# Assessment of Acoustic Deterrent Devices in Irish Gill Net and Tangle Net Fisheries

**Marine Technical Report : Project 05MT07**

**November 2005**

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## 1. Introduction

European Council Regulation No. 812/2004 lays down measures concerning incidental catches of cetaceans. As part of this regulation, all vessels of 12m or over in overall length are prohibited from using any bottom-set gill net, entangling net or driftnet from fishing without the simultaneous use of active acoustic deterrents. The fisheries in Ireland that will be most affected by the acoustic deterrent element of the regulation are those employing bottom-set gill nets or entangling (tangle) nets of any mesh size in ICES divisions VII g, h, and j (Figure 1). In these waters the regulation comes into force from 1st January 2006.

This regulation has major financial and operational consequences for Irish vessels over 12m using gill nets and tangle nets (commonly referred to as "static nets"). Static Net fisheries expanded in Ireland in the early 1990's before diminishing in the late 1990's with an increase in twin rigging for monkfish (*Lophius piscatorius*) and prawns (*Nephrops norvegicus)*. In 2003 approximately 39 vessels over 12m were involved in static net fisheries, primarily targeting hake off the west and south west coasts in the spring and autumn, cod off the south east coast in the winter and spring, and monkfish and turbot off all coasts during the summer months. In 2005 it is estimated that this figure has reduced to 20 vessels over 12m. On average these vessels operate a total of 40 - 50km of fishing gear although effort is generally divided between different fisheries for cod and hake at different times of year, using different gear types (source: Irish Fishermen's Producer Organisations and BIM area officers). A conservative estimate of total static gear effort by Irish vessels would be in the region of 800-1000km of gear at any one time. Irish salmon fishermen use drift nets in the summer months but this fishery is largely restricted to vessels under 12m and therefore acoustic deterrents are not required and are therefore excluded from this study.

Currently a number of models of active acoustic deterrents, also known as "pingers", are available and the specifications and costs vary considerably for each model. This study set out to examine the practical implications of deploying pingers in Irish fisheries affected by this regulation. Pingers were assessed in terms of their impact on fishing operations, basic specification, durability and potential costs to fishermen to comply with the requirements of the regulation. The study did not aim to directly examine the effectiveness of cetacean deterrent signals, although some anecdotal results are available in this regard; three porpoises were observed to be tangled in gill nets without pingers during this study. One was shaken out of the net alive and the other two were dead.

The Seafish Industry Authority (SFIA) in the UK has already carried out much work in this area. This study aims to complement and build on the Seafish studies by increasing the variety of fishing conditions to which the pingers are exposed. In addition, in consultation with SFIA, pingers have been extensively deployed on tangle net fishing gear in Ireland, as only limited work has been possible with this type of gear in the UK.

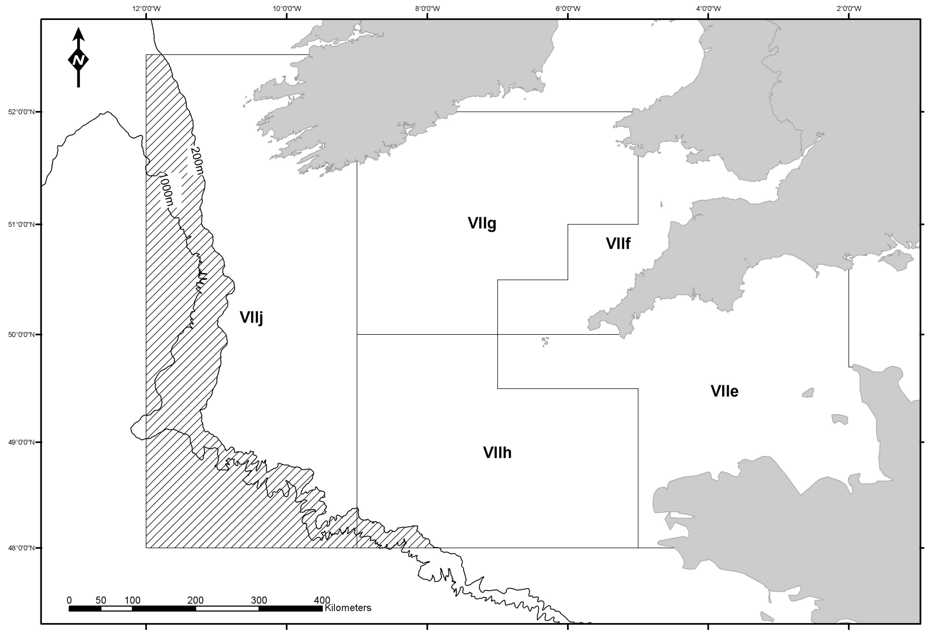



Figure 1. ICES Areas $VII_{g,\ h+j}$ where European Council Regulation No. 812/2004 will apply to Irish vessels

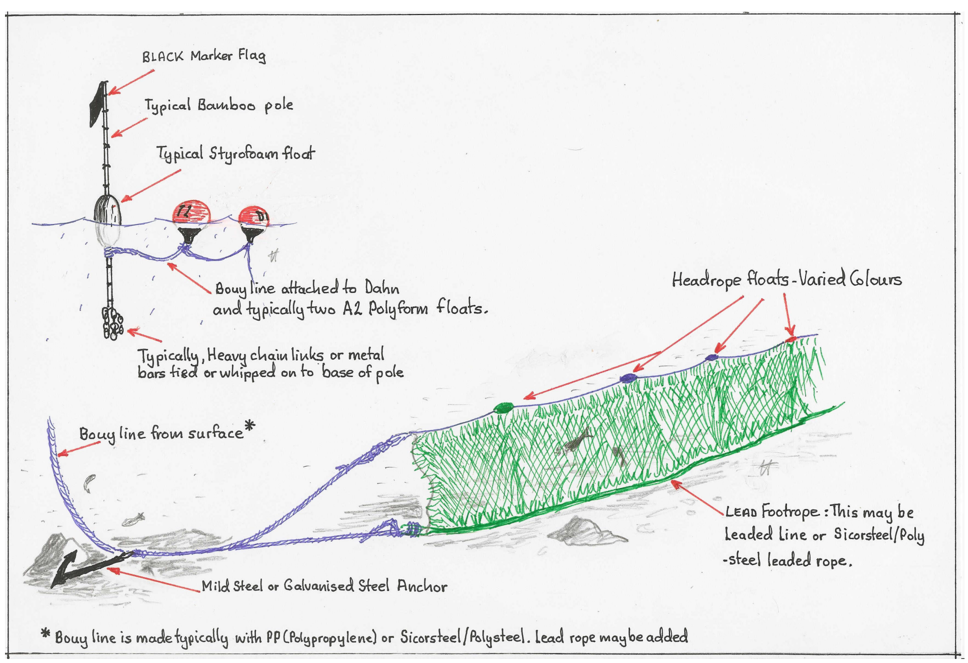



Figure 2. Outline of typical bottom set gill nets in Irish fisheries

## 2. Methods

### 2.1 Experimental design

This study was divided into two major trials. Trial 1 examined the impact of acoustic deterrents on gill nets and included an endurance trial to assess durability and battery life of pingers. Trial 2 examined pinger deployment on tangle nets and focussed on the expected difficulties with handling and deployment of the devices with this gear. These difficulties had been pointed out an early stage by fishermen involved in the trials and also during flume tank testing of pingers on tangle net gear carried out by SFIA in 2004. The Flume tank tests demonstrated that all pinger models were prone to tangling in large mesh nets. Details of the BIM trials are outlined in Table 1.

Trial 1 consisted of 6 fishing trips with onboard observers and a further 7 unobserved trips carried out on 2 different gill net vessels with all trips carried out under normal commercial fishing conditions. Two types of pinger were used during the first 4 trips and the other 2 types of pingers were used for the next 9 trips. Three slightly different forms of gill net were used during Trial 1 but it is assumed for the purposes of this study that the pingers had the same effect on these gill nets.

A total of 3 sampling trips *i.e.* one 7 day trip to sea and two blocks of day trips were conducted as part of Trial 2. Two different tangle net vessels were involved with all 4 models of pingers assessed during each trip.

The headropes on the tangle nets differed slightly for each vessel as described later. Normally tangle nets are deployed for a minimum period of 3 days. As such it was not practical to assess the effect of pingers on this type of gear under normal commercial fishing conditions and shorter soak times were employed during this study. Different pinger attachment methods were employed during the second phase of Trial 2 in an attempt to find a solution for attachment of these devices to tangle nets.

