal when tested, although when tested at sea 7 of the 9 appeared to be working. The difference between the onboard and shore testing of pingers may be a result of the high levels of background noises onboard the vessel when testing individual pingers using the bat detector.

Table 6 Acoustic testing results for SaveWave pinger; December 2004

No.	Working at Sea	Tank test	Notes
403	Yes	Not working	Casing misaligned & apart battery solid
358	Yes	Not working	Casing misaligned battery solid
375	Yes	Not working	Casing misaligned battery solid
397	Yes	Not working	Casing misaligned battery loose
418	Yes	Not working	Casing misaligned & apart battery solid
402	Yes	Not working	Casing misaligned battery loose
350	Yes	Not working	Casing misaligned battery loose
422	No	Not working	Casing misaligned battery loose
349	No	Not working	Casing misaligned & Lipped battery solid

The casing of the pingers were examined, all 9 casings were found to be slightly misaligned, in addition 6 of the 9 pingers had loose fixings inside the casing allowing the battery/electronic inserts to move.

The faulty pingers have been returned to the manufacturer for further testing. The Savewave pingers were discontinued at this point of the trial.

Manufacturer's feedback

No feedback has been received as to the reason behind the faults on the nine pingers returned to this manufacturer. However, feedback has been given by Seafish on a new prototype design being developed by this company.

5.2 Pinger endurance

These are the combined data at the end of the trials of the trials.

Table 7 Pinger totals at the end of 15 months

Total for 15 months

Pinger Type	**Fumunda***	**AIRMAR**	**AQUAmark**	**Savewave****
Total Number Deployed	53	50	25	10
No of pinger rotations	3088	2860	1267	760
Number accounted for	46	41	22	9
Working	35	18	9	0
Not working	2	23	13	9
Lost			1	
Unaccounted for	7	9	2	1
Totals	53	50	25	10

***** Fumunda pingers had their batteries replaced during March 05.
** Savewave pingers discontinued at the six month stage.

The figures above (Table 7) describe the state of each pinger at the end of the endurance trial. However as the sources of faults was different for all the pinger types these figures are not strictly comparable. Although the majority of pingers remained the same over the total period of the trial, the batteries in the Fumunda pingers were replaced before redeployment in March 05 and an additional 3 Fumunda pingers were deployed as a replacement for those unaccounted for at that time.

The faults identified are described below:

Fumunda

Of the 53 pingers used during the course of the gill net trial 44 of the pingers were still operative when tested with a new battery, 2 had taken on water and no longer operate and 7 remain unaccounted for.

AIRMAR

During final testing all batteries were inspected and found to have compressed the positive nipple of the battery including the pingers that were still operative. 18 of the 50 pingers first deployed returned satisfactory signals, 23 returned no signal of which 14 worked when tested with a new battery the remaining 9 did not return a signal due to electronic failure. A further 9 pingers remain unaccounted for.

AQUAmark

Over the course of the endurance trials 25 AQUAmark pingers were deployed. Of the 22 pingers tested at the end of this trial 9 remain operative, 13 inoperative with one loss and 2 unaccounted for. The feedback received from the manufacture of these pingers is that pingers are inoperative due to cracks in the resin allowing water to seep into the electronics. The manufacturer of these pingers has made a number of design changes intended to improve the performance of these pingers, These are discussed at length in Section 9.1.3.

5.3 Tangle net deployment trials

These describe the results of the deployment trials of pingers on tangle and trammel nets deployed of the East Yorkshire and Cornish coasts.

Dec 2004; East Yorkshire Coast tangle nets

The short trial using 10 dummies (no battery or electronics but the right size and weight) of these Fumunda pingers and also 10 of the same model but slightly bigger and designed to float. This trial was carried out off the NE coast of England on an under 10m vessel. The number of nets deployed by the vessel is few compared with the SW boats with the number of pinger cycles (200) much smaller than the gill net trial.

The observations made by the East Yorkshire Skipper indicated no serious problems with entanglements. Problems did occur when the pingers had worked themselves free from the headline a little. They used 50cm (18") of nylon cord to tie them into the headline at each end, but they did not use duck tape to bind to the headrope - which Fumunda has recommended to keep them tight to the headline, so the deployment could be improved. However, there remained a requirement for further trials since the combination of large mesh and pingers which could potentially fall into those meshes in the net pounds is identified as a potential for button holing.

August 05; Cornish coast trammel nets

The trammel nets used in this trial, have 3 sheets of netting rigged together, 2 outer walls with a mesh size of 36" and a single inner wall of 10 ½". The Skipper commented that that when working the pingers on tangle gear they had a greater propensity to drop through the meshes of nets thus causing problems when working the nets on deck and shooting. This problem was highlighted when the nets were being worked from the stern net pound. As these nets are rigged with little or no floatation and the footrope used is kept as thin as possible, these nets normally have few points liable to hitching. The crew monitor the nets and prevent the occasional bunch of net going out by pulling back on the net to ensure the net goes out cleanly. Through the attachment of pingers to this relatively "light" gear, the occurrence of these bunches of net were more common place and more pronounced. If button holing occurs large bunches of net, otherwise unseen whilst shooting, are dragged over the side. Due to the nature of buttonholing it is not possible to sort out the bunch of net by pulling back on the net as is normally done. This will have obvious effects on the efficiency of the nets but also have health and safety issues as large bunches being shot at once is creates a risk of entangling the crew member monitoring the nets with potentially fatal consequences.

The Skipper also commented that the AIRMAR and AQUAmark pingers, due to their size and weight became very noticeable when attached to these nets. Also due to the light rigging of the tangle nets, when travelling through the over ending machine, the pingers tended to be "spat" out of the machine. This was noted to be a more regular occurrence than seen when operating pingers on gill nets. Due too the dynamics of the tangle nets worked (large mesh sizes) button holing was also noted in particular when piles of netting built up on the deck and were then transported aft.

