The Banana Pinger Trial:

Investigation into the Fishtek Banana Pinger to reduce cetacean bycatch in an inshore set net fishery.

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Executive summary

In Europe, the use of pingers to reduce the bycatch of dolphins and porpoises by 'over-12m' fishing vessels using bottom set gill or tangle nets has been delayed by practical and cost issues, despite a 2004 European Commission regulation requiring the use of approved pingers. Mandatory use of pingers on these vessels came into force in England in July 2013.

Following on from previous work by Cornwall Wildlife Trust, this study assessed whether a new, cheaper, deterrent, the Banana Pinger, would be effective and practical for use on smaller vessels, which are a large proportion of the European static net fishing fleet.

Efficacy was measured acoustically using instruments ('C-PODs') that detect the presence of cetaceans in the vicinity of the instrument, as it is known that pingers that reduce bycatch also reduce the number of porpoise clicks that can be heard at the net. C-POD acoustic recording devices were used to log all cetacean activity around both pingered and non-pingered nets. This is a proven and published method for determining potential incidence of animals getting entangled in the nets rather than actual bycatch.

Four inshore netters placed C-PODs on nets that either had active Banana Pingers or no pingers. Despite some problems and concerns with the practical use, the detection rate of porpoises around nets with pingers was reduced by 82%, which indicates a larger reduction in porpoises at risk of entanglement than has been seen in previous studies of pingers that are known to be effective at reducing bycatch.

In a parallel experiment, a Banana Pinger was modified to run for alternate 21-hour periods and was deployed for eight months next to a C-POD. The aim of this experiment was to investigate behavioural effects of the pinger on porpoise and dolphins, such as long-term displacement, habituation, or attraction (the 'dinner bell' effect). For technical reasons dolphin detections are not possible from a C-POD next to a pinger so a second C-POD was moored 150m away. This 'cycling pinger' study showed a strong effect in reducing porpoise detections at the first C-POD when the Banana Pinger was active, and also showed a smaller, but also statistically significant, fall in detections of both porpoises and dolphins at the second C-POD. There was no decrease in the effect of the pinger on porpoises over the eight-month period.

The study gives strong evidence that the Banana Pinger is a practical and effective way of reducing porpoise bycatch in set nets, and provides the strongest evidence of any study that habituation of porpoises to pingers is unlikely to be a significant issue.

The Banana Pinger is carried in an elastomer housing that stays attached to the net, so that the pinger can easily be removed to change the battery - an alkaline C-cell - which is required about once per year.

Some practical concerns over the use of the Banana Pinger in the fishery were raised but have either been rectified or solutions are being investigated by the manufacturer through liaison with the skippers involved in this investigation. Concern was raised by some fishermen regarding the possibility that the flashing of the battery level light might be attracting seals in deeper water and the manufacturer has now modified the device so that it does not flash when immersed.

Following this work, Cornwall Wildlife Trust recommends:

1. That a wider 'trial' of Banana Pingers should be promoted to all under-12m vessels using gill or tangle nets within Cornwall's territorial waters, 0-12 nautical miles (nm), as a voluntary method to reduce cetacean bycatch. This will enable the modifications made by the manufacturers to be fully

tested such as the popping out and potential seal interactions. This trial should be undertaken with full support and input from local skippers from the offset.

2. Discussion should be had to undertake similar Banana Pinger trials in other fishing areas in the UK.
3. To encourage voluntary uptake of pingers, effort should go into raising consumer and public awareness of vessels using pingers as being 'dolphin friendly' and promote these vessels as using sustainable practices.
4. Further work to assess the durability and suitability of the Banana Pinger as a bycatch mitigation device on over-12m vessels is undertaken.

A much larger study of the effect of the Banana Pinger on actual bycatch of dolphins would also be of great value, both in the UK and worldwide.

Image 1: Fisherman attaching a Fishtek Banana Pinger to footrope on net tier. Photo by Malcolm MacGarvin, Pisces-RFR CIC.

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1.0 Introduction

The incidental catch of marine mammals in fishing gears, especially static nets, is one of the greatest immediate threats to marine mammals throughout the world; the death toll from fishing nets far exceeds the deliberate take of marine mammals (Reeves et al, 1996, Hodgson et al, 2007).

Pingers are acoustic deterrent devices which may alert cetaceans to the presence of a net or drive them away from its location and hopefully reduce their risk of accidental entanglement in the net, which is termed 'bycatch'. It is known that small cetaceans such as harbour porpoises (*Phocoena phocoena*), common dolphins (*Delphinus delphis*) and bottlenose dolphins (*Tursiops truncatus)* are able to 'see' nets acoustically when echolocating at a short distance from the net. Pingers may be 'alerting' and work by inducing silent animals to echolocate and 'see' the nets, or they may be 'aversive' and cause cetaceans to move away from the source of the pings, thus reducing their chances of entanglement.

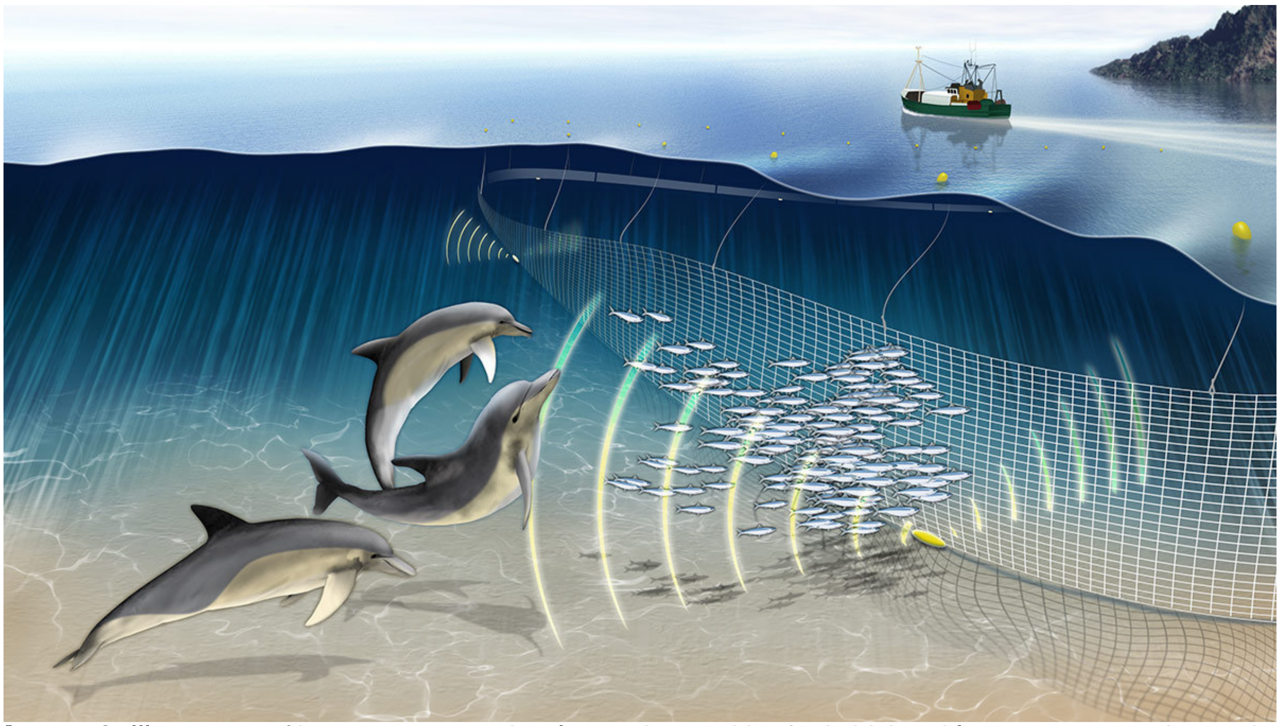


Image 2: Illustration of how a pinger works. Image designed by Andy McLaughlin at www.tcistudio.co.uk.