### 2.2 Data items recorded

Prior to trials commencing all pingers were checked to confirm they were working normally (i.e. “pinging”). An Ultra Sound Advice Mini-3 Bat Detector was used to test pingers that were inaudible to humans. The pingers were numbered with indelible marker so that individual units could be tracked for the duration of the trial.

The following data were collected during Trials 1 & 2: Vessel details, fishing operations equipment details, fishing gear specifications, sequence of pinger attachment and types of twine and knots used, external condition of pingers, functionality, effects of pingers on fishing operations and gear, dates and times, GPS positions, water depth, wind strength, commercial fish landings and cetacean bycatch. In terms of external pinger condition, in this study “damaged” refers to pingers that have undergone sufficient damage to the external housing as to be non-functional or are unlikely to survive subsequent shooting/hauling cycles. Tangling of the fishing gear caused by pingers was observed to occur but not quantified in Trial 1 on gill nets. Tangling caused by pingers that occurred at any stage during the hauling process was quantified during Trial 2 on tangle nets.

## 2.3 Fishing Operations

### 2.3.1 Vessel description

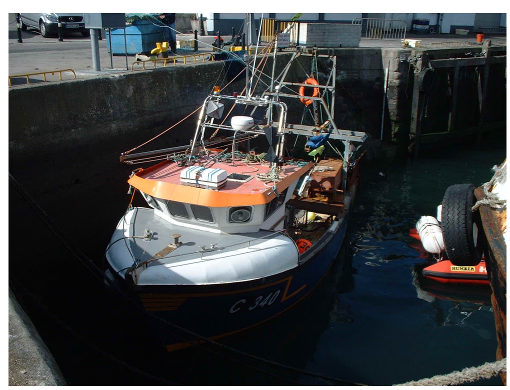
Four vessels (Figure 3) based in the south east of Ireland were chartered for the trials and are described in Table 2. Three of the vessels are full time gill netters based at the Co. Wexford port of Duncannon. The remaining vessel, the Stephanie Girl is based at the Co. Waterford port of Dunmore East and uses tangle nets for monkfish and turbot between May and September. All of the vessels had net haulers, and all with the exception of the Stephanie Girl had net flaking machines.

The Mellifont is wooden hulled with a forward wheelhouse, partially shelter decked and employs gill nets and tangle nets targeting cod, hake, monkfish and turbot throughout the year. The vessel successfully carried out trolling for albacore for the first time from July to October 2005. The Berachah is also wooden hulled but with a wheelhouse to the aft. The vessel also targets cod, hake, monkfish and turbot with gill nets throughout the year. The Western Dawn targets hake and cod using gill nets but had recently commenced trolling for albacore tuna in August and September 2005. The Stephanie Girl is a Holton 32 type trawler/potter, which carries out dredging for clams, tangle netting for turbot and trawling for herring on a seasonal basis. Both the Western Dawn and the Stephanie Girl are constructed from glass reinforced plastic with forward wheelhouses. Although the Stephanie Girl is less than 12m in length and will therefore not be affected by the acoustic deterrent regulation, the vessel uses fishing gear and methods similar to vessels over 12m in length and was therefore suitable for the tangle net work carried out in this study.

MFV Mellifont

MFV Berachah

MFV Western Dawn



MFV Stephanie Girl

Figure 3. The 4 vessels involved in the study

Table 1. Trial Details

| Fishing Vessel (MFV) | Trial No. | Pinger Model* | Observed/ Unobserved | Trip Start Date | Trip End Date | Days at Sea | Location | Fishing Gear |
|---|---|---|---|---|---|---|---|---|
| Mellifont | 1 | AM & AQ | Observed | 28/02/2005 | 05/03/2005 | 6 | Celtic Sea VII | Cod gill nets |
| Mellifont | 1 | AM & AQ | Observed | 05/03/2005 | 09/03/2005 | 5 | Celtic Sea VII | Cod Gill nets |
| Mellifont | 1 | AM & AQ | Unobserved | 18/03/2005 | 21/03/2005 | 4 | Celtic Sea VII | Cod gill nets |
| Mellifont | 1 | AM & AQ | Unobserved | 31/03/2005 | 05/04/2005 | 6 | Celtic Sea VII | Cod gill nets |
| Berachah | 1 | FA & SW | Observed | 12/04/2005 | 17/04/2005 | 6 | Celtic Sea VII | Cod Gill nets |
| Berachah | 1 | FA & SW | Observed | 01/05/2005 | 04/05/2005 | 4 | Celtic Sea VII | Hake Gill nets |
| Berachah | 1 | FA & SW | Observed | 11/05/2005 | 12/05/2005 | 2 | Celtic Sea VII | Hake Gill nets |
| Berachah | 1 | FA & SW | Observed | 16/05/2005 | 19/05/2005 | 4 | Celtic Sea VII | Hake Gill nets |
| Berachah | 1 | FA & SW | Unobserved | 29/05/2005 | 05/06/2005 | 8 | Celtic Sea VII | Hake Gill nets |
| Berachah | 1 | FA & SW | Unobserved | 08/06/2005 | 10/06/2005 | 3 | Celtic Sea VII | Hake Gill nets |
| Berachah | 1 | FA & SW | Unobserved | 10/06/2005 | 14/06/2005 | 5 | Celtic Sea VII | Hake Gill nets |
| Berachah | 1 | FA & SW | Unobserved | 14/06/2005 | 19/06/2005 | 6 | Celtic Sea VII | Hake Gill nets |
| Berachah | 1 | FA & SW | Unobserved | 20/06/2005 | 23/06/2005 | 4 | Celtic Sea VII | Hake Gill nets |
| Western Dawn | 2 | All Types | Observed | 27/07/2005 | 2/08/2005 | 6 | Celtic Sea VII | Tangle nets |
| Stephanie Girl** | 2 | All Types | Observed | 20/08/2005 | 25/08/2005 | 6 | Tramore & Creadan Bay | Tangle nets |
| Stephanie Girl** | 2 | All Types | Observed | 20/09/2005 | 22/09/2005 | 3 | Creadan Bay | Tangle nets |

* AM-Airmar, AQ-Aquamark, FA-Fumunda, SW-Savewave

** Day trips

Table 2. Vessel Specification

| Vessel Name (MFV) | Mellifont | Berachah | Western Dawn | Stephanie Girl |
|---|---|---|---|---|
| Registration No. | DA1 | W207 | T44 | C340 |
| Length overall (m) | 19.81 | 20.45 | 12.04 | 9.9 |
| Built | 1974, Killybegs | 1978, Arklow | 1987, Falmouth | 1996 |
| GT | 83.82 (GRT) | 85.71 | 35.07 | 6.5 |
| Engine power (KW) | 310 | 299 | 145 | 7.5 |
| Net hauler | Spencer Carter OH10 | Spencer Carter NH12 | Spencer Carter NH03 | Spencer Carter NH03 |
| Crew (excl. skipper) | 3 | 3 | 3 | 2 |

### 2.3.2 Fishing gear

A gill net can be defined as a length of multi- or monofilament mesh suspended between a buoyant headrope and a weighted footrope. Bottom set gill nets which are simply termed gill nets in this study are designed to catch fish whose body size is almost uniform since the mesh size must be matched to the fish's girth; the mesh size used depends on the species and size range being targeted. The headrope floats above the footrope that is set hard to the bottom and the meshes are spread between the two (Figure 2).

Tangle nets are a type of gill net generally with a larger mesh size than gill nets but are constructed much more loosely so that the meshes have smaller openings of elongated diamond form. In Ireland they are generally used to catch fish such as turbot, monkfish and rays, and also crawfish. In other countries they can be used to catch large size fish such as shark, swordfish and tuna. (Sainsbury, 1996). The types of fishing gears used in this trial are summarised in Table 3.

*Trial 1*

Trial 1 began during the Celtic Sea cod fishery but as the trial progressed the vessel switched to fishing hake with a smaller mesh size. The gill nets used in this trial were constructed of monofilament nylon meshes with a lead core, hollow braided line footrope, and 15mm twisted polypropylene rope with hollow gill net floats threaded at regular intervals for the headrope. Mesh size varied from 120mm for hake nets to 150 – 160mm for cod nets. Net sheets were approximately 235m in length with 18 sheets joined together to form fleets (also known as trains) of approximately 4,230m with a total of 6 fleets used by each vessel at a time.