The Skippers commented about these problems with handling and emphasised the health and safety issues of working these pingers on tangle nets.

BIM[2] (work in progress) have been carrying out deployment trials on tangle nets and report high levels of entanglement. They have also been investigating mitigation measures and reference to their report is recommended (it is due to be published at approximately the same time as this one).

5.4 Control pinger Trial

The pingers recovered from moorings near St Clements Isle contained 3 of each pinger type. When tested in an acoustic tank all the 3 AIRMAR pingers were still operating and producing a good signal. The 3 Savewave pingers and 3 Fumunda pingers did not produce a signal and as anticipated due to battery consumption levels. When tested in an acoustic tank 2 of the AQUAmark pingers returned a signal the other did not produce a signal. When tested with the AQUAmark T2 tester the same 2 of the 3 returned a signal with indicated battery levels of 4 (60-80% capacity remaining) and 5 (80-100% capacity remaining). These three pingers will be returned to the manufacturer for further testing.

5.5 Field testing and logistics

This trial highlighted the problems encountered with monitoring and testing of pingers during their deployment at sea. Due to the nature of the Cornish static net fishery large numbers of nets are deployed in harsh conditions. Nets are damaged and replaced on a regular basis and fishing methods alter, in terms of the type of nets used, with seasons. Depending on the individual operating practices of vessels and the levels of catches, some nets carried by the vessel may only spend only a small percentage of time deployed at sea compared with other similar nets. Add to this the damaged caused to nets by catching on the seabed and interaction with trawlers, some nets may only last for one or two hauls whereas others may last for a number of years. These factors cause distinct problems when trying to monitor and test pingers to ensure continuity.

During the trial the most effective method of testing pingers to ensure accurate results, was shore based testing, using an acoustic tank. The results of testing in the tank varied from those recorded during testing at sea, particularly for the high frequency (AQUAmark and SaveWave) types. This was mainly due to the noise onboard and the close proximity of other pingers on the vessel making it difficult to hear individual pings. Testing was done onboard during the hauling process as at this point that the nets are travelling slowly. It required an dedicated individual to monitor the net as it was being hauled and test each pinger as it came aboard either by listening to the pinger in the case of audible pingers or though the use of a bat detector or dedicated acoustic tester in the case of ultrasonic pingers. As the hauling process is the busiest time for all the crew a dedicated person needs to be allocated for this job. As trips generally last for the duration of approximately 6-8 days the person allotted to testing the pingers would have to commit to this period in order to test the pingers on one vessel unless the vessel returned to port to land their fish midway through the trip. This method of monitoring pingers, although labour intensive, does allow the individual testing the pingers to replace faulty pingers were necessary on those nets shot and hauled. Although if not all tiers of net are shot during that particular trip, some pingers, due to the nature of the storage of nets on the vessel, will be inaccessible.

[2] Board Iascaigh Mara; Irish Sea Fisheries Board

Another option for the testing of pingers is when the vessel is in port. As static netters are limited in the time they are able to work by the strength of the tide they generally spend the spring tides in there home port. This would seem to be the most appropriate time to monitor the pingers. The difficulties arise due to the need to remove all the nets from the vessel to provide access to all the pingers. This not only requires someone to test the pingers but also the presence of the Skipper and his crew to remove the nets from the vessel. Due to the numbers of nets worked by any one vessel this process is very time consuming so is not a practice carried out regularly. Space is also an issue as room on the quays in ports is generally at a premium so the facilities may not be available to carry out this work.

The third option would be to attach the pinger when the net is being rigged in the net loft. This would only be realistic for those pingers that had immersion switches as nets will remain in the net loft until they are required, this could possibly be months and in some cases upwards of a year. The advantage of attaching the pingers when the gear is rigged is that the net loft will be a dry and have the facilities to ensure a tight attachment to the net. As pingers will need to be attached initially to nets already on the vessel this option is only feasible for new or replacement nets being set. In the case of battery replacement this will need to be carried out in a dry environment to avoid damage to the internal components in the pinger. As pinger battery life will not necessarily coincide with the life of the net, the pingers requiring a new battery are unlikely to be in the net loft at the correct time.

In terms of devising an ideal method of monitoring and testing of pingers a combination of the three options may prove most successful. Initial deployment would be best carried out at sea as the nets are being hauled. Testing of pingers will need to be done on a regular basis to ensure continuity. This may have elements of shore based and sea based testing. Battery replacement will need to be carried out in a dry environment ashore. This will require the pingers to be removed from the gear and replaced afterwards, both these tasks best done at sea. Attachment of pingers to new and replacement nets will also require monitoring prior to deployment. All these tasks require a dedicated person(s) to act as a pinger "husband" ensuring that pingers are deployed where necessary, faulty pingers replaced and batteries or replacement pingers are available when required. This task, due to the numbers of pingers and vessels involved, will require substantial investment both in terms of time and money.

Identifying pingers

It proved very difficult to keep track of the pingers on the gear because of the changes in gear configuration due to normal fishing practices. This, compounded with not being able to effectively label individual pingers externally (labels almost always wore off) meant that it would be difficult to keep up maintenance schedules.

One manufacturer AQUAtec had installed a coded serial number in the signal emitted when the pinger was started up which would be detected by their bespoke AQUAmark T2 Tester. It would be useful if pingers could be identified easily using internal RFID[3] tags. These have been inserted into two batches of pingers

[3] Radio Frequncy IDentifcation

(AQUAmark and Fumunda) and satisfactory readings have been obtained (ashore) using a hand held detector. To exploit this system fully a bespoke detector could be included in the vessel's net handling gear and a record made of all pingers every time the pingers pass through it. This would yield valuable information on the whereabouts and service life of each individual pinger. However a bespoke detection and record keeping system would have to be designed and financed.