Field studies with acoustic pingers on set gillnets have shown reductions in bycatch of harbour porpoise in a bottom set gillnet fishery (Kraus et al, 1997, Trippel, 1999) and of common dolphins in a drift net fishery (Barlow and Cameron, 2003), plus a reduction in interaction between bottlenose dolphins and a gillnet fishery for Spanish mackerel (Waples etc al, 2013). Evidence of some degree of habituation has been seen in a number of studies (Cox et al, 2001) which have used visual or acoustic methods to study how close porpoises come to the pinger. However, there is also evidence of persisting long-term effects of pingers in fisheries trials, so the exact nature and significance of possible habituation is not clear. It may be that the effect moves from being aversive to being alerting with little change in bycatch rates. For dolphins, the picture of pinger efficacy is much less clear, with stronger evidence of habituation and concern over 'dinner-bell' effects, as dolphins, unlike porpoises, are known to take fish from nets in some locations.

Knowledge of the extent of cetacean bycatch in set nets, and successful trials of pingers contributed to the European Union Council Regulation No 812/2004 that made use of acoustic deterrents mandatory in certain sea areas on vessels larger than 12m in length using static bottom-set fishing nets. However, regulation 812/2004 imposes no direct action to reduce cetacean bycatch on vessels of less than 12m, but does require appropriate monitoring of their bycatch.

Within the Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA) district it is estimated that there are around 400 commercial under-12m fishing vessels which are suited to using bottom-set static gear (pots, lines and nets) working at present (May 2013). About 350 of these under 12m vessels have nets which may total from a few hundred metres in length to many thousands of metres per boat. The majority of the nets from these vessels are used for sea fish (incl. shellfish) in the 0 – 12 mile limit, but major estuaries (up to the tidal limits) and the sea well outside 12 miles are also fished by the same category of fishing vessel. Some vessels use nets only occasionally or seasonally (perhaps alongside other gears), whilst others are netting, full time, throughout the year. Neap tides and calm conditions are the favoured times to shoot most nets at sea, so in poor weather (especially during the winter months) and during spring tides there will be very many less nets at sea in the inshore waters compared with fine weather summer neap tides. This information comes from Cornwall IFCA and is an estimate based on current figures held by the Authority.

The South West UK inshore waters support 14 species of cetacean, and are recognised as a region of national importance with regard to cetacean abundance and diversity (Marine Connection and Cornwall Wildlife Trust, 2007). Of specific conservation importance are our small, but well recognised, resident group of inshore bottlenose dolphins, which has shown a decline in the average observed group size over the last 17 years to levels at which the loss of any individual will have a significant impact on the survival potential of this group (Wood, C. J. 1998).

Image 3: Porpoise removed from gillnet. Photo by Environment Agency.

The co-existence of a large number of fishing vessels deploying gillnets in waters with nationally important cetacean populations leads to problematic bycatch. Globally, there is extensive evidence that cetacean bycatch occurs in many areas where gill or tangle net fisheries occur within cetacean habitat (Perrin et al., 1994).

In Cornwall there is also evidence of a major decline in small cetaceans during the second half of the 20th century which may precede the introduction of nylon gillnets (Tregenza, 1992) and was most likely due to organochlorine pollution which still affects inshore bottlenose dolphins.

Evidence of bycatch in Cornwall is also provided by the data collected by the Cornwall Wildlife Trust Marine Strandings Network (CWT MSN), which is the official recorder of stranded cetaceans in Cornwall. In 2012, 132 live and dead stranded cetaceans were recorded by the CWT MSN. Of these, 23 (17%) were retrieved under licence for post-mortem examination at the Animal Health and Veterinary Laboratories Agency, Polwhele, on behalf of the Defra-funded Cetacean Strandings Investigation Programme (CSIP). Signs of bycatch were found in 35% (n=8). The remaining 109 cetaceans which were not autopsied were examined and recorded in situ by the CWT MSN. Of these, 26% (n=28) showed features consistent with bycatch, based on recognised net entanglement features such as fin edge cuts/slices, encircling net marks and severed appendages. The Trust's MSN annual report for 2007 identifies 75% of harbour porpoises examined as showing signs of having been bycaught in gillnets or tangle nets.

The CSIP 2009 Report documents the cause of death of one of the two bottlenose dolphins that stranded in that year in Cornwall as due to net entanglement. Due to their small numbers locally this is a significant threat. In addition, previous observer studies by Cornwall Wildlife Trust on offshore netters estimated a porpoise bycatch in the Celtic Sea of over 2000 animals per year. As a result of these studies which highlight the local issue of cetacean bycatch in nets, Cornwall Wildlife Trust has undertaken work to investigate a suitable device to reduce cetacean bycatch in these nets, in inshore Cornish waters.

The mandatory requirement announced by Defra in June 2013, for use of pingers on over-12m vessels, under their obligations to European regulation No 812/2004, is a positive step towards cetacean conservation which The Wildlife Trusts support fully. However, this regulation does nothing to control cetacean bycatch by vessels less than 12m long. Cornwall Wildlife Trust also has strong concerns about the 'DDD' pingers, recommended by Defra, due to their very high acoustic output (180dB re 1uPa @1m) which could potentially have detrimental behavioural effects on cetaceans such as deterring all cetaceans from inshore feeding grounds; they are very difficult to monitor and hence enforcement is a serious concern; and they give no indication to users of the expected battery life (max about one week). Cornwall Wildlife Trust's research has therefore focused on devices with a lower acoustic output that are compliant with the EU regulation and would be effective at reducing cetacean activity around nets, (Hardy et al, 2012).

Cornwall Wildlife Trust started research in 2008 into finding a suitable pinger that was both effective and practical as a bycatch mitigation device. A full desk study was conducted to determine which pingers would be suitable to trial. The study showed that many other pingers currently on the market had previously highlighted flaws, including safety of crew and issues with batteries. Therefore, the first inshore fishery trial by Cornwall Wildlife Trust was conducted using the Aquamark 100 pinger. This research showed that this device was effective at reducing cetacean activity around nets but had practical limitations that would impede their uptake by the fishery.

The limitations were:

1. The battery life was shorter than claimed by the manufacturers.
2. Sealed units that cannot be re-used after the battery dies.
3. High cost per year created by high initial cost and replacement costs.

The research described in this report (2013) therefore set out to test a new pinger, the Banana Pinger, which has been designed to overcome all the known issues with alternative pingers on the market. It has been developed by Fishtek Ltd., based in Devon, and Chelonia Ltd. in Cornwall as a direct result of previous work in the Cornish fishery. The Banana Pinger addresses the key issues of cost, ease of use and monitoring, and battery life. It meets the EU regulation Set 1 specification regarding output and spacing.

This study of the Banana Pinger consisted of two investigations:

1. Cycling pinger trial – to investigate behavioural effects of the Banana Pinger on porpoise and dolphins in the immediate area, such as possible long-term displacement and the rate and degree of habituation of porpoises to a pinger. A further aim was added of evaluating the use of a second C-POD, placed where it would not hear the pinger, as an acoustic method of studying the response of dolphins to the pinger.
2. Use in a fishery – to test the effectiveness of this device at deterring cetaceans from inshore set nets and assess their practicality in a normal commercial fishery setting.

For the purposes of this investigation, we define 'inshore' vessels as under-12m vessels and 'inshore' waters as fishing within 12nm of the Cornish coastline.

The research previously carried out by Cornwall Wildlife Trust (Hardy et al, 2012) demonstrated a method of acoustically monitoring the effects of pingers on small cetacean behaviour that was acceptable to the scientific community and had the major advantage over measuring actual bycatch rates (e.g. by the use of on-board observers), of being much quicker and consequently much less expensive. For species such as bottlenose dolphins in Cornwall measurement of actual bycatch is not feasible at all due to the very small number of individuals in the local inshore population. The same acoustic method was repeated here.

Image 4: Skipper collecting C-POD during net haul as part of the real time fishery trial. Photo by Malcolm MacGarvin, Pisces-RFR CIC.

2.0 Method

2.1 Fishtek Banana Pinger

The Banana Pinger meets the criteria set by the European Union Council Regulation 812/2004 for pingers that can be used at 200m spacing on nets (Set1). It produces pings with randomised intervals between pings of 4 to 12 seconds. Each ping last 0.3 seconds and contains a series of frequencies in a random order, with each lasting 20ms or more. The frequencies range from 50 to 120kHz and are above the level of seal hearing. The sound output is distributed radially evenly and overall meets the 145dB re 1uPa @ 1m level set in the regulation.