*Trial 2*

Tangle nets used on the Western Dawn were 270mm stretched mesh size attached to 15mm braided rope connected to a 15mm 3-strand polypropylene headrope. These nets were 6.5 meshes deep, with a weighted footrope attached at the bottom of the net. The tangle nets used on the Stephanie Girl were the same except that the headrope was constructed of solid braided nylon rope instead of polypropylene so it was not possible to tie knots through the lay of the rope when attaching pingers in this case. Net floats were not used on these tangle nets, which normally rely on the slight buoyancy of the headrope and water current to provide some degree of lift underwater. The total length of the tangle nets deployed during the trial varied from approximately 2000 – 3000m during this trial.

Table 3. Fishing Gear Specifications

| Trial (No.) | Vessel (MFV) | Target species | Mesh size (mm) | Meshes deep (No.) | Sheets per train (No.) | Train length (m) | Fleets (no.) | Total gear length (m) |
|---|---|---|---|---|---|---|---|---|
| 1 | Mellifont | Cod | 150 | 35 | 18 | 4230 | 6 | 25380 |
| 1 | Berachah | Cod | 160 | 35 | 18 | 4230 | 6 | 25380 |
| 1 | Berachah | Hake | 120 | 51 | 18 | 4230 | 6 | 25380 |
| 2 | Western Dawn | Turbot | 270 | 6.5 | 32 | 3150 | 1 | 3150 |
| 2 | Stephanie Girl | Turbot | 270 | 6.5 | 15 | 1500 | 1 | 1500 |
| 2 | Stephanie Girl | Turbot | 270 | 6.5 | 20 | 2000 | 1 | 2000 |

2.3.3 Fishing procedures

*Trial 1*
This trial was carried out under normal commercial fishing conditions. Although the 2 vessels involved in Trial 1 had alternatively positioned wheelhouses (forward on the Mellifont and aft on the Berachah), fishing procedures differed only slightly for each vessel. Both vessels hauled the gear at the side of the vessel with the skipper controlling the hauler (Figure 4). One crewman worked next to the hauler, removing the catch from the net and making sure that fish did not pass between the wheels of the hauler. Another crewman operated the net flaking machine (Figure 5). This machine moves on rails above the net pounds and hauls the gear into the pounds whilst spreading the headrope and the footrope. A third crewman was involved in gutting and washing the catch. The net pounds on the Mellifont were located aft of the wheelhouse so shooting the gear simply involved deploying the nets directly over the stern gunwale. On the Berachah the nets were transported from the net pounds in front of the wheelhouse to the stern of the vessel through a chute and deployed over the stern. Both vessels carried out shooting while steaming at a speed of 5 – 6 knots with normal soak times ranging from 11 to 30 hours.

*Trial 2*
In order to maximise the number of pinger deployments during this trial, tangle nets were shot for artificially short periods so this trial was not strictly carried out under normal commercial fishing conditions. Fishing procedures were similar on the Western Dawn as described for the Mellifont in Trial 1. This vessel also had a forward wheelhouse, used net pounds, a net hauler and a net flaking machine (Figures 6 & 7) The vessel deployed gill nets for hake but agreed to shoot additional tangle nets for the purposes of this study.

The Stephanie Girl did not use net pounds or a flaking machine. The nets were manually hauled by 2 crewmen from the hauler to a storage area bordered by pound boards on the deck at the stern. The vessel carried out day trips that provided ample opportunity to carry out gear and pinger modifications in the evenings. Shooting speeds of 5 – 7 knots were observed during Trial 2. Soak times were 11 to 22 hours during Phase 1 and reduced to approximately 1 hour during Phase 2 of Trial 2 when the main objective was merely to try different attachment methods.

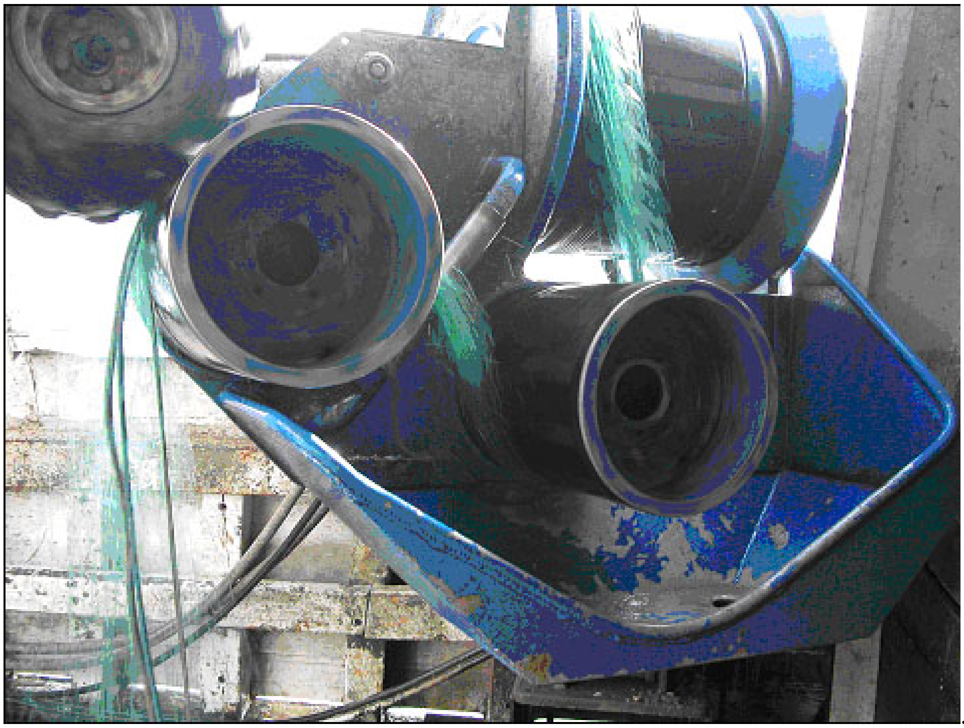


Figure 4. Spencer-Carter NH12 net hauler hauling gill nets on MFV Berachah.

Figure 5.  Net flaking machine and net pounds on MFV Berachah.

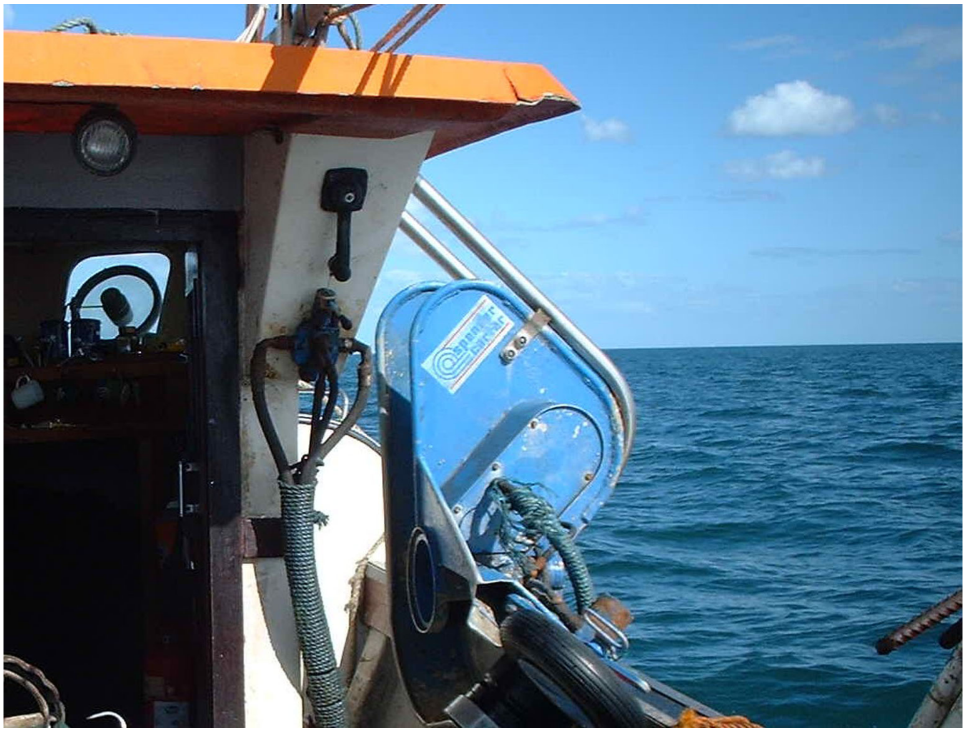


Figure 6. Spencer-Carter NH03 net hauler onboard MFV Stephanie Girl

Figure 7. Net flaking machine and net pounds onboard MFV Western Dawn

## 2.4 Acoustic deterrent devices

2.4.1 Pinger specification

Four types of acoustic deterrent devices/pingers were used in this study. The characteristics of these pingers are described in Table 4 and are based on the latest information acquired from the manufacturers. It should be noted that the Fumunda pingers were changed after Trial 1. In Trial 2, Fumunda supplied a new model with a modified battery holding tray and a stronger contact spring. The company also supplied 2 modified prototype pingers with increased buoyancy for use on tangle nets and these were tested in Trial 2. These prototypes were dummy models, as they did not contain any electronics (Figure 8). Apart from the changes to the Fumundas, the same pingers used in Trial 1 were used in Trial 2.