6. Economic Appraisal

The deployment and monitoring of acoustic pingers will have costs associated with it. Compared to other fisheries around the world that use acoustic pingers, this fishery is believed to be unique in terms of the numbers of nets deployed by any one vessel. Depending on the vessel size, their target fishery and time of year, Skippers may work upwards of 400 nets to a maximum of 1200 nets per vessel. The requirement to use pingers on all set nets will incur an associated cost per net depending on the type of pinger used. The table below shows the initial cost, annual replacement costs and the total running costs over a 4 year period for pingers with ranges of 100 and 200 metres.

Table 8 Pinger costs for 200 and 100m range pingers working 400 or 1200 nets; the Cost per pinger is based on the approximate bulk purchase price

	Pinger Costs			
Pinger range	200m		100m	
Nets worked (400/1200)	400	1200	400	1200
Pingers required	200	600	400	1200
Cost per pinger (estimate)	£50.00	£50.00	£40.00	£40.00
Initial cost	**£10,000**	**£30,000**	**£16,000**	**£48,000**
Cost per net	£25.00	£25.00	£40.00	£40.00
Annual net loss rate %	14%	14%	14%	14%
Annual pinger failure rate %	10%	10%	10%	10%
Annual replacement costs	**£2,400**	**£7,200**	**£3,840**	**£11,520**
Cost per net	£6.00	£6.00	£9.60	£9.60
Period before battery depletion (years)	4	4	4	4
Cost on depletion (£) per pinger	50	50	4	4
Total cost on depletion	**£10,000**	**£30,000**	**£1,600**	**£4,800**
Total running cost for 4 years	**£22,400**	**£67,200**	**£21,440**	**£64,320**
Cost per Net	£56.00	£56.00	£53.60	£53.60

The calculation of cost on depletion relates the pingers with a 200m range require replacement after battery depletion (4yrs) and the 100m range pingers only require a replacement battery. Note that the estimates of battery depletion rate are based on the manufacturers' estimates and bench tests; see Section 9.

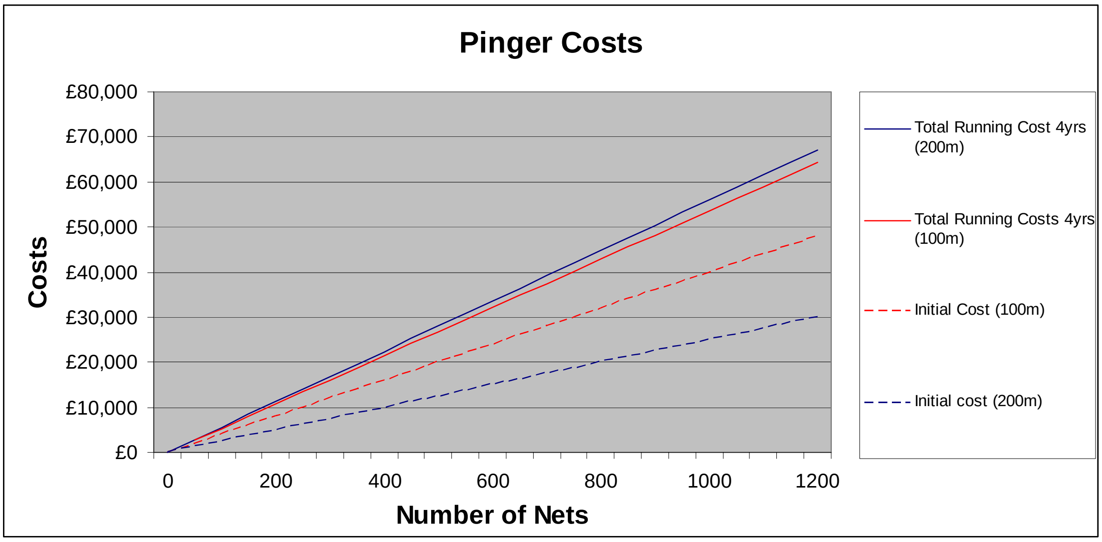


Figure 3 Estimated costs vis number of nets

This graph illustrates the costs associated with working various numbers of nets. For example a vessel working 800 nets during the year will incur initial purchase costs between £20,000 and £30,000 for 200m and 100m pingers respectively. With total running costs over for 4 years being £42,880 for pingers with a 100m range and £44,800 for 200m range pingers.

