Financial Instrument for Fisheries Guidance (FIFG) project

Trial of acoustic deterrents (porpoise pingers) for prevention of porpoise *(Phocena phocoena)* bycatch - Phase 1 Deployment trial

Seafish Report CR201

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Seafish Fisheries Development Group

Sea Fish Industry Authority
Cornish Fish Producers' Organisation
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Sea Mammal Research Unit

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

Phase 1 Deployment Trial

Summary
It has been recommended by DEFRA that static gear fisheries in ICES divisions VII e, f, g, h, and j (outside the 6mile limit) use active acoustic deterrents ('porpoise pingers') to deter porpoise by catch. Although pingers have been previously trialed in this fishery, there is a requirement to investigate the deployment of the currently available models in order to understand their deployment characteristics.

This report details the practicalities of attachment, deployment and testing of pingers. A deployment trial of four commercially available models of pingers on a vessel fishing from Newlyn (Cornwall) prosecuting the gill net fishery for hake was carried out. The trial took place over the course of a commercial trip with the pingers being attached to the gear as it was hauled for the first time, the pingers then remained on the gear for the duration of the trip and were removed on the final haul. The majority of the pingers (3 out of 4) models achieved approximately 100 shoot-haul cycles with the remaining model achieved 58 due to attachment problems.

Only one of the four pinger models tested performed satisfactorily. Suggestions for improving the functioning of the pingers are made and the manufacturers' proposals for improvements are included.

The practicalities of pinger attachment, battery changing and testing are discussed. Pingers could be attached in the net loft whilst the net was under construction, as the

nets were boarded for the first time or during hauling. The method used in this study was to attach the pingers as the gear was being hauled this being the most practical in the situation of this fishery. It is clear that this required more manpower than is currently available on the vessels in this fishery because the crew is fully occupied with hauling the gear and removing the catch from it. An extra crewman would be required if this method for attaching the pingers were adopted. Attaching the pingers in the net loft whilst the gear is under construction would be feasible, but the batteries may run down during storage (particularly for pingers that ping continuously without an immersion switch). Pingers could be attached whilst the nets were being boarded in port although this procedure is normally only carried out when the gear is replaced or when the vessel is painted or major maintenance is required. Battery changing would have to be done ashore due to the operating conditions on the deck. Testing of pingers is easiest for audible pingers that ping continuously but would require specialist equipment for inaudible pingers (pingers which ping at frequencies higher than human hearing) or those that ping only on immersion.

The implications of gaps created by two or more failed pingers on cetacean deterrence are modelled and discussed. This model demonstrates that when pinger failures are infrequent they are unlikely to produce large gaps in the pinger sequence provided that they are deployed at the recommended spacing.

Further work

There is a requirement to have more than one pinger suitable for use in the fishery if possible because this would improve competition and hence increase the likelihood of innovation. To proceed with an endurance trial with only one type of pinger functioning, increases the risk that no pinger would be found suitable for commercial use because a fault could develop in that pinger. However, it is recognised that there is a requirement to find a suitable pinger in a short period of time. Further work is required both in pinger design and deployment to fully evaluate the feasibility and cost implications of prolonged use within the commercial environment.

The endurance trial will commence in February 2004 so that the manufacturers should develop the means to avoid the faults in their pingers uncovered by the deployment trial. During the development period (November 2003- February 2004) the manufacturers will test their pingers in simulations and limited field-testing. The pingers would be tested after the first trip of the endurance trial and any designs not performing satisfactorily would be eliminated at that point.

Other aspects that would be developed would be protocols for pinger attachment, testing and maintenance. Phase 2 would include the estimation of costs of a pinger programme and consider how such a scheme could be accredited to secure its integrity.

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Acknowledgements

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1. Introduction

As part of the UK Government's efforts to conserve cetaceans it has set up a Biodiversity Species Action Plan Group for turtles and cetaceans which considers issues concerning conservation of these species in UK waters. The Fisheries Sub Group (FSG) of this Species Action Plan Group has, in its terms of reference, the requirement to seek practical and cost effective methods for reducing cetacean by catch in UK fisheries.

It has been recommended in a DEFRA consultation document (DEFRA 2003) that static gear fisheries in ICES divisions VII e, f, g, h and j (outside the 6 mile limit) use active acoustic deterrents ('porpoise pingers') to deter harbour porpoise by catch. The European Union may also ultimately require the use of these devices on static nets used over a wider area including within the 6mile limit.

Cornish vessels use static nets in these areas. There are approximately 15 vessels of 14 to 20m length and 40 of less than 14m length using static nets operating from Cornish Ports. Gill nets for 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.

From experiments which have been carried out in European (SMRU et al. 2001) and North American waters (Kraus et al. 1995) it is clear that in large scale experiments under commercial conditions, pingers have been found to reduce porpoise bycatches in static gear. Although there are a number of pinger types available on the market there is a clear need to test them in commercial fisheries in which it is proposed to operate. Operating conditions in these fisheries can be highly demanding, with gear being shot at speeds of up to 7 knots (3.5m/s).

The Fisheries Sub Group (FSG), includes representation from the fishing industry, Government and conservation NGOs. At its meeting in May 2003 it was agreed that there should be a deployment and endurance trial of the porpoise pingers in the Cornish gill net fishery for hake. Subsequent to the meeting it was agreed that a deployment trial should be carried out on tangle net fisheries but that this should be designed after the deployment trial for hake gill nets and when the tangle net fishery is in season (from March-September).

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

Phase 1; Deployment trial of acoustic deterrents (porpoise pingers) trial for hake gill net fisheries.

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 describes work carried out in phase 1 and discusses further work aimed at developing the means to introduce pingers into this fishery. It is recognised that this trial, as discussed by the Seafish board, is a first step towards determining the feasibility of deploying pingers in this fishery. Further work would be required to fully evaluate the implications of deployment on a commercial scale.

2. Aims

For this set of trials it is intended to concentrate on the use of acoustic deterrents on hake gill nets (mesh size=120-152mm (4.75-6inch) twine dia = 0.65mm, nets 45 meshes deep) used in the Cornish gill net fishery. There have been experimental deployments of these deterrents in this fishery previously, which were carried out in order to test whether the pingers actually deterred porpoises from being captured. It was shown that porpoise bycatch could be reduced in this fishery (Berggren et al. 2002) and similar results have been obtained in other fisheries (Kraus et al. 1995).

Since these trials were undertaken there have been advances in pinger technology and there are currently 4 types of pingers available for use in this fishery. This phase of the project aims to investigate the deployment of these pingers types in this fishery.

3. Objectives

This project intends to trial 4 types of pingers (see Table 1) in the Cornish gill net fishery for hake with the objectives of elucidating the following:

1. Ease and logistics of attaching pingers to nets, using bait-bags for attachment if required.

2. Effects on fishing operations; logistics of shooting and operating the gear.

3. Performance of pingers over the course of a trip. Two aspects of the pingers' performance will be examined:

   a) Visual checks on the casing to assess damage due to the shooting and hauling process and observations of the attachment method to ensure pingers remain firmly attached to the float line of the net.

   b) Acoustic tests in order to examine the failure rate of the pingers over the course of the trial.