Image 5: Fishtek Banana Pinger. Photo by Cornwall Wildlife Trust.

2.2 Cycling pinger trial

A single modified Banana Pinger was deployed in July 2012 to assess possible habituation of animals to the pinger, and also to assess the 'recovery time' before the return of animals after the end of pinger activity. The pinger had an approximately 21-hour cycle of normal pinging alternating with approximately 21 hours with no pings. The long cycle was chosen to ensure that tidal effects would not synchronise with the cycle of pinger activity and to allow time for 'recolonisation' of the area if porpoises have been driven out.

The cycling pinger was deployed on a long-term fixed mooring in approximately 40m of water off the coast of the Land's End peninsula in west Cornwall, with a C-POD to monitor cetacean activity, but with no associated net.

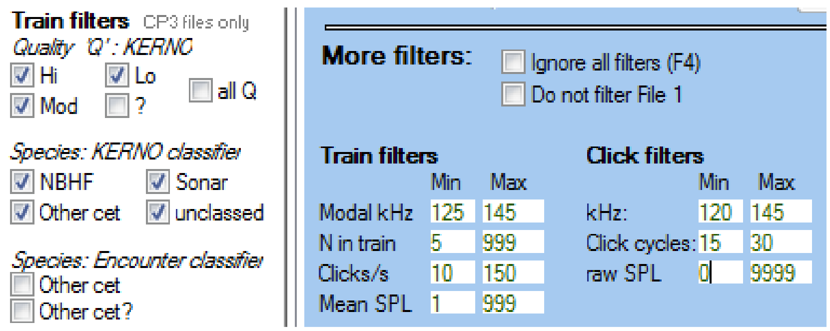
The first deployment used a heavy anchor and a surface buoy. This mooring was vulnerable to theft and storms and was difficult to handle so it was changed to a much lighter design that uses an acoustic release and a small anchor but has no surface presence.

Initial analysis showed that the system worked well and there appeared to be some aversive effect on dolphins as well as a strong effect on porpoises. The recognition of dolphin click trains is notoriously difficult and was complicated in this context by the presence of the pinger sounds in the data set. Development of an automated method of recognition of dolphins would be a substantial task and outside the scope of this project, so a second C-POD was moored at a distance of 150m from the cycling pinger.

The aim was that the adjacent C-POD would record the Banana Pinger activity, identifying exactly when it was ON and OFF, and would collect usable data on porpoise activity while the C-POD at the remote site would not hear the pinger and would provide data that could be used to assess any behavioural response of dolphins or porpoises at that range. The existing C-POD software is capable of identifying dolphins in the absence of pingers.

2.2.1 Identification of porpoises

The same filtering was used on all the data (graphics cut from CPOD software screen):



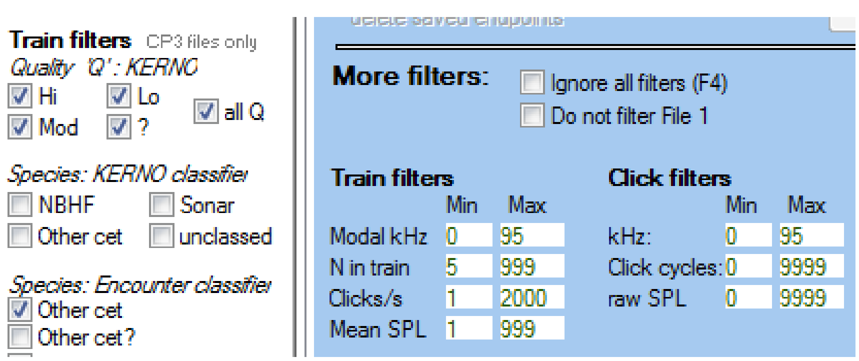
When the pinger is running it is identified as a man-made source, and that reduces the likelihood of identifying a cetacean. These filters are designed to avoid any such bias by ignoring the formal species identification and using a lower-level approach and filtering the clicks within trains, irrespective of the species classification, to include only:

- Click cycles in range 15-30: this avoids dolphin clicks that are shorter and boat sonars that are commonly longer.
- Frequency 120-145 (kHz): this avoids clicks and trains that are outside the narrow range used by porpoises. The range allowed for trains, 125-145kHz, is less than that for clicks because the value filtered for trains is their modal frequency.
- Slow and very fast click trains are excluded (clicks per sec 10-150) because slow trains are infrequent from porpoises and fast trains may include low quality non-cetacean sources.

This approach to classification has a particular strength in that the errors are all likely to reduce the apparent pinger effect rather than exaggerate them. These errors are the possible inclusion of clicks that actually came from the pinger or from boat sonars. A small source of error might be the inclusion of some long clicks from dolphins, but this also would only have the effect of exaggerating the pinger effect if dolphins were more strongly affected than porpoises (which proves not to be true).

2.2.2 Identification of dolphins

This was only undertaken in the data from the remote C-POD, and used these filters based on the GENENC classifier in the C-POD software (graphics cut from C-POD software screen):



The remote C-POD does not detect the Banana Pinger, which is a much weaker source than a porpoise, and far weaker than a dolphin. Consequently there is no bias introduced by logging a man-made source and it is possible to use the automated detection of click trains.

These filters exclude only trains above 95kHz in order to eliminate porpoise click trains that are mis-classified as dolphin trains due to the inclusion of lower frequency background noise clicks.

2.3 Real time fishery investigation

The nets used most by small vessels in Cornwall are tangle nets. Tangle nets generally consist of between 22cm and 35cm mesh monofilament netting with a leaded footrope and a headline with no, or minimal, buoyancy, usually with a hanging ratio of 0.3 to target benthic species such as angler fish (*Lophius piscatorius*), brill (*Scophthalmus rhombus*), turbot (*Psetta maxima*), ray species, and spider crab (*Maja squinado*). These nets lie flat on the bottom in tidal currents. They are set for approximately five days 'soak time' depending on weather conditions at depths ranging from 20 to 100m. The fishery operates throughout the year.

Discussions with Cornwall IFCA officers and a number of interested Cornish inshore tangle net skippers in September 2012 resulted in six confirmed vessels agreeing to be part of this trial. By the end of the trial, only four vessels remained actively involved in the trial, three working from the Helford area and one from Newlyn as two of the original six skippers changed their fishing practices and did no netting during the study period. Such changes of fishing method and target species in response to restrictions on quota, weather conditions and other external influences is not unusual.

The remaining four boats were less than 12m in length and worked between 8-10km of nets. They deployed their nets within a day's steam of their home port and inside the six nautical mile limit.

Each vessel was asked to deploy one set of 'test nets' which were equipped with Banana Pingers spaced at 200m intervals, and one set of 'control nets' without pingers. A C-POD was attached to a test net and to a control net. Following training, each skipper was entirely responsible for deploying and recovering the equipment with their fishing gear while continuing with all normal fishing activity to test the practical aspects of using pingers during all such work. Hauling and shooting of nets differs on these vessels from the larger offshore vessels, in that the nets are shot from the stern directly from net bins or the deck, without going through a tube, and are recovered using much smaller haulers than on larger vessels. Once the net has been hauled and the fish picked out, the nets are sorted by hand or via a flaking machine that helps lay the nets in a bin with the headline and footrope separated ready for a clean deployment next time they are shot away.

Skippers were requested to deploy test and control nets on the same days at similar times for comparable data. Incidences of cetacean bycatch were recorded by the skipper of each vessel recording: date, time, position and, where possible, species.

2.4 Click detectors

Acoustic click detectors (C-PODs, Chelonia Limited UK) were used to assess the response of cetaceans to the pingers as the total bycatch was expected to be too low to be statistically useful. C-PODs are fully automated, static, passive acoustic monitoring systems that detect echolocating odontocetes by recognizing their ultrasonic sonar click trains and distinguishing these from the sounds made by boat echo-sounders and other sources. The system achieves sufficiently low false positive rates to allow its use in areas of very low cetacean density (Verfuss, 2007). The approximate maximum detection distance for harbour porpoises by a C-POD is approximately 500m.