Figure 8. Airmar, Aquamark 100, Fumunda, Prototype Fumunda and Savewave (side and top view) pingers

Table 4. Specifications of available deterrent models October 2005.

| Manufacturer | **Airmar** | **Aquatec** | **Fumunda** | **Savewave** |
|---|---|---|---|---|
| Website | www.airmar.com | www.netPinger.net | www.fumunda.com | www.savewave.net |
| Model | Gill net pinger | AQUAmark 100 | FMDP-2000 | Dolphin Saver - High Impact System |
| Mitigation use | bycatch | bycatch | bycatch | depredation |
| **Physical and Practical Characteristics** | | | | |
| Cost (€) | 46 | 104 | 67 | 60 |
| Dimensions (length x diameter (mm) | 156 x 53 | 164 x 58 | 152 x 46 | 202 x 67 x 42 |
| Weight in air (g) | 408 | 410 | 230 | 400 |
| Max. Depth | 275 | 200 | 200 | 200 |
| Attachment details | 3-way holes each end | 2 holes each end | 3-way holes each end | 2 holes each end |
| Spacing along nets (m) (max recommended) | 100 | 200 | 100 | 200 |
| Signal human audible | Yes | No | Yes | No |
| Housing Material | Plastic Alloy | Urethane | Co-polymer | HIPS Styrosun |
| **Power Characteristics** | | | | |
| Battery type and Number | 1 D-Cell Alkaline | 1 D-Cell Alkaline | 1 lithium | 1 Sealed 9v unit |
| Approximate Battery Life (months) | > 12 | 16 - 24 | 15 | < 3 |
| Battery replaceable | Yes | No | Yes | No |
| Battery disposal | By operator | 20% discount on replacements | By operator | 20% discount on replacements |
| Wet switch | No | Yes | Yes | Yes |
| **Signal Characteristics** | | | | |
| Tonal/Wide band | Tonal | Wide band / tonal | Tonal | Wide band |
| Source Level (dB re 1µPa @ 1m) | 132 +/- 4dB | 140 | 132 +/- 4dB | 155 |
| Frequency (kHz) | 10 | 20-160 | 10 | 5-160 |
| Pulse duration (ms) | 300 | 200-300 | 300 | 200-900 |
| Inter-pulse period(s) | 4 | 4-30 | 4 | 4-30 |

### 2.4.2 Attachment methods

*Trial 1*

During Trial 1 all pingers were attached directly to the headrope of the gill net. Pingers were spaced at intervals of approximately 100m. Polyester, nylon and polypropylene twines of varying thickness and construction (braided and twisted) were used to attach the pingers to the headrope. The manufacturers of both the Fumunda and Savewave supplied materials to attach the pingers to the gear. The Fumunda was supplied with braided green twine and the Savewave with plastic cable ties. The Fumunda twine was used during Trial 1 but was attached using the same method as for other pinger models. The cable ties supplied by Savewave were used during trials carried out by Seafish on board UK vessels. Seafish found that the cable ties were unreliable. Therefore, the Savewave was attached using the same twine and knots as the other models. Regardless of the reliability issues it was also thought that the sharp ends of the cable ties would foul the gear.

A piece of twine, approximately 40 cm in length of twine was made fast to each of the 2-way attachment points located at either end of the pinger. The same attachment method using the 2 holes at each end was employed for all pingers (2-way and 3-way). The pinger was then knotted directly to the headline. The twine was anchored through the headrope by opening the strands of the polypropylene rope and passing a turn of twine through the lay of the rope. The knot used to attach twine to the pingers was the hangman's knot. The knot used to attach the twine to the headrope was the rolling hitch, with the addition of a turn through the lay of the polypropylene rope (Figure 9). Excluding the Savewave all of the pingers were negatively buoyant in water and were therefore attached adjacent to net floats in order to reduce the likelihood of the headrope sinking under the weight of the pinger.

Figure 9. Attachment of Aquamark pinger to 3-strand headrope

*Trial 2*

*Phase 1: Western Dawn*

The first phase of pinger trials on tangle nets focused on assessing the degree to which pingers foul the larger (270mm) mesh size of this type of gear. Pingers were attached directly to the headline of the tangle net in the same manner as Trial 1. Attachment took place in port as the tangle nets were being hauled on board the vessel. The Airmar, Aquamark and Savewave were attached in the same way as during Trial 1. An upgraded model of the Fumunda became available before the beginning of Trial 2 and replaced the previous model in the subsequent trials. The upgraded model was supplied with the same green polyester twine as was used during Trial 1. However in this case the manufacturer had already attached the twine to the pinger. The twine had been passed through the hole at the sharp end of the pinger and anchored using overhand knots so as to stop the twine slipping back through the hole. The new Fumunda was therefore attached using the manufacturer's method. Pingers were attached to tangle nets at intervals of approximately 50m for both phases of Trial 2.

*Phase 2: Stephanie Girl*

The second phase of Trial 2 focused on 2 issues. Firstly, as it became apparent during Phase 1 that tangling/buttonholing was a major issue when deploying pingers on tangle nets, attempts were made during this phase to modify and assess alternative attachment methods. The principal attachment modification involved placing pingers in 40 to 50cm lengths of 10mm knotless nylon mesh stocking with net floats, as suggested by Mr. Michael Murphy of Stuart Nets, Castletownbere. This modification aimed to soften the profile of the pingers and increase their overall dimensions in order to reduce gear fouling.

Secondly, the headrope on the tangle net in this trial was solid and it was therefore not possible to tie the pingers through the lay of the rope (Figure 9). Thus unmodified pingers were attached directly to the headline in order to assess the integrity of the knots on the single strand compared to the 3-strand rope.

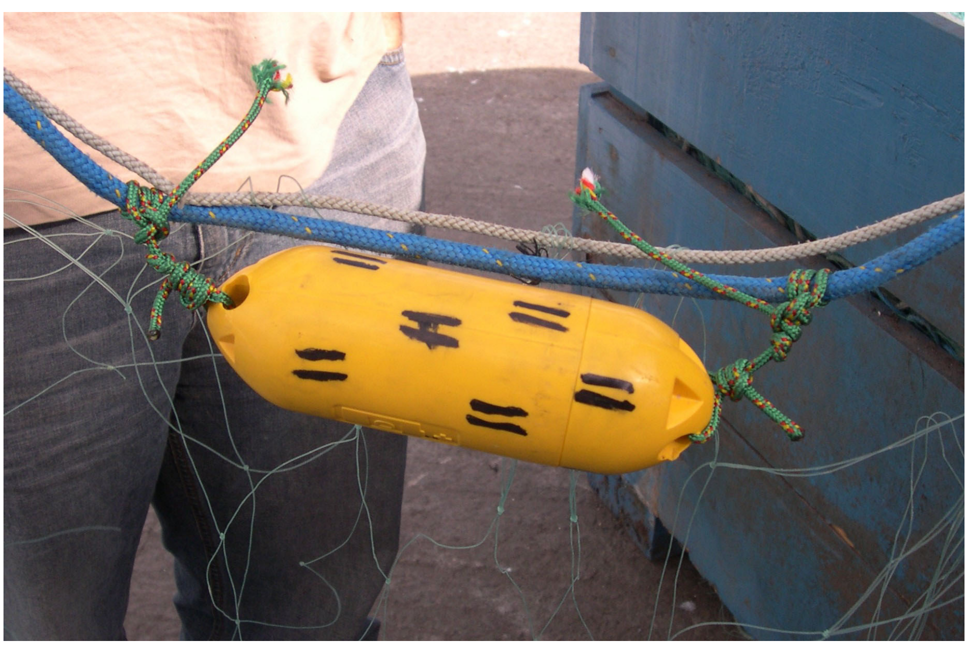


Figure 10. Attachment of Airmar pinger to solid braided headrope

## 2.5 Pinger assessment

### 2.5.1 Pinger performance

The proportion of pingers that were lost, became tangled in meshes, stopped pinging and were damaged was quantified at the end of observed hauls and at the end of unobserved hauls on gill nets in Trial 1, and at the end of all hauls on tangle nets in Trial 2.