4. The implications of the observed failure rates in terms of porpoise deterrence will be examined.

Table 1. Characteristics of acoustic deterrent devices used in this trial. See manufacturers' websites for full details and model range

Manufacturer	AIRMAR Technology Corporation	AQUAtec Sub Sea Ltd.	Fumunda Marine Products	SaveWave BV
Web site URL	www.airmar.com	www.netpinger.net	www.fumunda.com	www.savewave.net
Model	Gillnet pinger	AQUA*mark* 100	FMDP-2000	Saver
SIGNAL CHARACTERISTICS				
Tonal/wide band	Tonal	Wide band / tonal	Tonal	Wide band
Source levels (max - min) re 1 μPa@1m	132 +/- 4 dB	145 dB	132 +/- 4 dB	155 dB
Fundamental frequency	10 Khz	20-160 KHz wide band sweeps	10 KHz	30-160 KHz randomised sweeps
Pulse duration (nominal)	300 ms	300 ms	300ms	100-900 ms randomised
Inter pulse interval	4 seconds	4 -30 seconds randomised	4 seconds	4-26 seconds randomised
Note that for digitally synthesised signals which these pingers use, some signal characteristics can generally be reprogrammed by the manufacturer if necessary for specific applications				
POWER CHARACTERISTICS				
Battery type and number	1 Alkaline "D" cell	1 Alkaline "D" cell	1 lithium	Sealed 9v unit
[1]Operating life of battery (continuous use)	> 8700 hours (1 year)	13,000 – 17,000 hours (1.5 - 2 years)	~11000 hours (15 months)	350 hours: to be extended
Wet switch	No	Yes	Yes	Yes
Battery change possible?	Yes	No	Yes	No
Battery disposal	By operator	20% discount for returned spent units against replacement units	By operator	Sealed unit returned for 20% discount on new unit
IMPLEMENTATION CHARACTERISTICS				
Size (length, max diameter, mm)	156 x 53	140 x 56	152 x 46	202 x 67
Weight in air (g)	400	370	230	400
Weight in water (g)		120		Buoyant
Depth tested to (m)	277	200	646	200
Attachment details	3-way holes each end	1 hole at one end	3-way holes each end	One hole at each end
Spacing along nets (max recommended)	100*m	200m	100*m	200m
Test for failure	Signal is audible	Ultra-sonic testing device	Signal is audible	Ultra-sonic testing device
Housing material	Plastic alloy	Urethane	Co-polymer	HIPS Styrosun
SUCCESSFUL FISHERY TRIALS REPORTED				
A: Bycatch reduction				
Species/fishery:				
Harbour porpoise Bottom set nets		Larsen (1999)		
B: Net damage reductions				
Bottlenose dolphins set net fisheries		Goodson et al. (2001)		Northridge et al. (2003)

[1] These are manufacturers' estimated figures, which will vary with operating conditions.

4. Method

Pinger specifications

Four pinger types were used in this project, their specifications derived from manufacturers data are shown in Table 1; the pingers are illustrated in Figure 1. Their functioning as deterrents have been examined by experiment (references in the Table 1). In addition there were experiments carried out in North America (Kraus et al 1995) and in Cornish fisheries (Northridge et al. 1999; SMRU et al. 2001) using the Dukane pinger (no longer in production) which has similar acoustic characteristics to the AIRMAR and Fumunda pingers. The web-sites of the manufacturers (Table 1) should be consulted for detailed specifications of the pingers and also for details of other acoustic deterrents designed to deter other species.

Flume Tank observations

Flume tank observations were used to assess the best method for attachment and position relation to the floatation. It was decided to use net bags tightly sewn to the AQUAmark pingers to ensure that attachment could be achieved at both ends of the pinger to minimise buttonholing. Relative buoyancy of each pinger was assessed to ensure compatibility with the gill nets being used during the trial.

Trial conditions

The vessel was at sea during the neap tide from the 16-23rd of September 2003. Weather during this period was variable, the first 4 days were calm. The weather then deteriorated during the second half of the trip with winds up to Beaufort force 6/7 during the final 2 days. Depths fished in were up to 80m.

5. Description of vessel operating environment

Shooting

In this trial nets were always shot from the aft pound. Vessels can shoot nets at up to 7knots (3.5m/s). This means that the net runs out over the stern rail (Figure 2) where the hardest impacts are likely to be experienced. The net has previously been conveyed through a tube by a flaking machine situated above the after pound. This movement of the net is much slower than shooting itself. In other boats shooting is sometimes done over the side from net pounds forward of the wheelhouse. In that case the pingers will be exposed to an impact when leaving the pound and when going over the side. Also the first shot from the forward pounds was through the shooting tube and then out over the stern rail. However, no pingers took this route on this trial.

Hauling

A range of haulers are in use in the fleet. In this trial a Spencer-Carter hauler with three wheels was in use (Figure 3). During hauling pingers usually go underneath the third wheel. One type of pinger, attached using the cable ties supplied, usually broke off the headline at this point and flew across the deck. This problem was completely solved by use of white braided nylon to attach the pinger. No pingers appeared to suffer damage from going under the wheel.

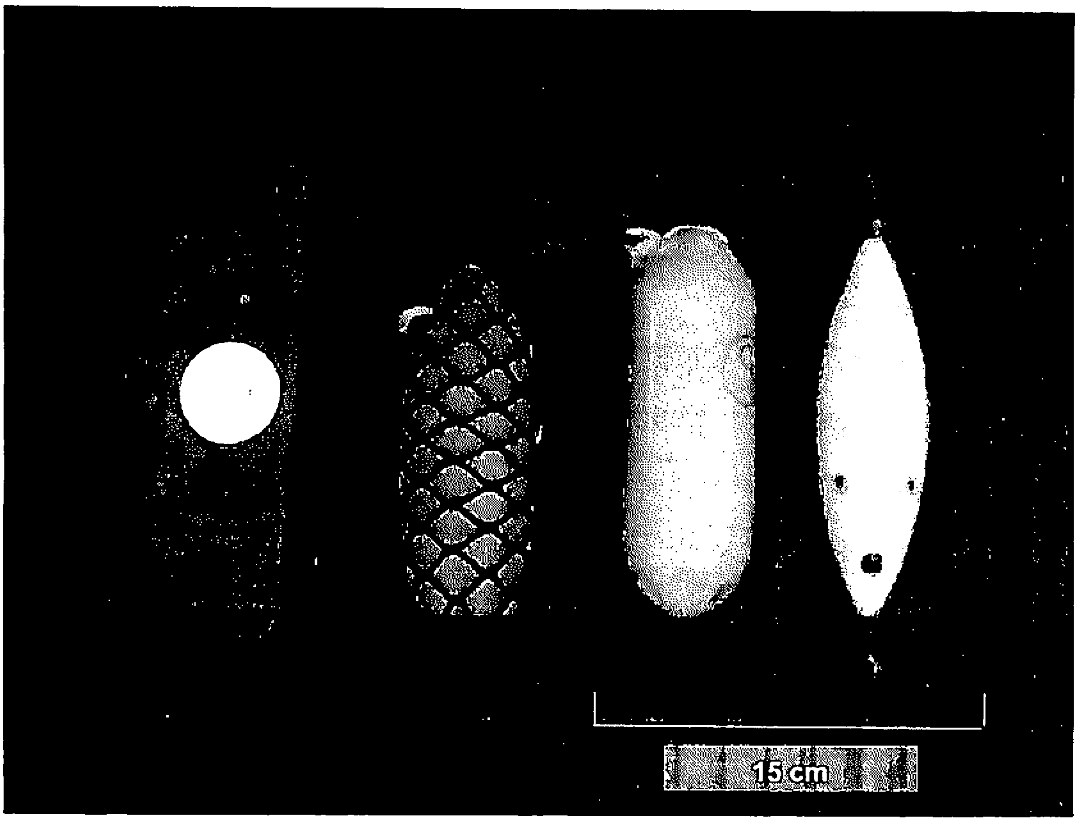

Figure 1 Pinger types Left to right: SaveWave Saver, AQUA*mark* 100, AIRMAR Gillnet pinger, Fumunda FMDP-2000