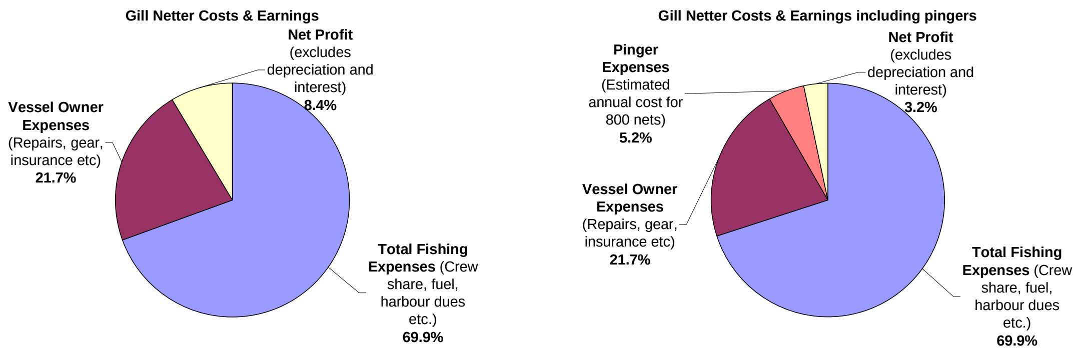
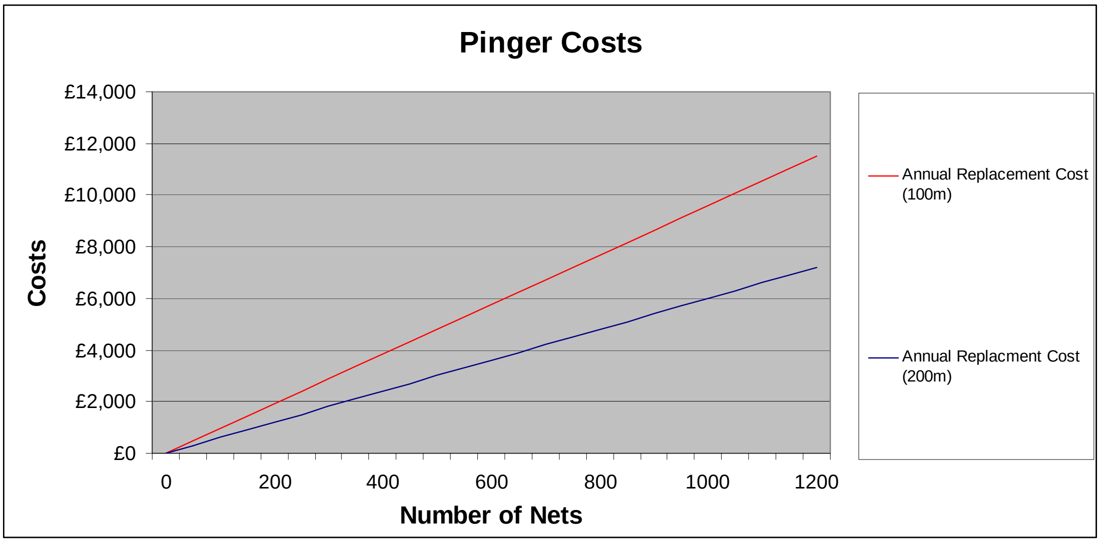


Figure 4 Estimated Costs and earnings with and without pingers based on 2001 survey of costs and earnings

From data collected as part of the 2001 Economic Survey of the UK fishing fleet (Watson and Martin 2002) carried out by the Economics department of the Sea Fish Industry Authority, average earnings of gill net vessels (12 vessels surveyed) between 10m and 21 m are estimated in terms of total fishing expenses, vessel owner expenses and net profit. Estimated net profit can be seen as 8.4% of earnings during 2001. Using the figures from the above table the introduction of pingers would increase the vessel owner's expenses by 5.2% thus reducing the net profit.

In addition to the initial costs of deployment there will be further costs in terms of replacing lost or faulty pingers the graph below shows annual costs associated with a pinger loss rate of 14% and an annual pinger failure rate of 10%. Some limited mitigation of the costs of faulty pingers may be obtained by negotiating a warranty with the manufacturers



The cost of attaching and monitoring of pingers by an individual(s) needs to be considered. Also who will be responsible for running a monitoring program and financing the costs associated with it? Due to the numbers of pingers and vessels involved in this fishery there is a requirement for at least one person to monitor the pingers on a full time basis. The post will need to be financed and these costs must be accounted for when considering the feasibility of a pinger program.

It is expected the initial purchase of pingers will be eligible for FIFG grant aid up to 40% of capital costs. Though as shown costs will be on going and add substantially to the running costs of these vessels, it is unclear as to whether these costs will be eligible for grant aid. In discussion with several Skippers about the cost implications of using pingers some suggested that these costs would no longer make the fishery a viable option and effectively forcing them out of business.

7. Pinger Implementation Schemes

This review covers literature and information on implementation schemes around the world and relevant information on acclimation and interaction with other species.

Pingers were introduced by law in the American static gear fisheries in 1997 and in Danish wreck net fisheries in 2000 and in the French fishery for tuna (*Thunnus thynnus*) in the Mediterranean. Information on implementation schemes; how the authorities have promoted and enforced pingers in the fishery is best found from talking to participants, thus the information is by necessity anecdotal. Such information is useful in that it gives an indication of the various approaches to implementation although the information is as seen from the view of that particular participant.

In the Californian drift gill net fishery (Barlow and Cameron 2003) for swordfish and sharks where there was a significant bycatch of cetaceans (predominantly short beaked common dolphins *Delphinus delphis*) experimental evidence indicated that these bycatches could be reduced by pingers. Discussion with Stan Pleskunas of Fumunda Marine Products elucidated how the pingers were introduced. The authorities hold annual seminars for fishery participants to appraise them of progress with bycatch reduction, observer programmes to ensure compliance and heavy fines for vessels not observing the requirements. There were no grants for pinger purchase. The observers are commissioned to listen to pingers and give the fishers notice to correct any deficiencies. Observation trips are frequent (approx 1 in 4 trips) and usually unannounced.

In the French bluefin tuna fishery that uses 'anchored drift nets' in the Mediterranean and which introduced pingers to counter a bycatch of striped dolphins, Imbert and Gaertner (2002) describe the use of AQUAmark 200 pingers in reducing striped dolphin (*Stenella coeruleoalba)* bycatch. The scheme was introduced by the local authorities and is described by Andrew Smerdon of AQUAtec Ltd. Pingers are checked annually ashore and a certificate of function issued. It is unclear exactly how the pingers were paid for, but the introduction of the scheme clearly requires a collective approach, taken by the local authorities. In the Danish static net fishery pingers were purchased, FIFG grant aided, by the fishermen's association. DIFRES[4] is carrying out a monitoring programme checking pingers, catches & bycatches.