### 2.5.2 Economic assessment of pingers

The long-term costs of pinger deployment will vary considerably for each pinger model given the different purchase prices and battery characteristics. Therefore an attempt was made to project the costs incurred by a typical Irish vessel using 20km of fishing gear throughout the year for a period of 5 years. A period of 5 years was considered adequate as pingers will probably need to be completely replaced and/or the technology may change with new types of pingers developed during this period. This model assumes that pingers emit continuous signals despite the presence of wet switches as described in the results and uses the maximum battery life specified by the manufacturer for each pinger. The cost of pingers was based on the exact price charged to BIM by manufacturers for the purchase of pingers used in this study. These prices may drop once large orders are placed but it is not possible to determine what these reductions will be at this stage.

### 2.5.3 Pinger score index

A scoring index based on the relevant specifications, practicalities of deployment and costs associated with each pinger model was developed. The index was not intended to provide an exhaustive guide to the best overall pinger, as important information concerning signal characteristics was not included. However given the large amount of information presented in this study, it does provide a useful and accessible summary of practical pinger performance in the specific fisheries described in this report. A simple score of 1 – 3 was applied to each pinger characteristic.

# 3. Results

## 3.1 Effect of pinger deployment on fishing operations

*Trial 1*

As the fishing gear was already present on both vessels involved in Trial 1, pingers were attached in port. The nets were manually hauled on to the quay, pingers attached and the gear hauled back on the vessel. This is considered as the best location for attaching pingers although ideally it should be carried out when the gear is first taken onboard the vessel to save on labour involved. Three men were required to carry out this work, two to haul the headrope and the footrope of the gear and one to attach the pingers. It is a time consuming process but less of a hindrance to fishing operations than attaching pingers at sea.

Attaching the pingers at sea would only be feasible during the hauling process. Attaching the pingers to the headrope generally takes 2 – 3 minutes and the speed of operations, in particular net flaking, will need to be reduced unless an additional crewmember is employed especially for this task. The Fumunda was the easiest model to attach because of their relatively small size and tapered ends. It was more difficult to secure the other models tightly to the headrope because of their size and shape. Consequently the knots attaching pingers to the headrope were frequently observed to loosen.

Pingers were observed colliding with the steel bars of the net pound during shooting but this did not slow down fishing operations. During hauling, the pingers were observed to come aboard cleanly and rarely fouled the gear. This could be attributed to the relatively small mesh size and the fact that deployed gill nets are relatively taut compared to tangle nets. The gear was hauled through the net hauler and piled beside the hauler while the catch was removed. When lying in a pile the pingers occasionally fouled the gear as they fell through the meshes and this caused problems when the gear travelled to the flaking machine.

The flaking machine hauled the gear from the deck, separated the headrope and footrope and transported the nets into the net pound. When a pinger was fouled, the gear tended to jam in the flaking machine and meshes were torn if the gear was forced through. In response the crew either hauled the net back in order to clear the gear before it was passed back through the flaking machine, or the crewman in control of the flaking machine climbed to the top of the pound to release the fouled pinger. It should be noted that this problem was not restricted to pingers and also occurred on occasion with net floats. Climbing to the top of net pounds (>2m high) was dangerous especially in heavy seas and the presence of pingers on the gear increased the frequency with which it was necessary to do this.

A record of fish landings was kept during this trial and no difference in catch rates was observed between gear with pingers and gear without. The skippers and crews expressed concern about the increased levels of gear fouling caused by the pingers but did not comment on catch rates.

*Trial 2*

*Phase 1 (Western Dawn)*
Pingers were attached to tangle nets in Phase 1 of Trial 2 in the same manner as Trial 1. The same problem with the pingers colliding with the net pound metal bars during shooting was observed as in Trial 1. The larger mesh size (270mm) of tangle nets was problematic as the meshes were bigger than the dimensions of the pingers. As a result pingers were observed to foul the gear as the net passed through the wheels of the net hauler, which compacted the head and footrope together (Figure 10). Pingers were found most likely to foul the gear as a pile of netting built up under the hauler.

Problems arose as the gear was lifted off the deck by the flaking machine. Pingers that had fouled in meshes did not allow the headrope and footrope to be separated in the flaking machine. Similar problems as occurred in Trial 1 occurred with the flaking machine jamming and gear transported fouled into the net pounds, but on a more frequent basis.

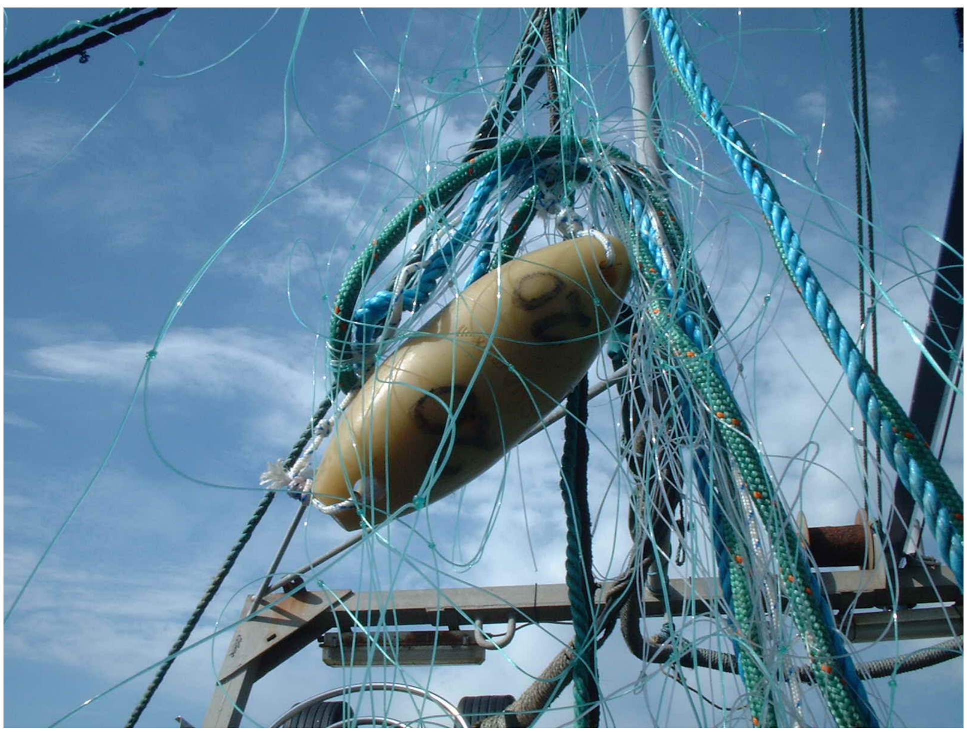


Figure 11. Pinger fouled in a tangle net

*Phase 2: (Stephanie Girl)*
Pingers were attached in port initially and the manual hauling process was the same as for the previous trials. Modified pingers took a similar length of time to attach as unmodified pingers.

The vessel had a stainless steel skirt that protected the stern from damage and pingers were observed to collide sharply with the edge of this skirt during shooting. The gear was hauled using the net hauler as in the previous trials. The single strand headrope tended to twist as it approached the hauler, which caused both modified and unmodified pingers to flip over the headline as they approached the hauler causing the gear to foul. The modified pingers, however, were observed to foul the gear less often than the unmodified pingers. No flaking machine was present so the two crewmen manually hauled the gear from the net hauler into the makeshift pound, which permitted them to clear tangles as they arrived.

The Savewave was the most prone to fouling the gear during the hauling process. The shape and weight of this model increased its propensity to foul and on several occasions Savewave pingers had to be removed in order to untangle the gear.

## 3.2 Effect of fishing operations on pingers

Relatively little external markings or damage was observed to occur during the hauling process during Trial 1 on gill nets. However the tangle gear was hauled aboard at an accelerated pace on the Western Dawn in Trial 2, as landings were low due to the short soak time. As a result nets were passed at speed through the hauler and net flaking machine, which was a particular area of heavy impact.

Most impact occurred during shooting when pingers came into contact with the steel bars of net pounds and the stern gunwale. This was a particular problem on the stern of the Stephanie Girl which had a stainless steel skirt with a sharp edge approximately 30cm below the gunwale. The external housing of pingers generally survived these processes well. Some deep cuts and scrapes were observed however after pingers were retrieved onboard the Stephanie Girl. Because of its size and shape the Savewave was particularly prone to heavy impacts. The Fumunda was less prone to impact at all stages of fishing operations because of its smaller size and tapered ends.