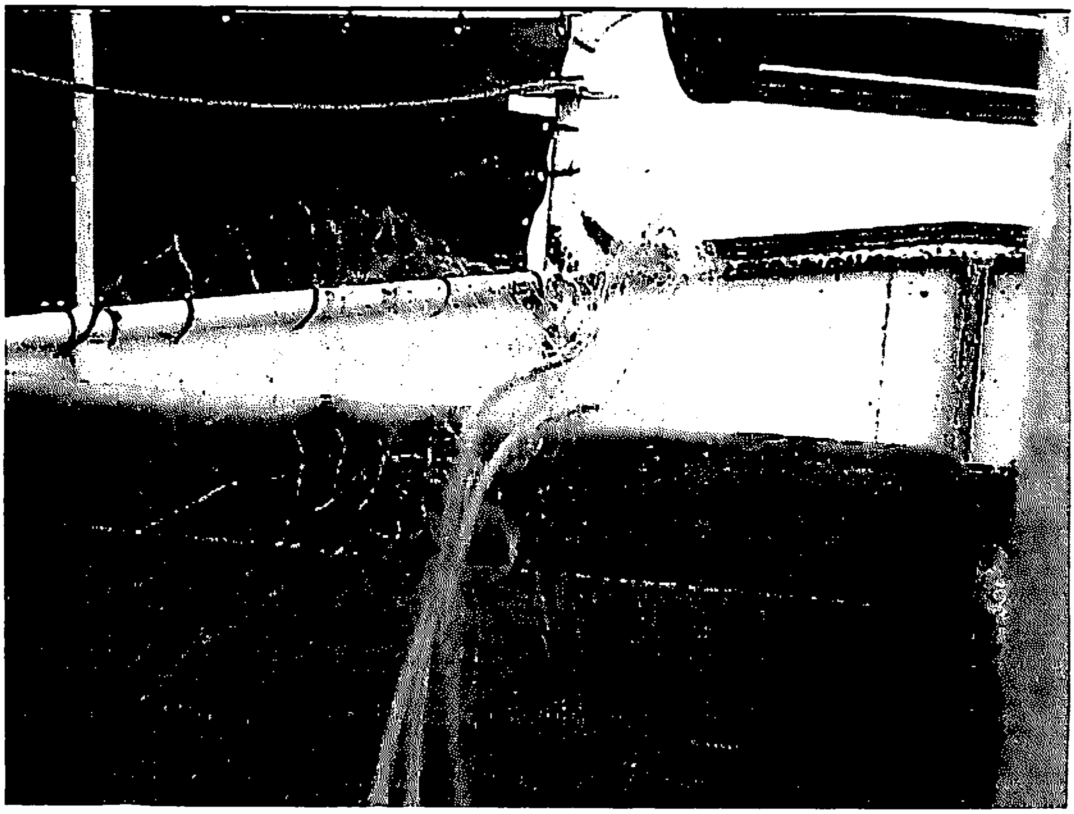

Figure 2 Shooting gillnet over the stern rail

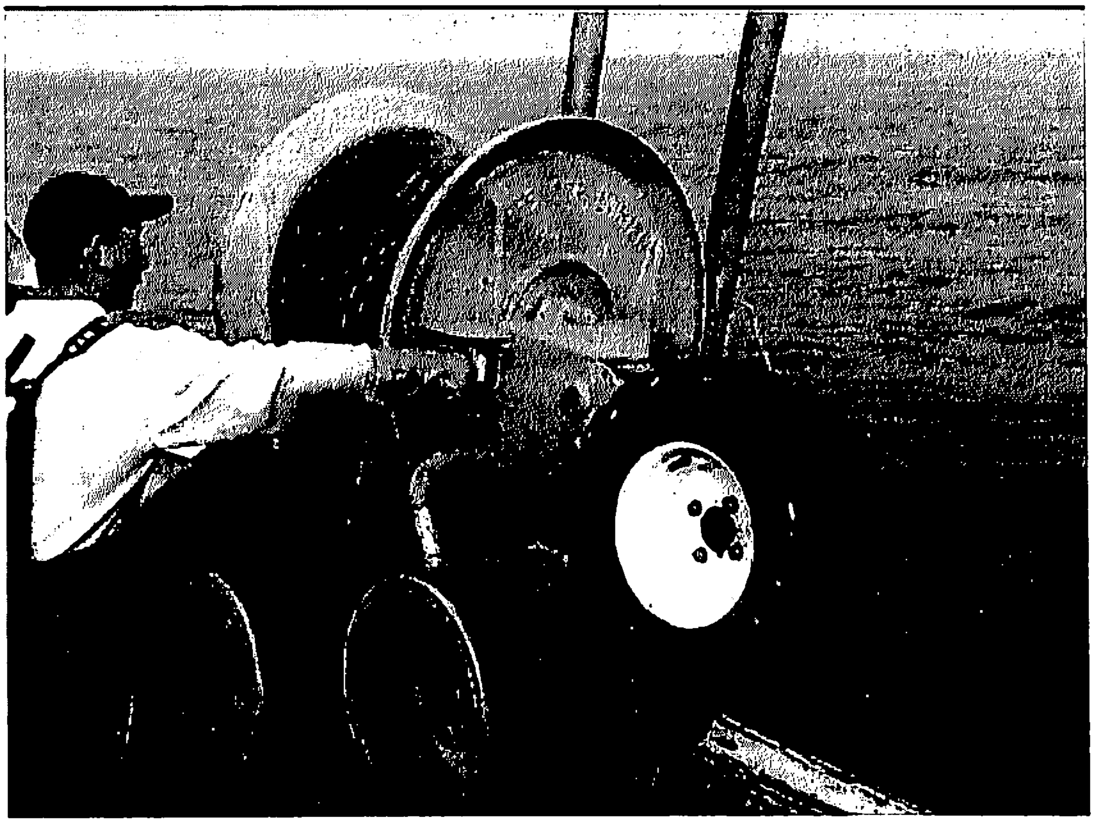

Figure 3 Hauling gillnet using the Spencer Carter hauler

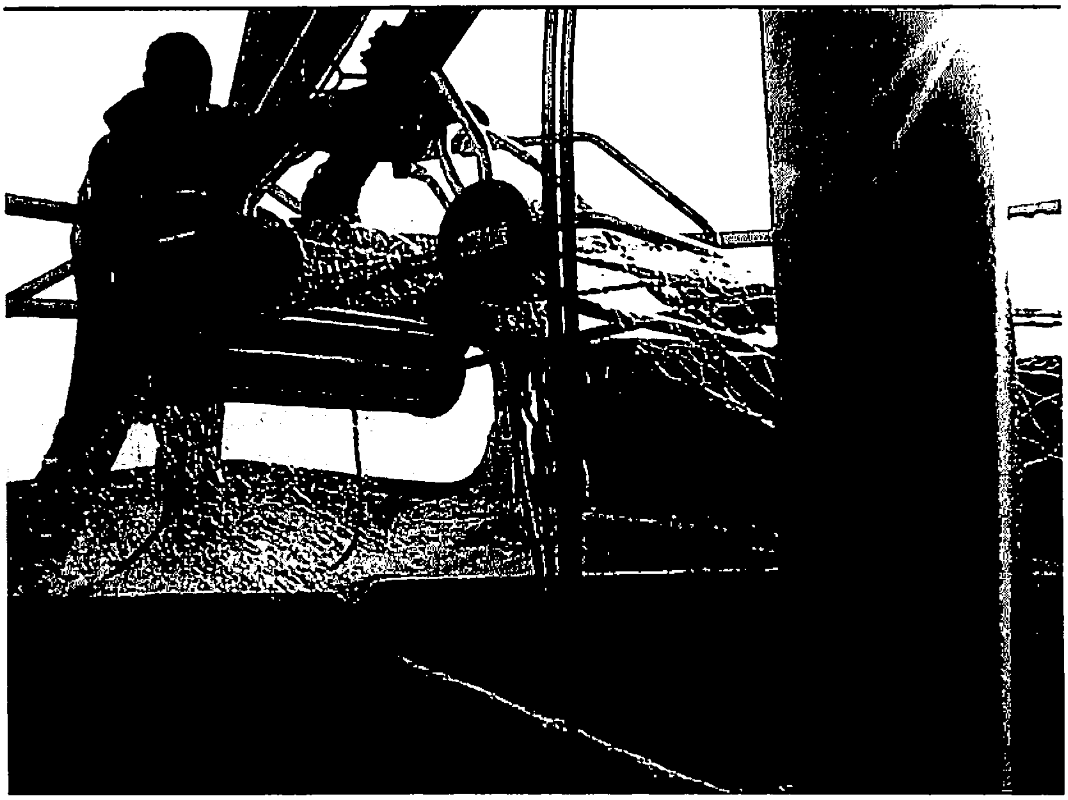

Figure 4 Net flaking machine

The speed of hauling is such that pingers are only visible for about 5 seconds before disappearing beneath following net.

Net Transport

After the fish have been picked out, the net is transported to the pounds by a flaking machine (Figure 4). This machine, which is situated over the after pound, pulls the net, via a metal ring set to act as a fair lead, down the shooting tube from the fore-deck where it has been hauled aboard by the hauler. Its purpose is to separate the headline and footrope to ensure proper deployment later. The only problem encountered was with pingers in net bags. These were liable to catch the net and/or footrope and the machine would then be unable to separate the two ropes. In this situation the net had to be pulled back by hand through the machine and reset.

'Unaccounted' pingers.

A number of pingers remain unaccounted for. This was due to either loss of the pinger from the net, loss of the net with the pingers on it due to the gear being towed away by trawlers. Alternatively its passage was unobserved when hauling the net for the last time on this trip. The latter can happen because the pinger is only briefly visible and there is usually a lot to attend to on deck, especially in poor weather conditions. Any pingers still attached to the net should be discovered and returned in the course of the next trip. No pingers were found on subsequent trips.

During the trip there was some gear towed away by trawl gear, which may have resulted in a section of net and pingers being lost. This interaction would be independent of pinger type so it is not possible to ascribe these losses to be due to the design of the pingers themselves or the method for attaching them to the gear.