3.0 Results

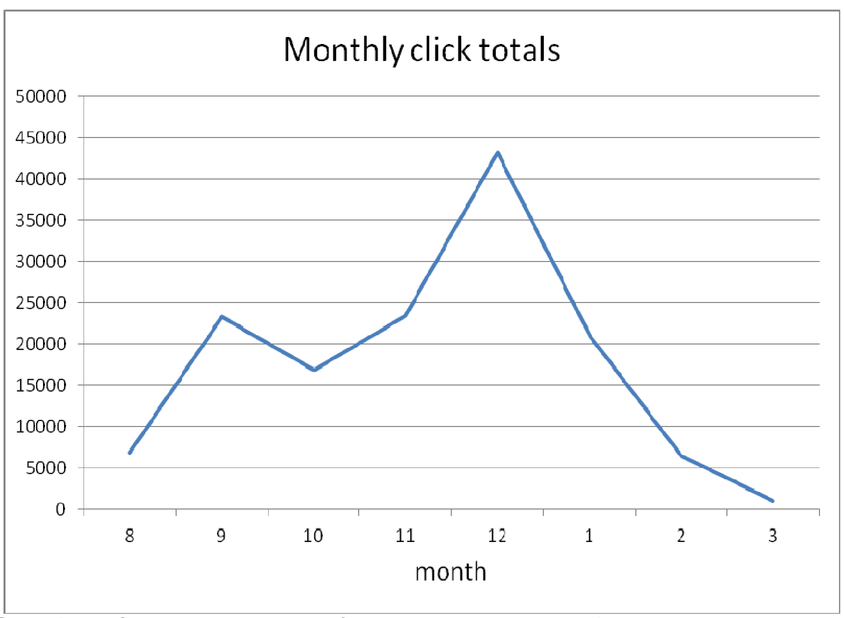
3.1 Cycling pinger trial

401 days of acoustic logging were completed:

FileName	POD	starts	ends
Kemyel 2012 07 29 POD1083 file01.CP3	1083	29/07/2012 08:22	12/08/2012 16:55
Mousehole pinger f2 POD495 file01.CP3	495	12/08/2012 12:46	28/09/2012 15:50
Kemyel cycling pinger 2012 11 08 POD1083 file01.CP3	1083	28/09/2012 13:00	02/11/2012 12:14
Kemyel cycling pinger 2012 11 08 POD1083 file02.CP3	1083	02/11/2012 12:13	08/11/2012 17:09
Kemyel 2012 11 08 POD1083 file01.CP3	1083	08/11/2012 16:18	12/12/2012 07:39
Kemyel 2012 11 08 POD1083 file02.CP3	1083	12/12/2012 07:40	16/01/2013 14:55
Kemyel 2012 11 8 POD495 file01.CP3	495	08/11/2012 12:45	24/01/2013 10:35
Kemyel 2012 11 08 POD1083 file03.CP3	1083	16/01/2013 14:56	19/02/2013 06:17
Kemyel 2012 11 08 POD1083 file04.CP3	1083	19/02/2013 06:18	17/03/2013 02:31
Kemyel 2012 11 8 POD495 file02.CP3	495	24/01/2013 10:37	27/04/2013 18:58

Table 1: Data file of the cycling pinger trial displaying total number of days of data recorded.

The entire acoustic data set contains 170 million click records that include 238,000 porpoise clicks (about 0.14% of the total). A strong seasonal pattern was seen during the course of the trial and has been recorded in previous studies in the same area:



Graph 1: Seasonal pattern of porpoise activity in the cycling pinger trial.

In the second part of the trial using two C-PODs, the C-POD nearer to the Banana Pinger stopped logging after 128 days because its memory was prematurely full due to the pinger sounds. The other C-POD was still logging when retrieved - at which point it had run for 24.3 weeks from November to April. The analysis has been confined to the period in which both C-PODs were logging.

3.1.1 Pinger activity

The C-POD next to the Banana Pinger clearly recorded its cyclical activity. In Figure 1 below the black line shows the number of tonal ultrasonic sounds recorded. This goes up dramatically when the pinger is active. The colours show the frequency of the sounds recorded. When the pinger is inactive a higher proportion of high frequency clicks (purple) from porpoises are logged.

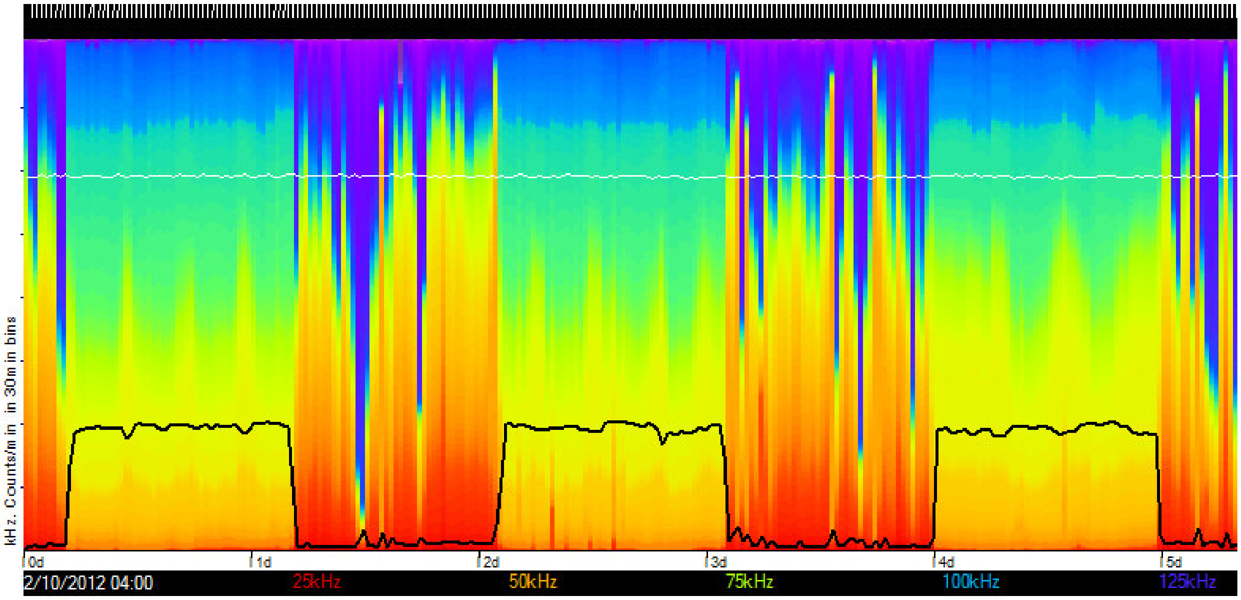


Figure 1: Distribution of ultrasonic frequencies over five days of logging, showing the ON and OFF periods of the cycling pinger

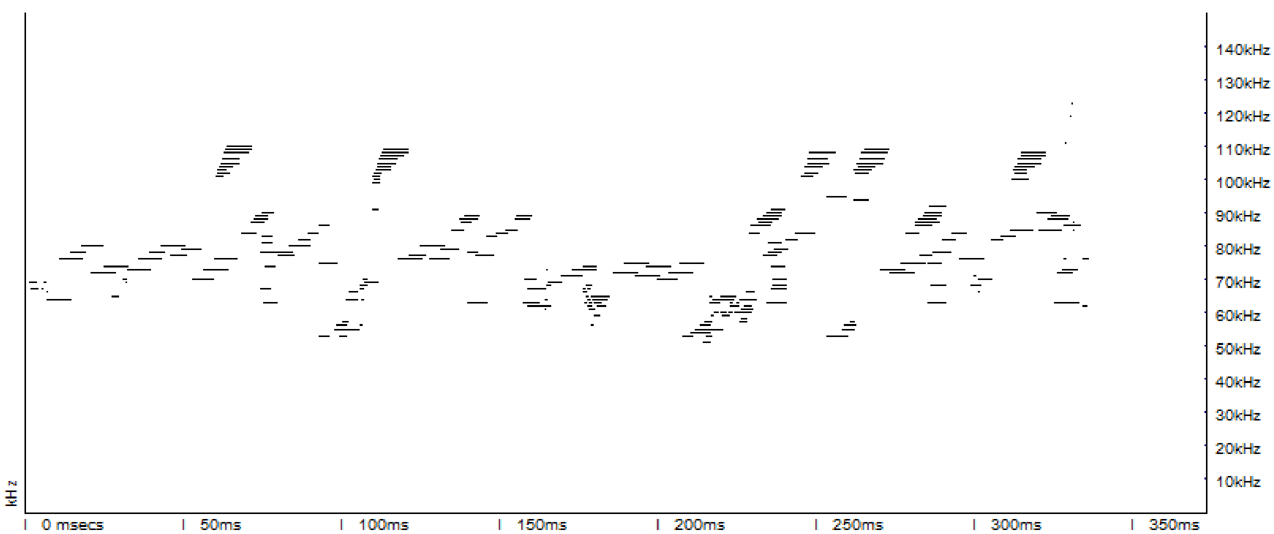


Figure 2: The sequence of dominant frequencies in a ping of the Fishtek Banana Pinger.