Internal damage, which may have occurred due to heavy collisions of pingers during fishing operations, was evident for all pingers when tested for functionality at the end of the trials. This damage is described in more detail in the proceeding section of the report.

## 3.3 Pinger assessment

### 3.3.1 Pinger performance

Details of the summary results of pinger performance are outlined in Table 5. Deployment cycles refer to the total number of pingers multiplied by the total number of hauls carried out for a particular model. Observed deployment cycles (ODC) occurred when a BIM observer was present. Total Deployment cycles (TDC) refers to the endurance trial when pingers were left on the gear after the BIM observer departed and is equal to the total number of observed and unobserved deployment cycles for a particular pinger model.

Table 5. Summary results from BIM pinger deployments

**Trial 1. Gill nets**

| Pinger Model | Pingers No. | **ODC* No.** | Pingers Lost No. | Fouled % | Not Pinging % | Damaged % | **TDC* No.** | Pingers Lost No. | Not Pinging % | Damaged % |
|---|---|---|---|---|---|---|---|---|---|---|
| Airmar | 15 | 105 | 0 | Nq** | 0 | 0 | 210 | 0 | 0 | 0 |
| Aquamark | 15 | 105 | 0 | " | 80 | 0 | 210 | 0 | 7 | 0 |
| Fumunda | 15 | 195 | 0 | " | 20 | 0 | 414 | 0 | 20 | 0 |
| Savewave | 15 | 165 | 0 | " | 33 | 0 | 450 | 2 | 62 | 7 |

**Trial 2. Tangle nets**

| Pinger Model | Pingers No. | **ODC* No.** | Pingers Lost No. | Fouled*** % | Not Pinging % | Damaged % |
|---|---|---|---|---|---|---|
| Airmar | 15 | 210 | 1 | 28 | 7 | 0 |
| Aquamark | 15 | 257 | 2 | 41 | 46 | 0 |
| Fumunda 1 | 15 | 223 | 1 | 23 | 15 | 0 |
| Fumunda 2 | 2 | 32 | 0 | 28 | n/a | 0 |
| Savewave | 13 | 211 | 0 | 47 | 83 | 17 |

*ODC: Observed Deployment cycles
TDC: Total Deployment Cycles (Endurance Trial)
**Not quantified
***These figures refer to unmodified pingers (not in bait bags)

*Trial 1*

No pingers were lost during the ODC in Trial 1. Pingers were observed occasionally becoming entangled in the gear coming out of the hauler and causing jams in the net flaking machine but this was not quantified in Trial 1. Pingers were tested for functionality at the end of the last ODC haul. After 105 deployment cycles, all of the Airmars were still pinging but just 20% of the Aquamarks appeared to be still functional after testing with a bat detector. Problems were encountered using this method to assess pinger functionality because of loud background noise and this figure was later proved to be inaccurate. Three out of fifteen (20%) Fumundas were found to be non-functional at this point and it was discovered later that this was due to internal damage. Five out of fifteen (33%) Savewaves were discovered not to be emitting an acoustic signal at the end of 16 days at sea during the ODC which may have been due to electrical problems encountered because of the high level of impact this model suffered during fishing operations. None of the pingers suffered sufficient damage to the external housings as to warrant their removal from the trial at this point.

At the end of the endurance trial (TDC), pingers were detached from the gear and examined ashore. Two Savewaves were lost, one without trace, while the other had snapped in half losing the electronics unit (Figure 11).

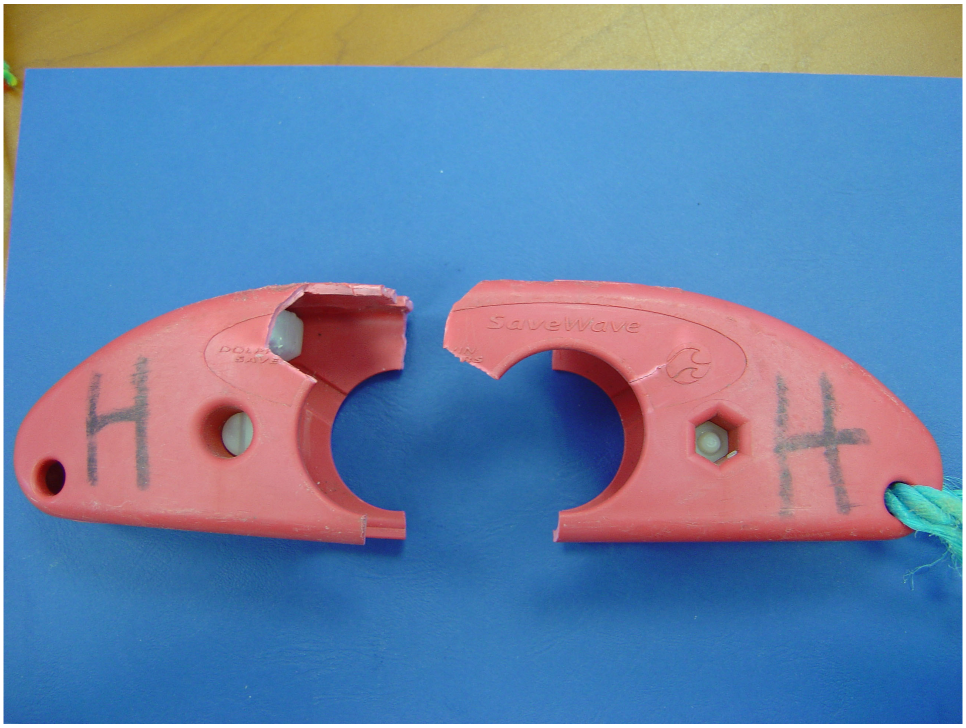



Figure 12. A Savewave snapped in two during gill net trials

All fifteen of the Airmars were still functional (still pinging) after a total of 210 deployment cycles and a total of 21 days at sea. However when the pingers were examined at the end of the trial it was observed that the positive terminal of the D-cell battery was compressed to some degree in all of the Airmars, which may have been caused by impact during fishing operations. Just one of the Aquamarks were discovered to be non-functional following testing with a bat detector ashore which was a considerable difference to the figure of 20% still functional at the end of the ODC. This highlights the problem of testing inaudible pingers at sea. Three of the Fumundas were still non-functional when tested ashore at the end of the TDC and it was discovered that this problem was due to internal damage to the spring, which made contact with the positive battery terminal. This problem was acknowledged and remedied by the manufacturer who provided an improved model in the subsequent batch of Fumundas, which were used in Trial 2.

Five out of thirteen (38%) Savewaves were non-functional at the end of the endurance trial. These pingers had been attached to the fishing gear and present in the sea or onboard the vessel for a total of 76 days which was approaching but still within their specified battery life of 2000 hours or 83 days. The one damaged Savewave (7%) refers to the pinger which had snapped in half.

*Trial 2:*

*Phase 1*

During Trial 2 each pinger model was tested between the joins of the nets as an alternative attachment location. This placed the full load of the gear on the pingers and resulted in one Fumunda and one Savewave coming apart. As none of the pingers were designed to endure this type of load, the units damaged in this fashion were not included when deriving the proportions of non-functional and damaged pingers outlined in Table 5. Thirteen Savewaves were available for Trial 2 because 2 were lost in Trial 1. One other Savewave was damaged after being deployed between the net joins. Fifteen new Fumundas with an improved battery holding tray and stronger spring were used in this trial instead of the older models. One of these pingers came apart having been placed between the net joins. In addition two prototype dummy Fumundas with greater buoyancy than the other Fumundas were tested. Trial 2 was restricted to observed deployment cycles (ODCs) and an endurance trial was not carried out. A higher quantity of ODCs were carried out in Trial 2 primarily because of the shorter soak times utilised in these non-commercial trips resulting in a greater number of hauls in less time.

A single Airmar, 2 Aquamarks and 1 Fumunda were lost during Trial 2 probably due to the attachment twine breaking. The twine attaching the Fumunda was observed to snap as the pinger travelled through the hauler and the pinger was lost through the scuppers before it could be recovered.

Fouling of the gear was a major occurrence for all pingers on tangle nets in Trial 2. The figures presented in Table 5 relate to unmodified pingers which had not been placed in bait bags and refers to tangles which occurred at all stages of the hauling process. In total an average of 34% of all deployed unmodified pingers became tangled during Trial 2.