Button-holing

Sometimes a float or pinger may fall through a mesh, or even through several layers, and these are then held together by this 'button' preventing the net from unfurling vertically as it is set. This was not seen during this sea trial, although it was observed in the flume tank tests.

Deployment

Prior to deployment all four models of pingers used on the trial were acoustically tested by listening to them using hearing or a bat detector where required. Pingers were attached at 200m intervals at the start of individual 100m nets. This was done during hauling in order that sufficient time was available to adequately tie each pinger. There was not enough time available in one hauling cycle to attach pingers at intervals of less than every 200m hence two pinger types were set at longer intervals than recommended (Table 2). Attachment was carried out using methods adapted to each pinger.

AIRMAR gillnet pingers were attached using white braided nylon as shown in Figure 5. A clove hitch was tied through the transverse hole at the end. The tail was half hitched around the standing part and the end of the nylon melted with a soldering iron to seal it up and prevent slippage.

AQUA*mark* pingers were attached using bespoke black knot-less nylon net bags tightly drawn around the pinger and white braided nylon, Figure 6. The nylon was passed under the net bag and through the single hole at the end of the pinger.

Fumunda pingers were attached using braided green nylon as supplied by the manufacturer; Figure 7.

SaveWave pingers were initially attached using cable ties as per manufacturer's instructions. This method failed and they were subsequently tied on to the float line using white braided nylon; Figure 8.

All pingers were attached as tightly as possible to the float line through the lay of the rope, using a rolling hitch at both ends, adjacent to a float.