Figure 2 above shows the sequence of dominant frequencies in a ping. The horizontal length of the lines represents the sound level of each successive dominant frequency. The frequency structure of each ping is varied randomly.

The pings occur with intervals that should vary randomly between four and twelve seconds. Examination of the data here shows that the cycling pinger was not performing exactly as specified as there are intervals of two seconds occurring at about one per minute and intervals of up to 34 seconds occurring about once every three minutes.

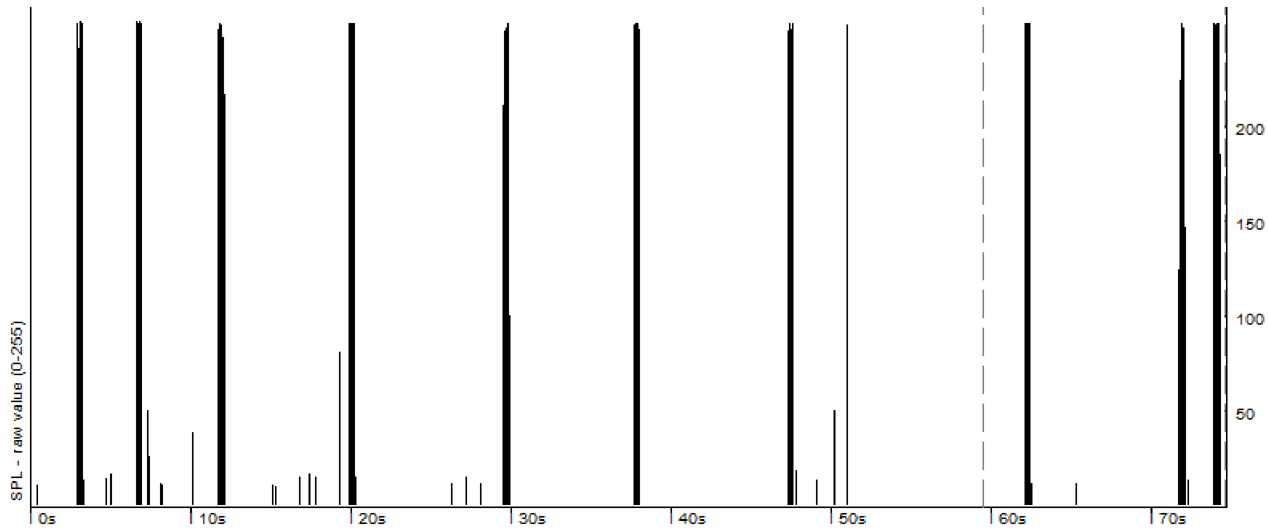


Figure 3: Sound pressure level recorded by the C-POD close to the pinger. The thick bars represent the ping whilst other bars represent natural noise sounds.

The Sound Pressure Level of the pinger is about 1% of the sound pressure level of a porpoise click, and the second C-POD, situated about 150m away, did not log the pinger at any time.

To identify 'pinger hours' we filtered clicks with more than 50 cycles in the range 65-75kHz and counted the number in each clock hour. Figure 4 below shows hours sorted by number of pinger-like clicks.

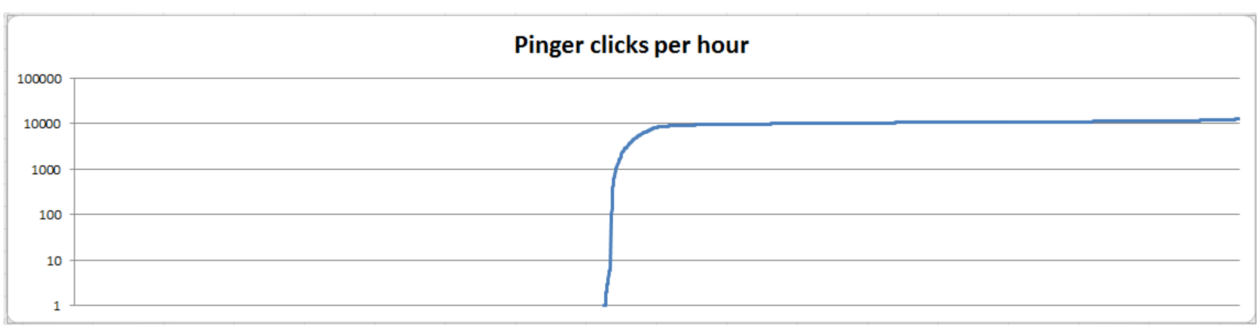


Figure 4: Total number of hours sorted by number of pinger-like clicks.

The transition is very distinct, with a slope that, above a value of 100, reflects the clock hour boundary falling at points with 1-59 minutes of pinger activity. So we have used hours with over 8000 pinger clicks as pinger ON and those with less than 50 as OFF. These are hours in which the pinger is active or not active for the whole of the hour.

3.1.2 Pinger effect on porpoises

Adjacent to pinger	ON	OFF
hours	1547	1420
clicks	19451	66807
Clicks/m	12.6	47.0
Detections falls to: ON/OFF	*27%*	
150m from pinger	ON	OFF
hours	1547	1420
clicks	69969	103123
Clicks/m	45.2	72.6
Detections falls to: ON/OFF	*62%*	

Click detections of porpoise when the Banana Pinger was on were reduced to 27% of those detected when the pinger was off. The same analysis using 'Detection Positive Minutes' gave a slightly smaller fall in detections to 64%. The same analysis on the preceding 'adjacent' data file that ran from 12th August to 29th September gave a detection fall of 29.4%.

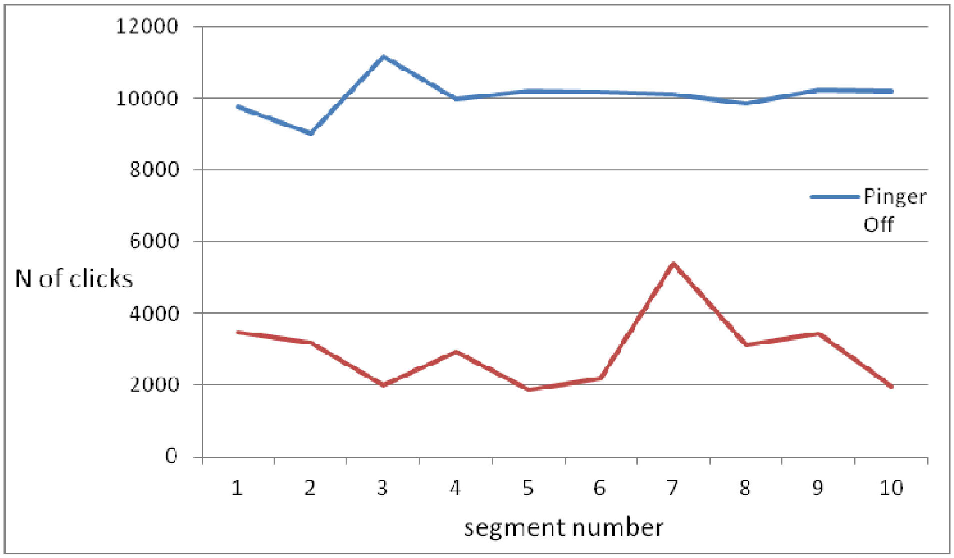
3.1.3 Pinger effect on dolphins

150m from pinger	ON	OFF
hours	1547	1420
clicks	7591	9341
Clicks/m	4.9	6.6
Detections falls to: ON/OFF	*75%*	

Click detections of dolphin when the Banana Pinger was on were reduced to 75% of those detected when the pinger was off. The same analysis using 'Detection Positive Minutes' gave a smaller fall in detections to 87%.