One Airmar out of fourteen (7%) tested was found to be non-functional (not pinging) at the end of Trial 2. It is not clear why, but again the positive contacts on all of the batteries were compressed to some degree and this may have been a factor. Six out of thirteen (46%) Aquamarks were found to be non-functional at the end of Trial 2. It was not possible to carry out an internal inspection of the Aquamarks because they are sealed units. External examinations, however, revealed extensive marking and scarring to the wet switch at the ends of the pingers, as well as numerous bubbles in the resin on the body of the pinger unit. Two out of thirteen Fumundas (15%) were non-functional and were found to rattle internally behind the spring so they may have been damaged because of impact during fishing operations. Two out of twelve (17%) Savewaves were found to be still functional at the end of Trial 2. However these pingers had been at sea for approximately 5 months at that stage thereby surpassing their specified battery life of 3 months.

However, it was observed during Trial 2 that the Savewaves were prone to damage. Two out of twelve (17%) pingers were found to be badly damaged on inspection. These units were cracked through key structural points of the housing and were subsequently deemed beyond further operational use.

*Phase 2*

*Modified pinger attachment*

As it became clear during the course of earlier trials that pingers were prone to heavy collisions and falling through the meshes of tangle nets a modified system which involved placing each pinger in a bait bag with 1 or 2 net floats was tested during Trial 2. A total of 21 shooting and hauling cycles were carried out in Trial 2 with approximately 50% of pingers deployed in modified bait bags and the other 50% deployed as normal.

The average proportion of all unmodified pingers that became tangled in meshes was 34% while the average proportion of all modified pingers that became tangled was 18%. Therefore the amount of tangling which occurred in tangle nets was almost halved as a result of the bait bag modification.

It was not possible in this study to quantify reductions in damage to pingers, which occurred because of the modification. The net floats on either side of pingers, however, were observed to provide considerable protection to pingers during heavy collisions and it is possible to surmise that this method does result in reductions in pinger damage during fishing operations.

The system of pinger modification was further developed during the trial and the final version consisted of a single pinger unit between floats within bait tubing, with the end parts of the tubing tightly whipped with 3mm white nylon cord around a 4mm flattened nylon central cord holding both the pingers and the floats. Electrical taping was used to bind the nylon cord tightly with the bait tubing, creating a loop of nylon cord at each end, which simplified and speeded up the detachment and reattachment process (Figure 12).

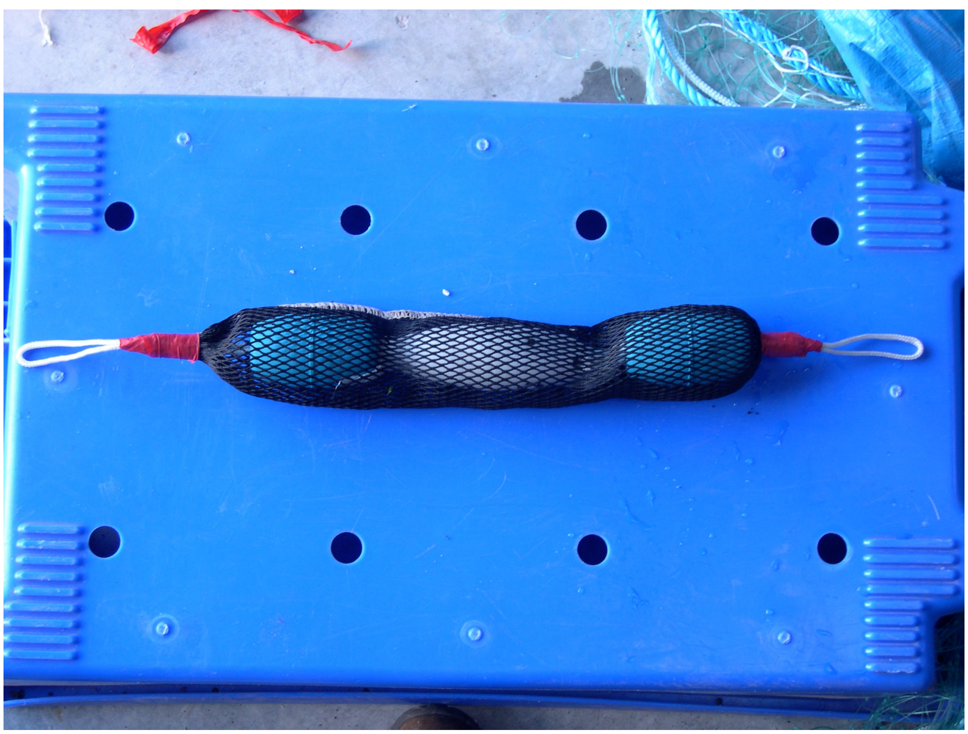


Figure 13. Modified Bait Bag

*Solid braided headrope*

Slightly different attachment knots were employed on the solid headrope in Trial 2 given that it was not possible to pass attachment cords through the lay of the rope. Consequently the knots attaching the unmodified pingers were observed to loosen over time and some eventually worked free (Figure 13). This problem was observed to occur more frequently on the solid headrope than other headropes. Heavier pingers such as the Airmar and Aquamark were more prone to knot slippage than the lighter Fumunda and the buoyant Savewave. Modified pingers attached directly to the headrope also showed signs of knot slippage.

One solution to this problem may be to place pingers at the "joins" where net sheets are connected by loops in the headrope and are designed to be taken apart quickly. However a system of attachment needs to be developed to ensure that pingers do not bare the full weight of the fishing gear between their attachment points, as they are not designed to take such a load.

Figure 14. A pinger coming loose on a solid braided headline

## 3.3.2 Economic assessment of pingers

Table 6. Estimated projected cost of deployment of pingers on 20 km gear for 5 years

| | Airmar | | Aquamark | | Fumunda | | Savewave | |
|---|---|---|---|---|---|---|---|---|
| Battery life (months) | 12 | | 24 | | 15 | | 3 | |
| Battery replaceable | Yes | | No | | Yes | | No | |
| No. pingers required | 200 | | 100 | | 200 | | 100 | |
| Unit cost (€) | 46 | | 100 | | 67 | | 60 | |
| Estimated battery cost (€) | 2 | | n/a | | 4 | | n/a | |
| End of year | Cost (€) | Fit | Cost (€) | Fit | Cost (€) | Fit | Cost (€) | Fit |
| (Initial fitting) 0 | 9200 | 1 | 10400 | 1 | 13400 | 1 | 6000 | 1 |
| 1 | 400 | 1 | 0 | 0 | 0 | 0 | 14400 | 3 |
| 2 | 400 | 1 | 8320 | 1 | 800 | 1 | 19200 | 4 |
| 3 | 400 | 1 | 0 | 0 | 800 | 1 | 19200 | 4 |
| 4 | 400 | 1 | 8320 | 1 | 800 | 0 | 19200 | 4 |
| 5 | 400 | 1 | 0 | 0 | 0 | 1 | 19200 | 4 |
| Total cost(€) & No. fittings | 11200 | 6 | 27040 | 3 | 15800 | 4 | 97200 | 20 |
| Average annual service cost (€) | 400 | | 3328 | | 480 | | 18240 | |

Table 6 outlines the estimated projected costs associated with fitting out 20km of fishing gear with gill net pingers for a period of 5 years. Fumundas are the most expensive at the outset due to a smaller spacing of 100m and the unit cost of €67. Airmar are the cheapest to purchase at €46 per unit, so the total initial fit out cost is not prohibitive despite the lower maximum spacing of 100m. Aquamark are the most expensive unit to purchase at €104, but this price is offset by their maximum spacing of 200m. Savewave is the cheapest pinger to fit on the gear initially with a relatively inexpensive unit cost of €60 and a smaller number of pingers required due to a higher maximum spacing of 200m.

However the costs change dramatically once projected beyond initial fitting. The 3 month life of the non-operator replaceable Savewave battery means that despite a 20% reduction on replacement pingers, the operator will face a total annual bill in excess of €20,000 in year 1 and over €19,000 and 4 replacement fittings each year thereafter. This does not take account of replacing damaged or broken units which is a problem for the Savewave and this would suggest that this device cannot be considered as economically feasible in Irish fisheries.

The Airmar is the least expensive pinger to use in the long-term. The operator replaceable D-cell battery which is easy to obtain and cheap to purchase is a major advantage. Also the battery life of 12 months may be considered as adequate as pingers should ideally be examined and tested at least once a year given the harsh working environment. Replacing the batteries during such an annual test would not be a major task.

The Fumunda is more expensive than Airmar due to a higher initial unit purchase cost with relatively little difference in the cost of batteries over a 5-year period. In addition the lithium battery is not readily available and the current recommended supplier is located in China. However with a battery life of 15 months the Fumunda will need to be replaced just 3 times in 5 years compared to 5 times in the same period for the Airmar with obvious savings in associated labour costs.