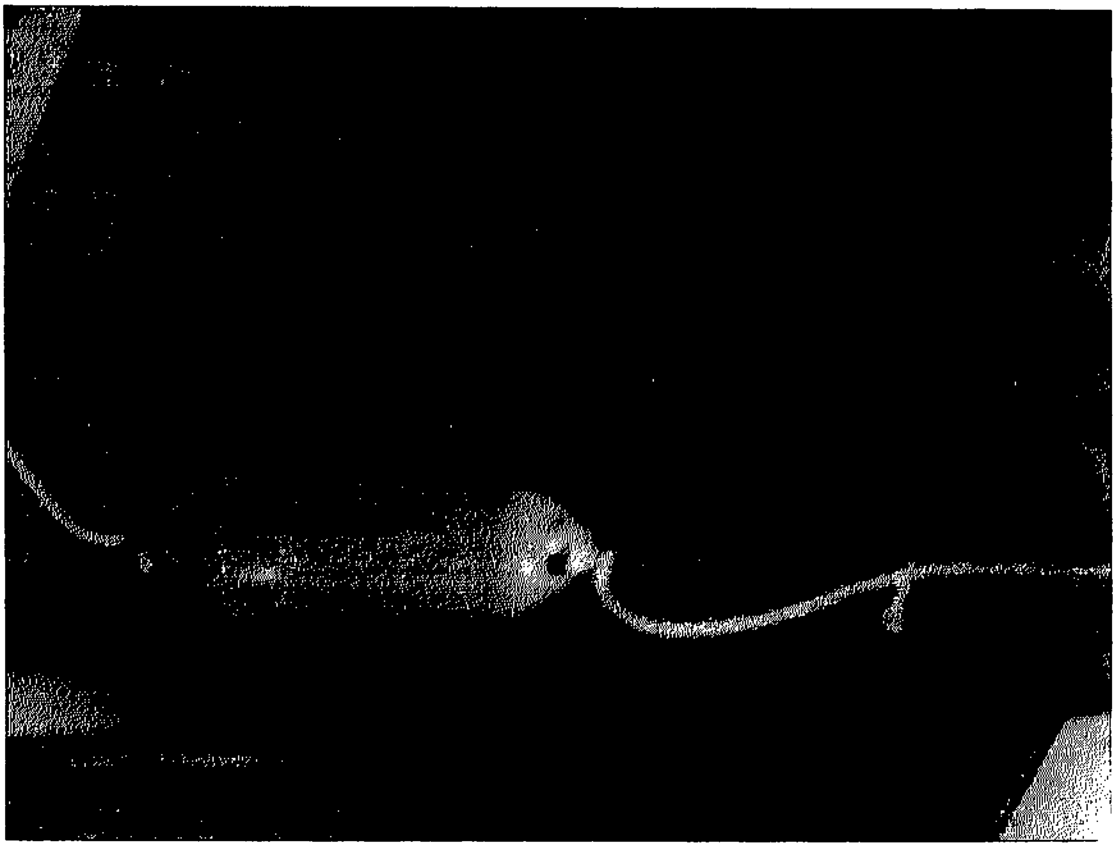

Figure 5 White Nylon for attachment of AIRMAR pingers

Figure 6 Net bags made up for attachment of AQUA*mark* pingers

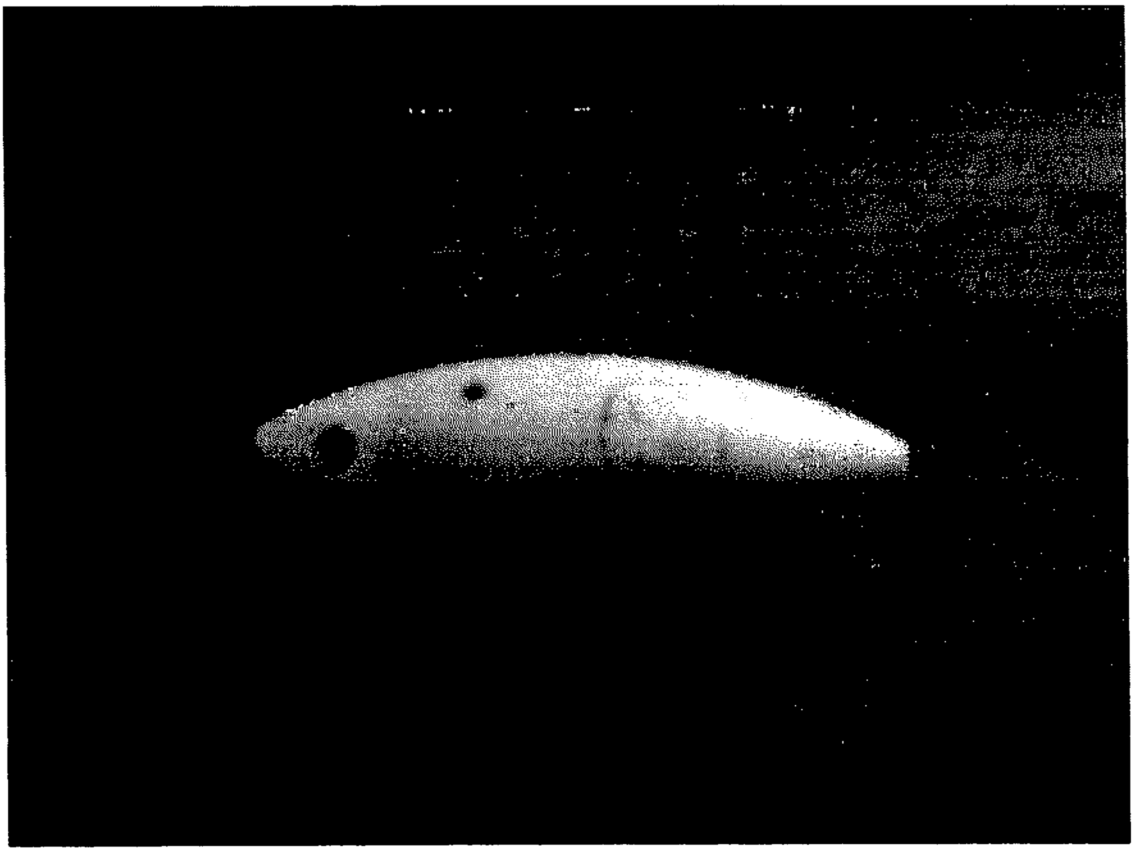

Figure 7 Fumunda pingers with nylon as supplied for attachment

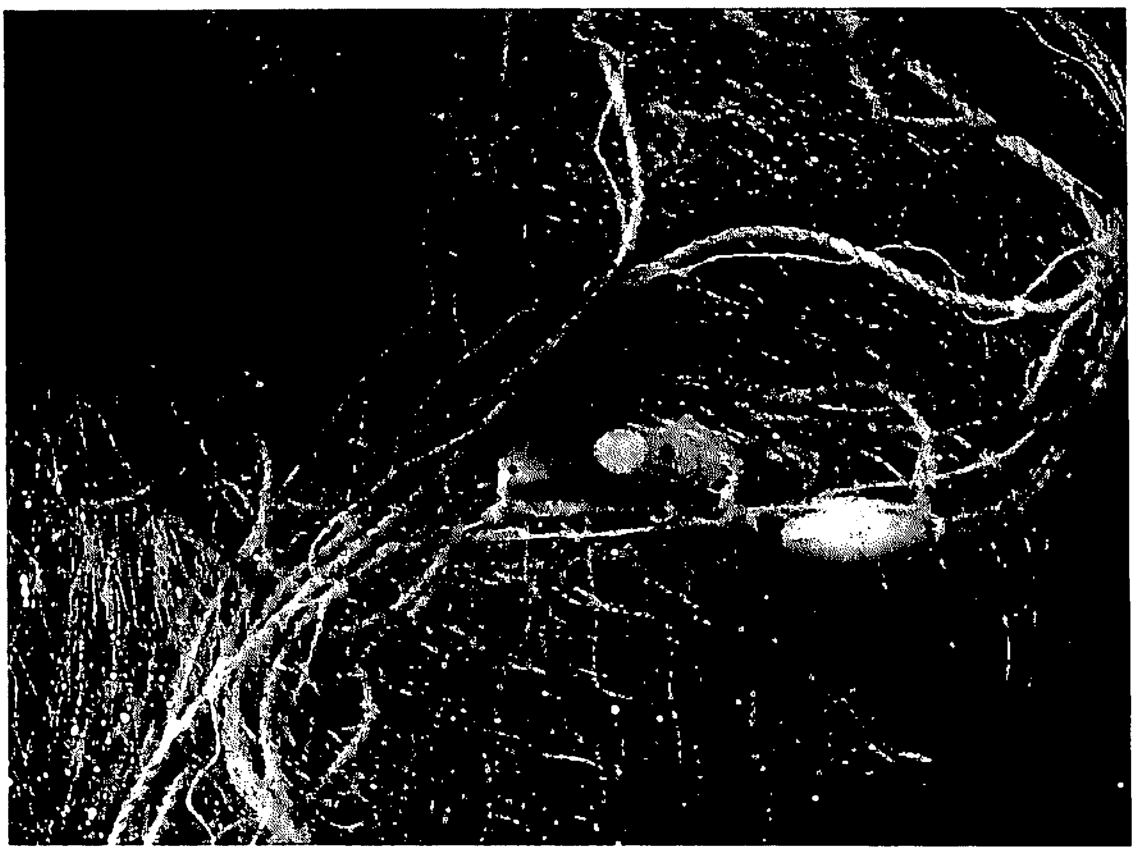

Figure 8 SaveWave pinger attached to net with white nylon

Table 2 Pinger Spacing

Type of Pinger	Spacing Recommended (m)	Spacing Achieved (m)	Number Attached*
AIRMAR gill net pinger	100	200	25
AQUAmark 100	200	200	25
Fumunda FMDP-2000	100	200	25
Save Wave Saver	200	200	25

The pingers were numbered and deployed on the gear as described in Table 3. This table shows the number of pinger deployment cycles achieved for each type. All the types except the SaveWave achieved approximately 100 shooting and hauling cycles. The reason for the SaveWave deficit was the attachment problems encountered during the trip.