3.1.4 Habituation

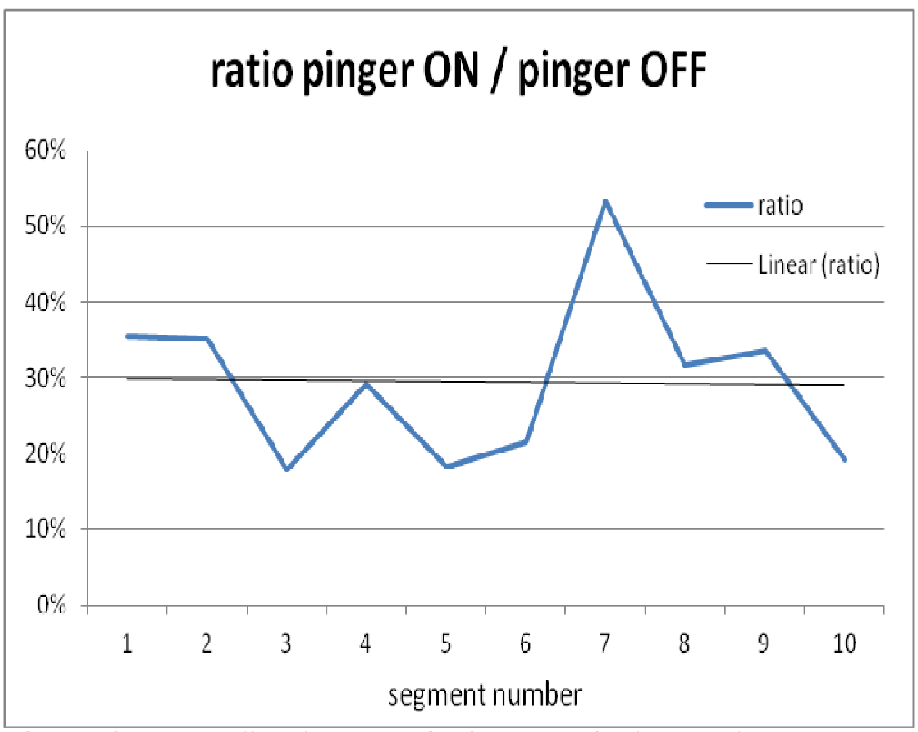
To assess habituation the data was segmented into 10 successive segments, defined by hour boundaries, with approximately equal numbers of clicks logged when the pinger was OFF (Graph 2).



Graph 2: Number of clicks logged when the cycling pinger was OFF and ON over 10 successive time segments. Blue line: *N* in OFF periods; Red line: *N* in ON periods

The number of clicks logged when the cycling pinger was ON was substantially lower than when the pinger was OFF.

The pinger effect, expressed as the number of 'pinger ON' clicks as a percentage of the 'pinger OFF' clicks shows considerable variation but no trend (Graph 3).



Graph 3: Pinger effect (N clicks ON/ N clicks OFF) over 10 successive time segments.

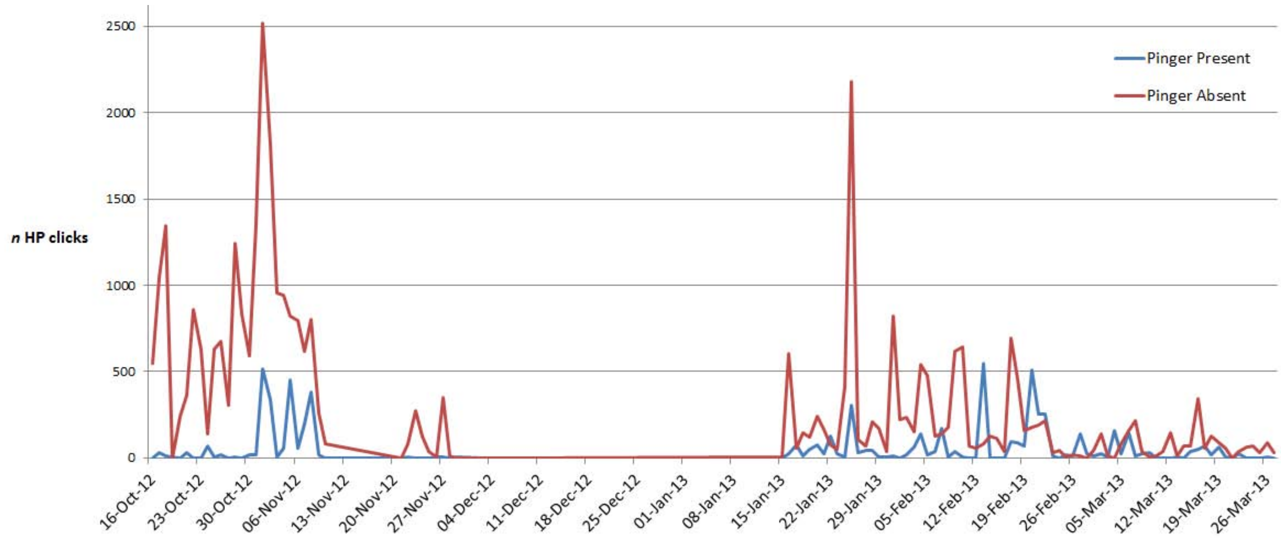
3.2 Real time fishery investigation

A total of 160.6 soak days of nets with and without pingers were recorded. Analysis was confined to whole clock hours from each boat in which acoustic data was obtained from every minute from both pingered and non-pingered nets.

FileName	POD	*starts*	days
Vessel1 NP Helford 6th Nov 2012 POD406.CP3	406	*16/10/2012 09:08*	21.11
Vessel1 P Helford 6th Nov 2012 POD414.CP3	414	*16/10/2012 09:21*	21.05
Vessel2 P Helford 1st Nov 2012 POD472.CP3	472	*21/10/2012 12:14*	1.88
Vessel2 NP Helford 1st Nov 2012 POD460.CP3	460	*21/10/2012 12:16*	1.88
Vessel2 NP Helford 15th Nov 2012 POD460.CP3	460	*03/11/2012 08:34*	7.1
Vessel2 P Helford 15th Nov 2012 POD472.CP3	472	*03/11/2012 08:59*	6.91
Vessel1 P Helford 2012 01 11 POD414.CP3	414	*06/11/2012 09:47*	2.97
Vessel1 NP Helford 2012 01 11 POD406.CP3	406	*06/11/2012 11:04*	2.91
Vessel4 NP Newlyn 13.11.2012 POD2109.CP3	2109	*07/11/2012 13:34*	0.83
Vessel4 P Newlyn 13.11.2012 POD2110.CP3	2110	*07/11/2012 13:34*	0.83
Vessel2 NP Helford 4th Dec 2012 POD460.CP3	460	*15/11/2012 09:31*	19.22
Vessel2 NP Helford17th Dec 2012 POD460 t.CP3	460	*15/11/2012 09:31*	19.22
Vessel2 P Helford 17th Dec 2012 POD472.CP3	472	*15/11/2012 09:31*	19.22
Vessel2 P Helford 4th Dec 2012 POD472.CP3	472	*15/11/2012 09:31*	19.22
Vessel2 NP Helford 2013 03 13 POD460.CP3	460	*04/12/2012 14:54*	98.98
Vessel2 P Helford 2013 03 13 POD472.CP3	472	*04/12/2012 14:54*	98.98
Vessel1 NP Helford 2013 02 15 POD406.CP3	406	*11/01/2013 15:21*	34.75
Vessel1 P Helford 2013 02 15 POD414.CP3	414	*11/01/2013 15:23*	34.7
Vessel1 P Helford 2013 04 04 POD414.CP3	414	*15/02/2013 08:21*	48.11
Vessel1 NP Helford 2013 04 04 POD406.CP3	406	*15/02/2013 09:25*	48.06
Vessel3 NP Helford 2013 02 11 POD0.CP3	0	*16/02/2013 10:45*	6.95
Vessel3 P Helford 2013 04 03 POD2111.CP3	2111	*16/02/2013 10:45*	6.95
Vessel3 NP Helford 2013 02 11 POD0.CP3	0	*06/03/2013 12:00*	1.9
Vessel3 P Helford 2013 04 03 POD2111.CP3	2111	*06/03/2013 12:00*	1.9
Vessel4 NP Newlyn 2013 04 04 POD2109.CP3	2109	*12/03/2013 09:21*	23.23
Vessel4 P Newlyn 2013 04 04 POD2110.CP3	2110	*12/03/2013 09:27*	23.23
Vessel2 NP Helford 2013 04 04 POD460.CP3	460	*13/03/2013 14:29*	21.84
Vessel2 P Helford 2013 04 04 POD472.CP3	472	*13/03/2013 14:29*	21.83