Acclimation and interaction with other species

On the eastern coast of America pingers have been used on a time area closure basis. The difference between the porpoise bycatch in pingered and non pingered nets was maintained over 5 years of commercial fishing in American east coast waters (Rossman 2001). Short term studies indicate a degree of acclimation over 11 days (Cox, Read et al. 2001). Thus although there is evidence for acclimation in the short term, longer term studies show that this does not affect bycatch levels in the longer term. The animals may well loose any acclimation quite quickly, thus responding whenever they encounter another pingered net.

Interaction with pingers by other species has been observed, as would be expected and is dependent on whether the other species are sensitive to the frequency which

[4] Danish Institute for Fisheries Research

the pingers are transmitting on. The controlled experiments (Kraus, Read et al. 1995 : SMRU, UCC et al. 2001) which tested for changes in the catch and for demersal fish found no significant difference between pingered and non pingered gear. Aitken, Peddemors et al. (2000) examined the effects of pingers (both high frequency AQUAmark and Savewave types and low frequency Fumunda, AIRMAR) on 17 species of fish. Only the red eye round herring (*Etrumeus whiteheadi*) and the mackerel (*Scomber japonicus*) showed any reaction; both were attracted to the sound of the high frequency pinger. However, field studies have not revealed effects on herring (Culik, Koschinski et al. 2001) of either type of pinger.

In an experiment in Argentinean waters (Bordino, Kraus et al. 2002) South American sea-lions (*Otaria flavescens*) have been found to damage significantly more fish in nets fitted with 10kHz (low frequency) nets than the control with no pingers. This provides evidence for a 'dinner bell' effect, which was avoided by using high frequency AQUAmark type pingers (Kraus pers comm). In an experiment in Washington state, western USA an experiment using pingers producing broadband signals with peaks at 3 and 20kHz, there was no increased net depredation in gill nets set in salmon fisheries in the presence of common seals (*Phoca vitulina*) (Gearin, Gosho et al. 2000). However not only were these pingers producing different frequencies from the ones tested here, they were significantly quieter at around 122db compared with 132db (re 1 μPa@1m) for the 10kHz pingers used in this study.

8. Pinger Accreditation Schemes

Reports on possible approaches to pinger accreditation schemes are given in Appendix 1. Two approaches were identified based on existing or developing standards applicable to fishing vessels. Both take account of potential environmental impacts associated with fishing operations and would include the appropriate use and maintenance of pingers to avoid cetacean entanglement. Such schemes would provide assurance to retailers etc requiring of environmentally-responsible food sourcing.

The first approach is an Environmental Management System (EMS) for fishing vessels based on British Standard BS8555. While an EMS scheme appears viable, implementation requires development, consultation and documentation. For all but the larger fishing companies, this is likely to be prohibitive.for implementation to be realised. However, implementation could follow if guidance is provided to Skippers in implementing a scheme (e.g. through provision of suitable codes of conduct).

The second approach is the developing Sea Fish Industry Authority Responsible Fishing Scheme. Although far more general in nature, this scheme will have significant documentation and guidance produced for interested Skippers and boat owners. This will specifically include guidance and policies on avoiding cetacean interactions, including the use of pingers where appropriate. A third approach, Marine Stewardship Council certification, was not considered appropriate for the species targeted in the SW fishery.

Since this project was initiated the legal requirement for use of pingers on static nets has been introduced. Accreditation schemes centred on the use of pingers are therefore not now required to promote pinger deployment. However, potential market advantage which could be gained from a vessel or group of vessels participating in accreditation schemes remain. Specifically, such schemes would include independent verification of pinger use, recording of any cetacean interactions and compliance with appropriate codes of conduct.

9. Discussion

This trial has covered a 15 month period of effort on a Cornish gill netter amounting to 27 trips of which 7 were accompanied by an observer. During the course of this trial the pingers have undergone the rigors of the shooting and hauling process with approximately 8000 set/hauling cycles completed (No. of pingers x No. of deployments). The discussion covers the relative performance of the four pinger types, and developments and a discussion of pinger design and deployment with the fishermen.

9.1 Relative Performance and further developments

This section outlines the relative performance of the 4 types of pingers on trial and discusses modifications which the manufacturers have made to their products since the start of the trial. Most of these modifications were made as a result of feedback from this trial.

9.1.1 Fumunda

This pinger proved to be the most successful in terms of compatibility with the gill nets, its dimensions, very close to that of a net float, and the attachment points at the very end of the pinger enabled the pinger to be attached tightly to the headline of the net. It had little impact on the working practices for gillnets onboard the vessel and flowed smoothly through the hauler and over-ending machine. The casing on this model stood up well to the shooting and hauling process with all retrieved pingers showing little signs of casing damage.

The biggest issue of concern with this pinger is its battery life, as at the 6th month stage only 12% of the pingers returned a signal. Fumunda have recently redeveloped their pinger to increase its battery life. As the duration trials are now completed extended sea testing of the new models is not possible within this project. Some bench testing has been carried out to assess the expected battery life of the new pinger, the results of which give an estimated continuous pinging time of 590 days (19 months) or 1458 days (4 years) in standby mode.

A battery life of 19 months is adequate if the pingers successfully turn off when out of the water. As the nets will only spend approximately 100 days a year submersed thus increasing the pinger battery life to around 4 years (allowing for discharge when the pinger is not active). These tests showed that due to the moisture retained by the nets when onboard the boat some of the pingers continue to be active. Whilst improvements to the switch design have been made, it is very difficult to achieve 100% of the pingers switching off in damp conditions.

Thus potentially if the pingers run continuously a battery change would be required after 19 months. This is not only of an additional cost to the fishermen in terms of battery replacement, it would require 2-3 days work ashore when in port as the pingers need to be removed in order to change the batteries. It is not feasible to do this task at sea as the internal workings of the pinger need to remain dry.