Table 3 Deployment Data

		Pingers Deployed			
Date	**Ties Hauled**	**AIRMAR**	**AQUA *mark***	**Fumunda**	**SaveWave**
16/09/2003		4 Tiers of Hake nets shot			
17/09/2003	4	25 set	25 set	22 set	
18/09/2003	4	25		22+3set	25 set
19/09/2003	3	25	25	25	
20/09/2003	5	25	25	25	*12 set
21/09/2003	3		25		11
22/09/2003	5	25	25	25	11
Total deployment cycles		**100**	**100**	**97**	**58**

*= 23 Pingers fell off during hauling. 10 pingers reset using braided nylon ties + 2 remaining cable tied on the gear: one of these two pingers were subsequently lost.
Total deployment cycles= Number of Pingers Deployed x Number of times soaked (shot and hauled)

Role of the Observer

The Seafish observer remained onboard for the full duration of trip and carried out the above tasks. Video and photographic observations were made and records of pinger performance were taken. A note was made of functioning pingers adjacent to bycatch.

The observer removed all observed pingers at the end of the trip, although there remains the possibility that some pingers may remain attached to the gear (see unaccounted for pingers).

6. Results

Practicalities; Pinger attachment, battery changing, and testing

It was possible to attach, monitor and subsequently remove pingers with the use of an observer. However, normal manning levels are such that it would be extremely difficult for a member of the crew to carry out these tasks.

There are three possible times for attachment:

1. In the net loft during rigging of the net. This could be several months before sale and use of the net, and in that time a large part of the pinger's battery power could have been used, particularly in models without immersion switches. This would be the ideal location for attachment, being dry, safe, and operating at the speed appropriate to this task.

2. During boarding of the gear for the first time. This is generally done in port alongside the quay, and uses the whole crew for this task. It occurs only when gear is replaced or when the vessel is being painted or major maintenance is required. A person stationed in the net pound could attach pingers during this process. The removal and boarding of the gear requires the involvement of the entire crew and skipper (usually 5 men) and takes approximately two days to complete this task.

3. During hauling, as done in this trial. Although the most practical it is the most problematic; it is done at sea, which may be rough, under time pressure and with other activity in the very limited deck space. This method requires an extra crew member, as it occurs when the crew are at their busiest. The addition crew member would be required to remain onboard for the duration of the trip, approximately 8 days.

The time constraints on all these processes mean that that attachment must be easy to use but robust so that it does not have to be carried out too often and can stand up to the rigorous environment.

Battery changing at sea is impractical due to the corrosive nature of seawater. Furthermore, the tightness of the attachment to the headline that is needed to prevent button-holing also makes it impossible to open pingers without removing one end from the net. This would greatly slow down the process of changing the battery.

Testing

Pingers with both audible pings and no switches are easily tested; in this trial the AIRMAR pinger operated in this way. Other models with switches all switch off very soon after leaving the sea, and they are then difficult to re-test as this requires re-immersion. One model then requires up to 20 seconds to restart (the Fumunda) but is audible. Manufacturers of audible pingers with switches have said they would be able to make the pingers run for a few minutes after leaving the sea.

The others (AQUA*mark* and SaveWave) cannot be heard without use of a bat detector. Seaworthy bat detectors are not currently available and present models would need headphones to be heard on the noisy deck of a ship.

Testing all pingers ashore is a major task as all the gear has to be hauled off the boat using the full crew, and hauled back after testing. Opportunistic testing of small samples of accessible pingers is practical at sea or ashore, but the system would have to be designed to give a valid sample.

Pinger Models Trialed

The summary of pinger attributes is shown in Table 4 and a detailed breakdown of the results by model is shown in Tables 5-8 (Appendix 1).

AIRMAR: gill net pinger; Table 5
This was one of the two models that were all still pinging at the end of the trial. Pings are audible at all times as there is no switch, and may prove irritating to crews. Limited damage from the attachment lines was seen on most, and there may be some risk of failure of the attachment points at each end after repeated impacts. One unaccounted for at the end of the trial.

AQUAtec: AQUA*mark* 100; Table 6
Many were not pinging at the end of the trial when tested with bat-detector or hydrophone. Pings are inaudible to the unaided ear. At the end of the trial one was pinging even when not immersed.

These pingers were deployed in bags to prevent the button-holing seen in the flume tank tests. These bags were constructed of small-mesh knotless nylon net sewn tightly around the pinger to achieve attachment points at both ends. This successfully prevented button-holing but may not last for the lifetime of the pinger. Two pingers unaccounted for at the end of the trial.

FUMUNDA: FMDP 2000; Table 7
23 of 25 were not pinging at the end of the trial. This was due to problems with the battery contacts, which may be easily remediable by the manufacturer. Pings are audible when immersed.

These gave the most easy and trouble-free attachment to the gear. They are the smallest and can be difficult to spot as they come inboard. No damage was seen to the pinger housing. All accounted for at the end of the trail.

SaveWave: Saver Table 8
All were pinging at the end of the trial. Pings are not audible. Manufacturer's attachment with nylon cable ties did not work well, but a braided nylon line attachment was satisfactory. This is the most buoyant pinger.

Five pinger housings were seriously damaged with cracks through key structural points of the housing, and others had minor internal damage that allowed the acoustic unit to move around. This damage occurred after half the set/haul cycles experienced by the other models. All but 1 accounted for at the end of the trail.