Aquamarks are relatively expensive models in the long term principally due to the requirement to replace the pinger after 24 months of continuous use. However the pinger requires the least number of replacements of all the models due to the long battery life with half the number of pingers to be replaced compared to the Airmar and Fumunda due to a higher maximum spacing of 200m. This effectively reduces the labour required to replace Aquamarks to one third and one fifth of the labour required to replace Fumundas and Airmars respectively. The estimated average projected annual service cost is included in Table 6 for comparison purposes.

3.3.3 Pinger score index

Table 7 summarises relevant pinger specification and performance information from Tables 4, 5 & 6, applying a simple scoring system to relative pinger characteristics and performance. Airmar scored highest in the ‘unit cost’ category with a price of €46. Savewave and Fumunda were similarly priced with Aquamark the most expensive. Fumunda scored highest in the size and weight categories as it was the smallest model available, and the fishermen found it to be the least obtrusive on the fishing gear. The Aquamark and Airmar were similar in size while the Savewave was the biggest model and so scored the lowest in the size category. The Airmar had the highest maximum depth rating at 275m.

Maximum spacing is a major consideration, as a spacing of 200m will effectively halve the number of pingers required when compared to a spacing of 100m. As such the Aquamark and Savewave models scored high and the Airmar and Fumunda scored low in this regard.

The Aquamark scored highest in the battery life category with an expected life of up to 24 months. The Savewave battery life was poor at just 3 months. The batteries in the Airmar and Fumunda can be operator changed which like the maximum spacing has a major effect on the overall cost of pinger deployment. The D-cell batteries used in Airmars are relatively inexpensive and easy to source compared to the lithium cell in the Fumunda, which in terms of providing a score, balances out the difference in battery life of these two models.

Only the Airmar model does not have a wet switch. This can be a disadvantage in terms of battery life and associated costs. However the majority of Irish vessels are unlikely to remove any model of pinger from their nets when not in use. Nets are generally stored outside exposed to rain and the elements, which may negate the effect of wet switches. If they do remove pingers it will most likely be to place them on other nets at sea. As such the Airmar may not be at a particular disadvantage because of its lack of a wet switch, particularly given the relative ease of battery replacement. As such the Airmar scored just 1 point behind the others in this category.

The figures in the category for ‘Not pinging’ were taken from Table 6 when pingers were examined at the end of the endurance test during Trial 1. All of the pingers were still within their specified battery lives at this point, which permitted a suitable comparison to be made. The percentage (%) damaged category is taken from the figures produced at the end of Trial 2 as the Fumunda model that had suffered damage during Trial 1 was replaced. Only the Savewave was observed to have suffered damage to the housing at the end of Trial 2 with two out of twelve (17%) models beyond use. Therefore this model scored poorly in this regard.

Airmar scored joint highest with Fumunda in the estimated average annual service cost and highest in the projected 5-year cost as outlined in Table 6. The Aquamark was a good deal more expensive than these models to maintain and use in the long term so achieved a poor score in these categories. The Savewave failed to score in these categories due to excessively high costs, which worked out as multiples of the costs associated with the other models.

Audibility of pingers was not scored, as the advantage of being able to hear the pingers in terms of testing, is effectively cancelled out by the disturbance caused to fishermen exposed to large numbers of beeping pingers on the deck of a vessel. This was found to be case during this study and earlier studies carried out by Seafish UK. Three-way holes may offer more possibilities when lashing pingers to the fishing gear but for the purposes of this study all of the pingers were tied in the same way through the side end hole so this was not scored. In addition the problem of pingers tangling in the gear was relatively uniform for all models so this category was also omitted from the scoring system.

Table 7. Pinger score index

| **Model** | Total Score | Unit cost (€) | Size (mm) | Weight (g) | Max. Depth (m) | Spacing | Battery Life (months) | Battery replaceable | Wet switch | Not Pinging % | Damaged % | Est. Service Cost (€) | 5 year cost (€) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Airmar | **29** | 46 | 156 x 53 | 408 | 275 | 100 | 12 | Yes | No | 0 | 0 | 400 | 11200 |
| | *score* | *3* | *2* | *1* | *3* | *1* | *2* | *3* | *2* | *3* | *3* | *3* | *3* |
| Aquamark | **23** | 104 | 164 x 58 | 410 | 200 | 200 | 24 | No | Yes | 7 | 0 | 3328 | 27040 |
| | *score* | *1* | *2* | *1* | *2* | *3* | *3* | *1* | *3* | *2* | *3* | *1* | *1* |
| Fumunda | **29** | 67 | 152 x 46 | 230 | 200 | 100 | 15 | Yes | Yes | 20 | 0 | 480 | 15800 |
| | *score* | *2* | *3* | *3* | *2* | *1* | *2* | *3* | *3* | *2* | *3* | *3* | *2* |
| Savewave | **16** | 60 | 202 x 67 x 42 | 400 | 200 | 200 | 3 | No | Yes | 62 | 17 | 18240 | 97200 |
| | *score* | *2* | *1* | *1* | *2* | *3* | *1* | *1* | *3* | *1* | *1* | | |

## 4. Discussion

It is clear from the results of this study that the introduction of acoustic deterrent devices on gill nets and tangle nets in Irish fisheries will have major implications for fishermen in terms of cost, slowing fishing operations and possibly safety issues.

An extra crew member or alternatively an increase in the workload of existing crew will be required to complete operations such as attaching pingers to the gear, and clearing and storing nets during hauling. Even if extra crew are employed it is still likely that fishing operations will be slowed considerably because of the occurrence of tangles in the gear caused by pingers falling through net meshes. The problem of tangling was quantified during Trial 2 with tangle nets and approximately one in three pingers deployed became tangled during fishing and the hauling process. This problem was particularly evident on all vessels when nets were passed through flaking machines for net storage. Health and safety issues arose because of the increased frequency with which fishermen had to climb up into net pounds to untangle gear.

Pingers were not found to have a negative effect on catch rates in the gill net trials. It was not possible to assess catch rates during the tangle net trials. It is worth noting, however, that tangle nets are normally deployed without net floats and rely on the slight buoyancy present in the headrope and water currents to provide some degree of lift in the net. The presence of non-buoyant pingers will undoubtedly keep the headrope on the seabed. Combined with increased tangling of the gear caused by pingers, it seems therefore likely that pingers will have a negative effect on the performance and fish landings of tangle nets.

Buoyant pingers such as the prototype Fumunda could help alleviate this problem. Using modified systems such as the bait bag/net float system developed during this study could also assist. This system also achieved a reduction in tangling during the hauling process from 34% (unmodified) to 18% (modified) on tangle nets. However further development of this system is required as it is likely that the bait bags will fray and become weakened after long term usage. There are also additional expenses and man hours involved in utilising such a system and it is not clear at this stage if this is an issue which should be addressed by the fishermen or the pinger manufacturers.

Although not quantified, the bait bag system undoubtedly protected and preserved pingers from heavy collisions during fishing operations. Fishermen could also consider introducing some form of padding to areas of high impact such as steel bars in the net pound and along the stern gunwale.

None of the pingers tested were found to be 100% reliable. The Airmar came closest with just one unit out of 14 not functioning at the end of the trials. Airmar and Fumunda scored the same number of points in the pinger score index, which summarised the relevant specifications, practicalities of deployment and costs associated with all of the pingers tested. The Airmar scored well because of its reliability and relatively low cost. The Fumunda achieved a high score because of its relatively small size and weight, and inexpensive servicing costs. However the Fumunda is more expensive to purchase and some issues have arisen regarding reliability as observed at the end of Trial 2, when 3 out of 14 models were not functional at the end of the Trial.

The Aquamark was third in the score table and lost points principally because of higher costs and a non-operator replaceable battery. The main advantages of this model are its relatively long battery life of up to 2 years and its maximum spacing of 200m that will lead to considerably less labour requirements than other models. The Aquamark, however, also suffered from unreliability with 6 out of 13 models non-functional at the end of Trial 2. Major problems occurred with the durability, reliability and estimated cost implications of the Savewave and this model cannot be considered as suitable for use in Irish gill net fisheries in its present format.

The overall cost to the Irish fleet in complying with the Council regulation will largely depend on the pinger model they decide to use. If fishermen collectively choose to obtain the cheapest available model then the total investment required will be in the region of €200,000 which will fit out 20 vessels working 20km of fishing gear each. This equates to an initial cost per boat of between €5,000 - €11,000 depending on the device, not including spares and replacement batteries.

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