Noise is also an issue with this pinger as it emits an audible tone every four seconds, this will obviously be compounded due to the numbers required to service all the nets worked by the vessel. This may give rise to some heath and safety issues. However, having an audible tone is an advantage as it is easy to find out whether the pinger is operating effectively.

The initial costs associated with the purchase of all the pinger types are obviously of a concern to fishermen. Due to the range on this particular model being only 100m, twice as many pingers will be required compared with other manufacturers' pingers with a range of 200m.

9.1.2 AIRMAR

This make of pinger proved to be the only pinger actually functioning after the first set of trials (Sea Fish Industry Authority, Cornish Fish Producers' Organisation et al. 2003) though during the course of the trials problems have arisen. There have been a number of problems with this pinger in terms of shape and weight. Firstly the shape of the pinger is not conducive to simple attachment on the gear, although its attachment points are at the very end of the pinger, similar to the Fumunda, its shape makes it difficult to attach tightly. This led to the pinger loosening over time as the nets were hauled and shot.

In terms of the pingers acoustic performance this pinger emits a similar signal to that of the Fumunda, an audible tone every four seconds with pingers at 100m intervals, thus incurring the same advantages and disadvantages. Unlike the Fumunda this model does not incorporate an immersion switch and 'pings' constantly from start up.

During final testing after 15 months all batteries were inspected and all were found to have compressed the positive contact of the battery including the pingers that were still operative. This problem is being addressed by the manufacturer though due to the varying sizes of the D cell batteries this is proving difficult.

9.1.3 AQUAmark

This pinger is of a similar size and weight to the AIRMAR pinger and similar problems of attachment, over-ending and health and safety have been encountered. The size and weight of this pinger is limited by the battery, a reduction in battery size would compromise the longevity of the battery life. The ultra-sonic emissions used does not give rise to the noise issues incurred with the Fumunda and AIRMAR pingers and its range of 200m reduces the number of pingers required for a given distance of net.

Testing of this pinger initially required the use of a bat detector; a dedicated tester was designed for this product and tested during the final trip. The tester gave out a reading of the pingers individual code and battery power on start up. This worked well during onshore testing. However, at sea a number of problems were encountered, the vessel's noise, not only in terms of engine noise but the signals from the fish finders were being picked up by the tester's hydrophone making it very difficult to hear the pinger and impossible when the pinger was more than a few metres from the hydrophone.

The manufacturer of these pingers has made a number of design changes, essentially to do with the resin and moulding process. It is understood that further improvements in the mouldings are envisaged for the next generation of this model, with the use of epoxy resin rather that polyurethane which should bond better to the metallic components.

As this pinger is moulded it is not possible to replace the battery so the whole unit must be replaced at the end of the batteries life. Predicted battery life is 1.5-2 years continuous as this pinger incorporates an immersion switch this should give the pinger an extended lifespan depending on use and the reliability of the switch. As this trial is limited in duration it is not possible to substantiate these claims although the battery levels observed would be consistent with a lifespan considerably longer than 12months. The cost implications of having to replace the whole unit on cessation of the battery are an issue with this model.

Savewave
The Savewave pinger proved to be too bulky and of the wrong shape to flow easily through the on deck machinery causing problems when hauling and over-ending. Although alterations were made by the manufacturer after recommendations from Seafish the overall design remained the same. From the outset the Skipper was not happy with this pinger and it proved to be the most problematic of the four on test. The casing of the pingers were prone to distortion and cracking, although the pinger was promoted as being positively buoyant this did not prove to be the case as the inserts became saturated with water over time. At the 6 month testing stage all 9 pingers recovered were found to be faulty. No feedback has been given by the manufacturer as to the reason for these faults. Input has been given by Seafish into a prototype design of pinger by this company; it has yet to be tested.

9.2 Overview of pinger design and deployment

The most compatible design for a pinger for use on gillnets is one that is a similar size to the floats currently used, positively buoyant, replaceable battery, with a hole through the middle so that it can be threaded on the headline. This ideal proves problematic in terms of design as the shape and size are limited by the battery and electronic components, with a requirement for a reasonable battery life. The cost of pingers will radically increase gear costs to individual vessels. Estimated impacts on profits are shown in Section 6. It is estimated that in order to service a single vessels fleet of nets total costs of pingers double the overall gear costs for that vessel. This adds to the costs due to loses, (an average of 14% pinger loss over the course of the trail) with nets being towed away, loses of pingers with seabed interaction and pingers becoming detached from the gear.

Pinger battery replacement needs to be carried out in a relatively dry environment to ensure the internal workings of the pinger remain dry. It is therefore only feasible to do this when the vessel is in port, as the nets are stored in pounds onboard the vessel it would require the crew to pull all the nets off the vessel untie the pingers, replace the old batteries and reattach the pinger then pull the nets back onboard the vessel. This is a very labour intensive operation adding additional work for the crews involved.

Of the four pinger types on trial it is difficult to recommend a model that will fully meet the requirements of the fishery. Each pinger has had its individual problems some of which have been solved others have not.

The pinger that worked well in relation to the gear was the Fumunda, though there are still uncertainties as to its battery life. A shore based estimate is possible but cannot replicate the conditions undergone by a pinger when attached to a net in a commercial environment. The ultrasonic signal and range of the AQUAmark are advantageous in that it is inaudible to the fishermen and there is a requirement for less pingers because of the longer range of this pinger; 200m vs. 100m of the AIRMAR and Fumunda. However, its dimensions and weight and need for total replacement at the end of the battery life militate against this pinger. Also although the mouldings have been improved by the use of epoxy and this has been tested in the laboratory, the new version is slightly heavier and has not been tested in the commercial fishery. The economies of total replacement are very much influenced by the amount of pingers loss rate and the eventual life of the units. Thus under certain circumstances the need for total replacement may not be such an important factor in the overall cost of pingers.