Table 4 Summary of Pinger attributes - quantitative where possible

	AIRMAR	AQUAmark 100	Fumunda	Save Wave Saver
Number of deployment cycles	25 X 4 hauls = 100	25 X 4 hauls = 100	22 X 1haul + 25 X 3 hauls = 97	25 X 1haul +11 X 3 hauls = 58
Deployment				
Ease of attachment	Average - tied with white braided nylon	Difficult: only one attachment point. Requires attachment using netting bags and white braided nylon; potential for chafing through netting over time.	Excellent:- Green braided Nylon used as supplied by manufacturer	Poor by manufacturers instructions using cable ties; OK when tied on with white braided nylon
Propensity to buttonhole	Not seen	Low with netting; high without netting, buttonholed in flume tank when hung from a single point	Not seen	Not seen
Propensity to foul gear in other ways	Not noted	Twice noted snagged in net flaking machine	Not noted	Not noted
Shoots and hauls successfully	Yes	Yes	Yes	No; detached during hauling
Proportion of Pingers accounted for	24/25	23/25	25/25	24/25
Robustness				
Proportion of pingers damaged externally	18/24	0/23	0/25	5/24
Proportion of pingers seriously damaged	0/24	0/23	0/25	5/24
Proportin of pingers not functioning	0/24	12/23	23/25	0/24
Batteries				
Availablity	Very good	N/A	Available through industrial distributors	N/A
Ease of replacement	Excellent - standard batteries used	Manufacturer's job - Whole pinger replaced	Needs care due to risk of damage to contacts	Manufacturer's job - Acoustic section removed

Cetacean bycatch

The crew observed one bycaught porpoise during hauling. The animal dropped out of the net prior to boarding. Tests of the adjacent pinger post-hauling (within 100m of the porpoise) indicated that the pinger was operating. This cannot be considered a valid observation of pinger function as a deterrent, since no trial has reported zero bycatch in the pinger containing nets and this trial was not large enough to have sufficient statistical power.

Significance of failure rates

Sea trials of pinger strings (Dukane pingers at 100m spacing) have shown that porpoises rarely crossed a 2 pinger gap (Berggren et al. 2002). We have modelled the frequency of gaps created by two or more failed pingers for different rates of randomly distributed pingers failures.

The results are shown graphically in Figure 7. These demonstrate that when pinger failures are infrequent they are unlikely to produce large gaps in the pinger sequence, and consequently are likely to have little effect, providing that pingers are deployed at the manufacturer's recommended spacing. The Aquamark 100 and SaveWave Saver are acoustically more powerful than the other pingers and have 200m as their recommended spacing, as opposed to 100m for the others.

The assumption is that a pinger covers the net up to the next pinger, so no acoustic gap appears until two adjacent pingers fail and the gap is then only one pinger spacing long:

Gap length = pinger spacing * (number of adjacent failed pingers – 1)

This model assumes the end pinger is 100m in, and a gap appears if this one fails.

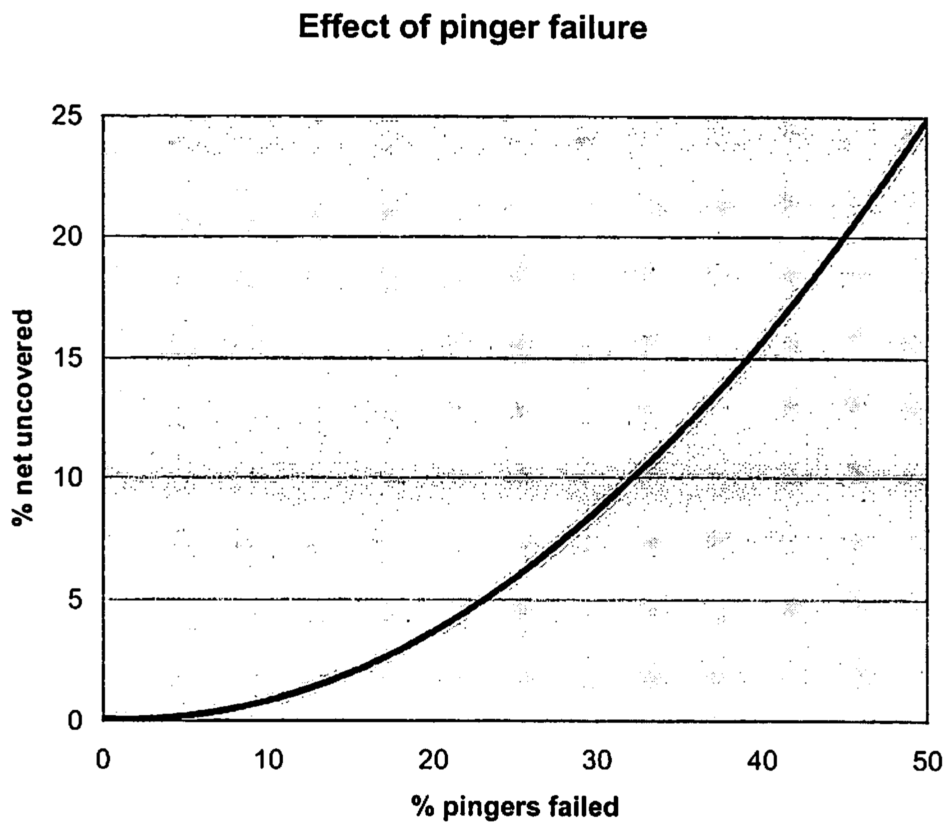

Figure 7 Percentage net not covered v percentage of pingers failed.

7. Discussion

Despite covering only 4 set/haul cycles this has been a very useful trial, with results that indicate that some pingers are unsuited to use in this off-shore gill net fishery in their current commercial form. In other gillnet fisheries with different shooting and hauling practices the results might be very different. The pingers are discussed below with the manufacturers' comments in italics

Relative Performance

At present only the **AIRMAR** gill net pinger is suitable, without any modification, for further trials.

The manufacturer's engineers analysed the AIRMAR pinger housings and came to the conclusions that the plastic deformation (at the attachment eyelets) was minor and should not result in mechanical failure. They consider that there would have been no mechanical deformation if the attachment lines had exited from the centre hole. However, they recognise that with the existing design this is difficult and they will be modifying the design to make this easier.

The **AQUAtec** AQUA*mark* 100 has both attachment and electronic problems. Improved attachment would require re-design of the casing including attachment points at both ends. We are unable to assess the difficulties of rectifying the electronic problems.

The manufacturer has redesigned the casing to include attachment points at both ends and the vulnerable end plate switch removed. The electronic problems were found to be a consequence of the batch of resin used for the trial pingers being contaminated. This made the resin case more liable to cracking and hence water ingress into the components. This has been established through controlled trials of pingers of this and previous batches. This problem will be solved by elimination of contaminated resin from the manufacture.

The **Fumunda** FMDP 2000 pinger performed particularly well in terms of compatibility with the gear, and appears to have only a battery contact problem that may be easily rectified by the manufacturer. The battery is an unusual type of lithium cell that may be less easy to source than standard D cells. *The manufacturer intends to alter the design of the battery contacts in order to avoid the contact problems.*

The **SaveWave** Saver pinger housing in its present form is not able to withstand the conditions of this fishery although the pinger otherwise performed satisfactorily. *The manufacturer intends to improve the materials and design of the pinger case and its means of attachment.*

As this trial was limited in duration the longer-term durability of the pinger types cannot be inferred reliably. Also the trial was carried out during

September when sea temperatures were relatively high there is a need to ensure that plastics used will not become brittle in cold conditions.

8. Further Work

The Fisheries Sub Group met in November 2003 to discuss these results with the pinger manufacturers. Three manufacturers were present; Aquatec, Fumunda and SaveWave, whilst AIRMAR sent their comments in writing. The group recognised that there was a requirement to have more than one pinger suitable for use in the fishery if possible, because this would improve competition and hence increase the likelihood of innovation and avoid escalation in pinger costs. To proceed with an endurance trial (phase 2) with only one pinger functioning, increases the risk that no pinger would be found suitable for commercial use because a fault could develop in that pinger. However, the group recognised that there was a requirement to find a suitable pinger in a relatively short period of time.