Table 2: Data files collected over the six-month trial period, totaling 160.6 days of data for analysis.

There was a gap in fishing activity due to bad weather in November, December and January (Graph 4), but results show a lower number of porpoise clicks from nets with pingers present than from nets without pingers.



Graph 4: Time sequence of fishery trial: the number of harbour porpoise clicks recorded by the C-POD with pinger present (blue line) and on control nets without pinger presence (red line).

Skipper	**Hours**	**N of clicks P**	**N of clicks NP**	**P/NP ratio**
Vessel 1	2204	6061	31310	19%
Vessel 2	932	185	2616	7%
Vessel 3	167	11	508	2%
Vessel 4	44	64	166	39%
ALL	**3347**	**6321**	**34600**	**18%**

Table 3: Number of clicks recorded on test and control nets by each vessel.

Table 3 shows an average reduction of porpoise click detections to 18% on pingered nets compared to non-pingered nets.

No actual bycatch of cetacean species was recorded in either the pingered or control nets.

4.0 Discussion

4.1 Cycling Banana Pinger trial

The behavioural response of cetaceans to the Banana Pinger shown by this study is strikingly consistent with the results found in the trial on fishing boats, giving some confidence that this 'cycling pinger' design does provide a useful method of assessment of the effect of pingers. The effect appears smaller in the cycling pinger trial, with click detections falling to 27% in contrast to 18% on nets. In part this is expected as the animals 'deterred' during the active period may no longer be near the pinger when it stops, creating a 'recolonisation time'. That effect could not be large enough to explain the whole difference and there must be other factors, which could include the excessively long gaps in the cycling pinger ping sequence and local factors such as differing ambient noise levels, differing feeding opportunities for porpoises, etc.

There is no evidence of any diminishing trend in pinger effect despite the fact that this might be seen as a particularly severe test in that the pinger remains in the same location for many months. This supports the investigation by Carretta et al, 2011, where no evidence of habituation to pingers by cetaceans was apparent over a 14-year period of use.

However there is significant variation over time in the pinger effect and the cause is not obvious. Two post-hoc tests were applied to try to explain this. The first was a possible way of testing for a reduction of pinger effect during active feeding and was a test for correlation between the pinger effect and the proportion of porpoise trains with mean inter-click intervals below 10ms. The second was a test for a reduced pinger effect during periods of noise, as shown by Hardy et al, 2012, and was a test for a correlation between the pinger effect and the total number of clicks logged. Neither test showed a significant fit to the pinger effect time series.

Another possible cause for the varying pinger effect could be that it is affected by changes in the prey species over time, or changes in the predominance of pelagic as opposed to benthic prey. The second of these could be tested using the methods described here by using pairs of PODs deployed at different levels in the water column, but neither can be tested in the data set obtained here.

The dolphin response is statistically significant. It appears much smaller than the porpoise effect but could indicate a similar level of local displacement of dolphins away from the pinger. This is because the detection range is much larger for dolphins than porpoises, with maximum ranges at around 2000 and 400m respectively, so an adequate dolphin exclusion zone would not displace them far enough to make many of them inaudible to the C-POD.

Sustained and substantial reduction in bycatch of dolphins (and beaked whales) by mandatory pinger use has been shown in a drift net fishery for porpoises in California (Barlow 2003), indicating that in situations where no dinner-bell effect is suspected then enduring benefit to dolphins from use of pingers is possible.

4. 2 Real time fishery trial

4.2.1 Effect on cetacean activity

The results from individual boats vary as 3 boats had low data volumes and show levels of effect that are considerably bigger or smaller than the mean. These differences are likely to be mainly due to small sample sizes. Each boat showed an effect similar to, or greater than, the effect seen in a previous similar trial of the Aquamark100 pinger (Hardy et al, 2012). However, the average from all vessels showed a reduction in porpoise clicks to 18% on nets with Banana Pingers, compared to non-pingered nets. This indicates a reduction of cetacean activity around pingered nets, and hence a reduction in the chance of bycatch of 82%. This reduction in the risk of entanglement is a significant result and larger than has been seen in previous studies of pingers that are known to be effective at reducing bycatch.

4.2.2 Practicalities of using pingers in a real time fishery

Once attached to the nets, the Banana Pingers stay in situ and are not removed until nets are replaced for reasons such as fixing or re-configuring. Even when replacing the battery, the pinger can remain on the footrope and the internal structure removed easily to access the battery pack. Feedback from skippers on the handling of the pinger was generally OK although some modifications had to be made, with pingers functioning well other than a few isolated incidences highlighted below. One 'button-holing' event was reported, which resulted in the crew adjusting their shooting practices to prevent it happening again which may not be possible on all netting vessels. One incident with the pinger potentially causing the wrapping of the net around the prop was also reported, however the skipper says that this serious event was not necessarily attributable directly to the pinger as it could have occurred from coral or any other cause of tangling being present in the net.

The method of rigging the Banana Pingers was developed by the commercial fishermen involved in the 2011 study by Hardy et al*,* and has continued to work well. The placement of pingers on the footrope rather than the headrope of the set nets appears satisfactory for most vessels and there is usually less tension on the footrope during hauling, reducing the stress on the pinger.

It was confirmed that once on the net, Banana Pingers do not cause a hazard to the fishermen when hauling or shooting as they remain static on the net, tight to the rope, and move with ease through the hauling machine. However there was a concern from one skipper about the pingers popping out of their plastic casing when under tension. This was probably due to the circumstance of the net being hauled by the footrope (where the pingers are attached) rather than the headrope. Fishtek will be investigating this further and hope to be able to rectify the problem, however a short-term solution has been suggested with the application of a small cable tie around the pinger to hold the interior mechanism within the casing. It is hoped that the skipper in question will be able to trial this modification and provide feedback to the manufacturers.

One skipper was concerned about the method used to rebuild his gear with new netting, as this involved sliding the new net on to the old foot and head ropes and that would require taking the pinger carrier off, which would take time. Discussions are still ongoing to investigate a solution to this issue.

It should be recognized that there are different methods of rigging gear, and shooting and hauling gear, for which the Banana Pinger may not be suited or which may require changes to normal shooting procedures. However, the manufacturers wish to continue amending their device to ensure it is as easy to use by as many vessels as possible, and will endeavour to make changes to design as necessary.

A pinger was returned with a fractured housing and this is being investigated and may have been due to the moulding having been made at too high a temperature. One pinger also failed for no apparent reason and was replaced within the first week.

In our trials in 2011 skippers were mainly concerned by the actual battery life of the pinger being tested at that time (the AQUAmark100) and the cost of putting them on all their fishing gear. The early battery failure of several pingers in the AQUAmark100 pinger trial may have been due in part to the immersion switch on the AQUAmark100 being constantly ON during storage in net bins in which they do not fully dry out. However, the Banana Pinger does not seem to have experienced the same problem and has proved to have excellent battery life, with all pingers still active (measured by the number of flashes displayed at each interval) at the end of the six month trial. One skipper commented that he found the LED flashing light to be very useful as an indicator that the pingers were still working. The ability to change the batteries of the Banana Pinger without having to replace the whole device at additional cost is also attractive to fishermen.