To date all the pinger types have been trialled almost exclusively on gill nets. Deployment trials with tangle and trammel nets have produced mixed results (Section 5.3) with reports of entanglements being more frequent particularly with the heavier pingers. Corroboratory evidence is available from Ireland (BIM work in progress) which describes entanglement rates by pinger type.

Development of pingers has been ongoing largely stimulated by results from this project with improvements being made by Aquatec and Fumunda and a new prototype being designed by Savewave. Within the remit of this project, time constraints have limited the amount of testing that has been achieved using the new designs of pingers so uncertainty will remain as to the durability and battery life when worked in a commercial environment.

Skipper's Comments

Although the Skipper is sceptical about the impact of this fishery in terms of cetacean bycatch, he is aware of the implications if this issue is not considered. In discussion with him, a number of issues were raised, which included logistics, costs and responsibilities of working pingers on nets. Together with colleagues, he also suggested another approach to the design of pingers intended to make them more compatible with shipboard operations.

Operational considerations

With some designs of pingers it proved difficult to attach them tightly on the net, due to the repeated hauling and shooting process, these pingers tended to loosen, thus causing problems with entanglement when handling the nets. The Skipper considered that there is a requirement to re-tie the pingers tightly on the headline after 4-5 trips. This would require a dedicated member of the crew during the hauling process to carry out this task, and which may not be feasible as hauling is the busiest time for all crew.

Responsibility

Another issue raised by the Skipper was establishing who would be responsible for monitoring the pingers and who would be responsible for ensuring all pingers are working effectively. The crew's time is already fully dedicated to the working and running of the vessel; for them to take on this extra responsibility for no financial reward would be unworkable.

Costs

The cost of pingers will radically increase gear costs to individual vessels. It is estimated that, in order to service a single vessel's fleet of nets, total costs of pingers would approximately double the overall gear costs for that vessel. This adds to the costs due to losses, with nets being towed away by trawlers, losses of pingers with seabed interaction and pingers occasionally becoming detached from the gear.

Although it is envisaged that pingers will be eligible for grant aid for initial deployment, there will be ongoing costs in terms of crew time dedicated to attaching and reattaching pingers, battery or unit replacement costs and the associated work involved. Pinger battery replacement needs to be carried out in a relatively dry environment to ensure the internal workings of the pinger remain dry. It is therefore only feasible to do this when the vessel is in port, as the nets are stored in pounds onboard the vessel. As nets are piled one on top of another, up to 150 nets deep, battery replacement requires the crew to pull all the nets off the vessel, un-tie the pingers, replace the spent batteries with fresh ones, re-attach the pingers, and then pull the nets back onboard the vessel. This is a very labour intensive operation, adding additional work for the crews involved.

Profit margins are currently very tight within this fishery, exacerbated by the costs of leasing quota and the rising price of fuel. The added cost in terms of manpower and ongoing financial commitment to ensure continuity of pinger performance may lead some vessels being forced out of the fishery.

Estimated initial costs of pinger deployment by a vessel working a similar amount of gear as seen deployed during this trial will incur initial costs of £15,500 -£28,800, annual costs of between £3,700 and £6,000 and replacement/battery costs of £15,500 and £2,480 respectively, depending on the type of pinger deployed.

In addition to these costs there will be a requirement to employ a dedicated person to attach and monitor the pingers on a regular basis. As fishermen are paid a share of the catch, after the vessel costs and expenses have been deducted, the crew share will be reduced not only due to the increase in costs associated with pingers, but also if another crew member is required to service the pingers the crews share will be divided between 6 individuals rather than the standard 5 members of the crew. This will reduce gross income to each individual by 17% for those trips where the extra crewmember was required.

Due to the increases in running costs and reduction in catches many vessels Skippers, not only in this fishery, but UK wide are finding it difficult to recruit crews as earnings have fallen. The requirement to work and monitor pingers and its impact on earnings may result in crews currently working on the larger over 12 metre gill netters moving to smaller gill net vessels or into other fisheries where earnings are higher. This may lead to vessels going to sea "short handed" thus impacting on safety or vessels being tied up due to the unavailability of crew.

Pinger design

In discussion with other Skippers it is suggested that a larger, more powerful pinger should be designed, that could be attached to the anchor ends of each tier of nets. Due to the configuration in which nets are generally shot (as described below in Figure 5) the larger range of the pingers would overlap, covering the whole area over which the nets had been shot.

The pingers could be clipped on individually by a crew member as the each end of the gear is shot over the side. The size of the pinger is not as critical as it is for mounting on a net. This means that the pingers could be larger and so carry enough batteries for the extra power output required. . The issues of entanglement, storage and impact damage could also be avoided by only having one large pinger attached to each anchor end when shooting the gear. Pingers could be removed for re-charging whilst hauling and at the end of each trip; this would also aid maintenance and monitoring through easier access to fewer pingers. Individual unit costs may increase though total costs should reduce due to the reduction in the numbers of pingers required. Monitoring could also be achieved by picking up the more powerful signal emitted by the pingers in the sea, and this would also aid in locating any lost nets.