It was agreed that the endurance trial should commence in February 2004 and that the manufacturers should develop the means to avoid the faults in their pingers uncovered by the deployment trial. During the development period (November 2003- February 2004) the manufacturers would test their pingers in simulations and Seafish would provide industry liaison for limited field testing where appropriate. The pingers would be tested after the first trip of the endurance trial and any designs not performing satisfactorily would be eliminated at that point.

Other aspects that would be developed would be protocols for pinger attachment, testing and maintenance. These would be developed as a part of Phase 2, the endurance trial.

Possible approaches include:

1. Further work developing attachment methods in order that there is minimal interaction with the gear, attachment is made as quick and easy as possible and impact damage to the pingers minimised.

2. Designated personnel ('accredited pinger fitters') to assist fishermen with the attachment, testing and maintenance of the pingers. These personnel could be responsible for keeping records of the pingers on the different vessels in the fleet and keeping stocks of pingers to supply vessels when required.

3. The development of technology for testing pingers. The first step would be to design those pingers which are seawater activated to function for a period after they have left the water so that they could be checked as they are hauled aboard. Those pingers that are in the ultra sonic range, (including the 10 Hz for some people) are best tested in the water and it may be feasible to develop a hydrophone system that would enable the skipper or enforcement authorities to test the pingers as they were being hauled[2].

[2] It is understood that one manufacturer is already developing such a device.

Phase 2 would include the estimation of costs of a pinger programme and consider how such a scheme could be accredited to secure its integrity.

9. References

Berggren, P., J. Carlstrom and N. Tregenza (2002). Mitigation of Small Cetacean Bycatch; Evaluation of Acoustic Alarms. Report to European Commission on Study Contract 00/031.

DEFRA (2003). UK Small Cetacean bycatch response strategy DEFRA,London 33pp

Goodson, A. D., et. al. (2001). Project ADEPTS: Acoustic Deterrents to Eliminate Predation on Trammels, Final Report to the European Commission DG XIV 898/019 European Commission, 110pp+Appendices

Kraus, S., A. Read, E. Anderson, K. Baldwin, A. Solow, T. Spradlin and J. Williamson (1995). A Field test of the use of Acoustic Alarms to Reduce Incidental Mortality of Harbour Porpoises in Gill nets IWC. Document SC/47/SM17 submitted to the IWC Scientific Committee May 1995

Larsen, F. (1999). The effect of acoustic alarms on the by-catch of harbour porpoises in the Danish North Sea gill net fishery: A preliminary analysis presented to the IWC Scientific Committee, May 1999, Grenada, West Indies (unpublished), Paper SC/51/SM41 available from the IWC office. International Whaling Commission, 8pp

Northridge, S., D. Vernicos and D. Raitsos-Exarchopolous (2003). Net Depredation By Bottlenose Dolphins in the Aegean: First Attempts To Quantify And To Minimise the Problem International Whaling Commission, SC/55/SM25

Northridge, S. P., N. Tregenza, E. Rogan, M. Mackey and P. Hammond (1999). A sea trial of acoustic pingers in Celtic shelf gillnet fisheries. Paper presented to the Scientific Committee of the International Whaling Commission, May International Whaling Commission, Grenada, SC/51/SM43

SMRU, UCC, CFPO and ISWFO (2001). Reduction of porpoise bycatch in bottom set gillnet fisheries. Report to the European Commission, Study Contract 97/095.

Appendix 1 Tabulations of results by pinger type

This Appendix tabulates and summarises the results by pinger type and individual pinger using either manufacturer's serial numbers or numbering system devised by observer and written on the pinger cases with indelible marker. Not all pinger types were deployed for the same number of deployment cycles; see Table 3 p 16 for details.

Table 5 AIRMAR gill net pinger results

Code No.	Working Yes/No	External Damage	Description
1	Y	No	
2	Y	Yes	Slight Compression both ends
3	Y	Yes	Slight Compression one end
4	Y	Yes	Impact Damage
5	Y	Yes	Slight Compression one end
6	Y	No	
7	Y	No	
8	Y	Yes	Slight Compression both ends
9	Y	Yes	Slight Compression one end
10	Y	Yes	Slight Compression one end
11	Y	Yes	Slight Compression both ends
12	Y	Yes	Slight Compression one end
13	U		
14	Y	Yes	Slight Compression one end
15	Y	Yes	Slight Compression one end
16	Y	Yes	Slight Compression both ends
17	Y	No	
18	Y	Yes	Slight Compression one end
19	Y	No	
20	Y	Yes	Slight Compression one end
21	Y	Yes	Slight Compression one end
22	Y	Yes	Slight Compression both ends
23	Y	Yes	Slight Compression one end
24	Y	Yes	Slight Compression one end
25	Y	No	

Summary	Numbers
Pingers Deployed	**25**
Pingers Unaccounted	1
Pingers Active	24
Pingers Inactive	0
External damage observed	18

Table 6 AQUA*mark* 100 pinger results after

Pinger ID.	Working Yes/No	External Damage
3921	N	No
3926	Y	No
3928	N	No
3929	Y	No
3933	N	No
3937	N	No
4084	N	No
4096	Y	No
4099	N	No
4164	N	No
4168	N	No
4174	Y	No
4179	N	No
4240	Y	No
4241	Y	No
4243	Y	No
4246	Y/Constant	No
4249	Y	No
4250	N	No
4253	N	No
4254	U	No
4257	Y	No
4400	N	No
4413	Y	No
4419	U	No

Summary	Numbers
Pingers Deployed	25
Pingers Unaccounted	2
Pingers Active	11
Pingers Inactive	12
External damage observed	0

Table 6 Fumunda FMDP 2000 pinger results

Pinger ID.	Working Yes/No	External Damage
1	N	No
2	N	No
3	N	No
4	N	No
5	Y	No
6	N	No
7	N	No
8	N	No
9	N	No
10	N	No
11	N	No
12	N	No
13	N	No
14	N	No
15	N	No
16	N	No
17	N	No
18	Y	No
19	N	No
20	N	No
21	N	No
22	N	No
23	N	No
24	N	No
25	N	No

Summary	Numbers
Pingers deployed	25
Pingers Unaccounted	0
Pingers Active	2
Pingers Inactive	23
External damage observed	0

Table 8 SaveWave pinger results

Pinger ID.	Working Yes/No	External Damage	Description
3405342	Unaccounted		
3405344	Y	No	
3405356	Y	No	
3405357	Y	No	
3405370	Y	No	
3405390	Y	No	
3405398	Y	No	
3405409	Y	No	
3405411	Y	Yes	Crack
3405415	Y	No	
3405417	Y	No	
3405419	Y	No	
3405427	Y	No	
3405430	Y	No	
3405443	Y	No	
3405452	Y	No	
3405461	Y	No	
3405466	Y	No	
3405467	Y	Yes	Multiple Cracks
3405473	Y	No	
3405475	Y	No	
3405476	Y	No	
3405478	Y	Yes	Serious Crack
3405493	Y	Yes	Slight Crack
3404595	Y	Yes	Cracked Broken

Summary	Numbers
Pingers Deployed	25
Pingers Unaccounted	1
Pingers Active	24
Pingers Inactive	0
External damage observed	5