One skipper felt that the LED light caused the attraction of commercially non-viable white fish, such as juvenile ling, to his nets, which in turn led to excessive scavenging from crustaceans and conger eel. He combatted the problem by turning the pinger around within its casing so that the light was blocked by the plastic cover, and also as a double measure taped up the casing to prevent a glow from within. This, he felt, solved the problem but meant he no longer had any indication of battery life. Fishtek have since modified the LED battery indicator light so that it only comes on when out of water, which should alleviate this problem.

Two skippers also felt that the pinger LED was potentially attracting seals (see discussion 4.2.3).

The feedback from the fishing community has been invaluable in both the present study and the previous work. Without the co-operation of the fishermen involved, this trial assessment of the practical elements of using these pingers would not have been possible.

4.2.3 Effect on other marine mammals

During a previous investigation by Cornwall Wildlife Trust into the prototype Banana Pinger (in 2011), the possibility was raised of the pinger being audible to seals and leading to bycatch. The pinger output was revised to remove frequencies below 50kHz and make the pinger inaudible to seals except at very short range. It is the revised Banana Pinger which was being tested in this study.

However, two skippers involved in this trial commented that they still felt juvenile seal bycatch in their nets had increased due to the Banana Pingers. One skipper reported catching one juvenile seal in a fishing ground with a depth of around 85 metres where seal bycatch historically is unheard of. Another skipper reported catching three seals in his nets during the trial, all close to the pingers.

In response to this feedback the Trust carried out an additional investigation at the Cornish Seal Sanctuary in Gweek, involving 17 rehabilitated wild and captive bred seals. The new (2012) 50kHz - 120kHz Banana Pinger was tested on Atlantic grey seals in an outdoor pool by immersing randomly active or inactive pingers and observing the proximity and behaviour of the seals to the acoustically transparent tube that held the pinger. In over 140 tests the investigation demonstrated no significant movement towards or away from the pinger, although the seals were often close to the tube, indicating no significant attraction or deterrent effect of the Banana Pinger on the seals. This supported the theory that the revised output of the new Banana Pinger is now outside the audible range of grey seals, and that the animals were unlikely to be attracted to nets due to the pinger being an acoustic attractant.

It remains possible that the LED flashing battery indicator light emitted by the Fishtek Banana Pinger may have visually attracted juvenile seals. As stated above, Fishtek have now changed the indicator light program in the Banana Pinger so that it does not flash while immersed. It is hoped that this will overcome the seal attraction issue, but further trials are required.

4.2.4 Ownership of pingers by fishermen

During post-trial discussions skippers generally said that they do not feel there is a significant enough level of cetacean bycatch in their tangle net fishery to warrant the use of bycatch mitigation devices such as pingers. Three of the four skippers commented that they catch between one and three porpoises a year and due to the costs (cost of purchasing enough pingers, time cost of rigging nets with pingers, and running costs) they would not support the use of pingers in their fishery at present.

However there is substantial evidence of inshore (within 12nm and under-12m vessels) net bycatch of both porpoises and dolphins from Cornwall Wildlife Trust's Marine Strandings records and DEFRA's Cetacean Strandings Investigation Program. Studies of drift patterns of dead cetaceans have shown that many bycaught animals do come from inshore, and post mortem examinations has proved that bycatch in static nets is a significant cause of death for cetaceans in the South West.

Image 5: Fisherman with C-POD. Photo by Malcolm MacGarvin, Pisces-RFR CIC.

Consideration must also be given to the potential benefits that the use of these pingers can bring, not just to cetacean conservation but to skippers by way of better public perception of their fishery as 'dolphin friendly'.

Cornwall Wildlife Trust hopes to follow up initial discussions with funding bodies for the possibility of securing funds to cover initial set-up costs and purchase of Banana Pingers for local fishermen who wish to use them voluntarily, which we believe would offset many of the negative responses from skippers during these post-trial discussions.

5.0 Conclusions

In conclusion, the Banana Pinger is suitable for deployment on certain set ups of nets in an inshore set net fishery and shows a strong 'pinger effect' that can be expected to translate into a greatly reduced bycatch. It also gives confidence that habituation is not a problem. There is also strong evidence of a response by dolphins to the Banana Pinger, displayed in the cycling pinger trials. However, the level of reduction in dolphin bycatch that may come from their use is not so clear.

The Banana Pinger has a long battery life and easily replaceable batteries. It does appear to overcome the previous issues with small pingers:

- Low cost (approximately £30 per reusable unit compared with approximately £80 per unit of disposable pingers, tested previously).
- Easy to attach to fishing equipment at a spacing of 200m and safe to use during fishing practices with some modifications.
- Battery indicator light therefore easy to monitor and enforce.
- Environmentally friendly (batteries can be replaced rather than the whole unit having to be thrown away).
- Light in weight.

In comparison with loud pingers such as the DDD:

- Greatly reduced noise pollution and potential for cetacean exclusion areas.
- Reduced risk of creating acoustic barriers across estuaries and along the coast.
- Safe to remain on entire length of net throughout fishing practices such as hauling and shooting.
- Achieves the same benefit at lower cost.

By minimising the number of cetaceans accidentally caught in fishing nets, effective pingers would reduce one of the main threats to the survival of these highly valued and nationally protected species.

The project has contributed directly towards the achievement of goals within the UK, South West and Cornwall Biodiversity Action Plans (BAPs) for harbour porpoise, and small dolphins. Strategically, the work will help deliver the UK's obligations under the European Habitats Directive and meet recommendations on reducing bycatch made by international agreements such as the Convention on Migratory Species of Wild Animals (CMS) and the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS).

Cornwall Wildlife Trust has worked closely with Cornwall IFCA throughout the establishment and progress of this project. Cornwall IFCA officers assisted in finding fishermen who were interested in participating in the trial, and we have continued to form a close working relationship with the respective fishermen and officers. Discussions are ongoing with Cornwall IFCA officers and members of the fishing community with regard to future trials and the possibilities of progressing of the use of pingers on inshore set nets.

The fishermen directly involved in the trial have contributed valuable advice and experience on the attachment and handling of pingers on small commercial fishing vessels. The Cornwall Wildlife Trust project officer met and interviewed the skippers on a regular basis, to receive feedback and share this with the pinger manufacturers. The fishermen have been invaluable to the project and their input and feedback on practical aspects of using pingers was paramount to the success of the trial.. Their assistance and cooperative approach to the project has enabled the pingers to be thoroughly tested and the acoustic monitoring gear consistently deployed to ensure the collection of statistically viable data. Their opinions on possible acoustic and visual causes of seal bycatch have directly led to design changes in the Banana Pinger that are now in place.

6.0 Recommendations

Possible management measures to minimise bycatch of marine mammals in inshore set nets have been discussed throughout this project, and in light of the positive result of this trial of the Banana Pinger, Cornwall Wildlife Trust recommend the following:

1. That a wider 'trial' of Banana Pingers should be promoted to all under-12m vessels using gill or tangle nets within Cornwall's territorial waters (0-12 nm) as a voluntary method to reduce cetacean bycatch. This will enable the modifications made by the manufacturers to be fully tested such as the popping out and potential seal interactions. This trial should be undertaken with full support and input from local skippers from the offset.
2. Discussion should be had to undertake similar Banana Pinger trials in other fishing areas in the UK.
3. To encourage voluntary uptake of pingers, effort should go into raising consumer and public awareness of vessels using pingers as being 'dolphin friendly' and promote these vessels as using sustainable practices.
4. Further work to assess the durability and suitability of the Banana Pinger as a bycatch mitigation device on over-12m vessels is undertaken.

A much larger study of the effect of Banana Pingers on actual bycatch of dolphins would also be of great value, both in the UK and worldwide.

Image 6: Common dolphins. Photo by Eleanor Knott.

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Image 7: Bottlenose dolphins off cliffs in St Ives Bay. Photo by Dan Murphy

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Image 8: Harbour porpoises. Photo by Niki Clear.