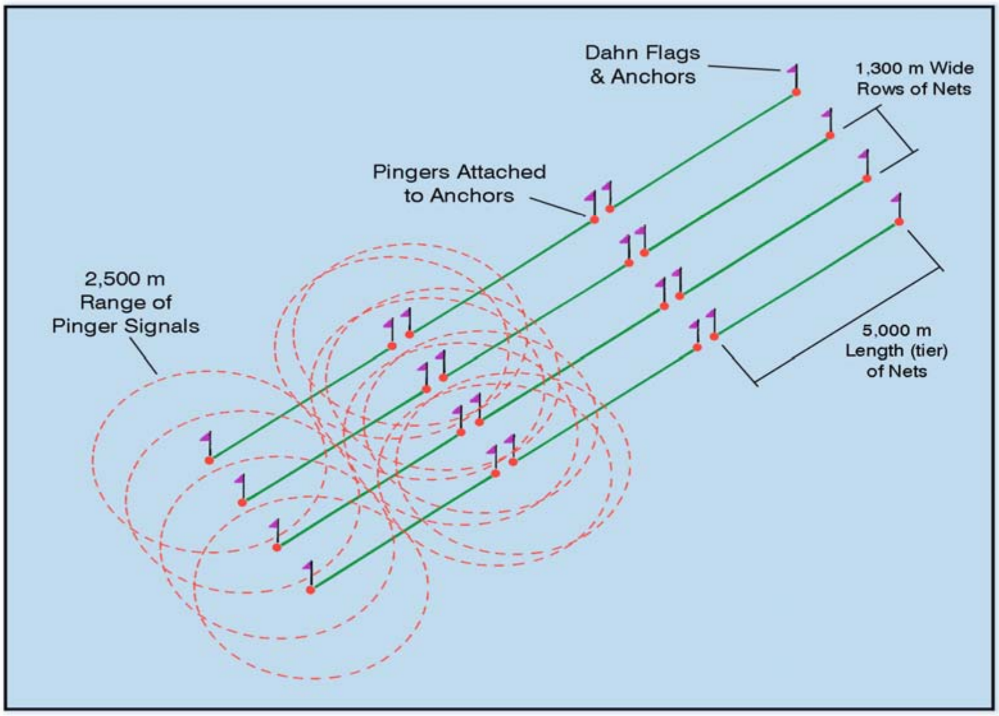


Figure 5 Possible configuration of large scale pingers

The technical feasibility of this idea would need to be examined, and if such a pinger were considered viable, it is recommended that sea trials should be conducted with prototypes.

Some design considerations are as follows;

1. Preliminary calculations suggest that a source level for 10kHz pinger for a spacing of 3000m would be around 160db (ref 1 μPa@1m). Although this is a substantial increase on the 132db of the 10kHz pingers used in this study (decibels are on a logarithmic scale) it does not exceed the upper limit for marine mammals indicated by Richardson, Greene et al. (1995). At 10kHz the pinger would be audible to humans. If it was decided to use higher frequencies beyond the audible range for humans and seals, but effective on porpoises, this would reduce the spacing of the pingers for the same source level since higher frequency sound is more rapidly absorbed by seawater.

2. This level of sound production would require frequent battery charging (possibly every haul). This could be mitigated by less frequent pings. If the nets are set out in the layout shown above there might be scope for reducing the numbers of pingers because of the overlap between pinger ranges.

3. Although the regulations refer to sound emissions which currently tested pingers are compatible, there is scope for derogating this for experimental gear.

Pingers meeting similar specifications have been manufactured for trawls so it might be possible to modify these designs. A high proportion of the costs would be field testing for efficacy. There would need to be discussions with government as to whether such an approach would be acceptable if it proved effective.

Truly Alerting Device (TAD)

In recent years TAD (truly alerting device) has gained support amongst environmentalists as a potential alternative to pingers. Both the pinger and the TAD are designed to emit pulses of ultrasound on a continuous basis. There are however some important differences which may favour the development of the TAD over the pinger.

The pinger is designed to create noise to scare the porpoises away. The TAD is designed to sound like a porpoise emitting short pulses of ultrasound signals every four seconds. These resemble short trains of sonar clicks produced by cetaceans and so act as a porpoise "play back". Whether this will result in reduction of bycatch is unknown, but there is some supportive evidence from a study of porpoise echo-location around nets which showed that most encounters with nets did not result in entanglement (Tregenza, Northridge et al. 2001; Northridge et al. 2003). On hearing these pulses porpoises investigate the source, possibly believing it to be another porpoise and in doing so discover the presence of the net.

The potential benefits of TAD over pingers included: improved battery life and efficiency as well as a reduction in maintenance time, cost and noise pollution. Given these potential benefits there is a need to further develop and test these devices in the near future.

Thinner twine diameter nets

In work carried out in the East Yorkshire coast tangle net fishery (Northridge, Sanderson et al. 2003). experimental tests showed that smaller meshed and thinner twined nets have a significantly lower bycatch rate than larger meshed thicker twined nets.

The use of thinner diameter net twines allows the porpoise the ability to more easily break free of the net if they become snared. Nets with larger twine diameters are currently employed by fishermen as they are more durable than thinner equivalents. Adopting nets with thinner twine diameters should not result in a reduction in catches and could even slightly improve catch rates. Though would reduce the durability of the gear and may increase costs to the fishermen.

The use of thinner diameter net twines as an alternative to pingers needs further investigation to assess levels in the reduction of bycatch and the feasibility of using these nets in the longer term in a commercial environment.

10. Conclusion

In terms of deployment within the Celtic sea static net fisheries pingers can be seen to still be in the development stages; consequently fishermen are not confident about their effectiveness. The advances made during this project have increased pinger efficiency though feedback to manufacturers, although the pingers tested are very expensive and still fall short of meeting the full requirements of the fishery. The costs of implementing a pinger program are such that it may lead to vessels and crews being forced out of the fishery due to reduced profitability. The problems highlighted in this report need further investigation alongside developments of alternative solutions which will successfully reduce by-catch while at the same time not significantly increasing fishermen's workloads or costs.

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Appendix 1 Moody Marine Ltd - Certifiable System

