Bord Iascaigh Mhara
Irish Sea Fisheries Board

Development of acoustic deterrent device to mitigate seal fisheries interactions interim report

January 2017

M. Gosch[1], C. Luck[1], R. Cosgrove[2], T. Goetz[3], P. Tyndall[2], and M. Cronin[1]

[1.] MaREI Centre, Beaufort Building, Environmental Research Institute, University College Cork.

[2.] Irish Sea Fisheries Board (BIM), New Docks, Galway.

[3.] Scottish Oceans Institute, Sea Marine Mammal Unit, St. Andrews, Scotland.

MaREI Centre for Marine and Renewable Energy

ERI Environmental Research Institute University College Cork

UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh

1. Background

Interactions across the range of most seal species and the fishing industry are an on-going problem. Such interactions typically occur at both the biological level (competing for shared resources) and operation level (seal-induced damage to fishing gear and catches). The reported increase in grey seal abundance in Ireland (Ó Cadhla *et al*., 2013) has furthermore resulted in frequent calls from the Irish Fisheries sector to introduce a seal cull. However, this species is protected under the national and EU legislation, including under Annex II of the Habitat's Directive (Council Directive: 92/43/EEC).

In 2015, a BIM study entitled "Seal depredation in bottom-set gillnet and entangling net fisheries in Irish waters" was published in the scientific journal 'Fisheries Research'. The study suggests that seals pose a substantial threat to the livelihoods of fishermen operating along the western and southern Irish coasts. Damages to catches caused by seals (depredation) ranged from 59% of monkfish, 18% of pollack and 10% of hake catches over the course of 12 months of extensive on board observations on inshore and offshore vessels. The study concluded that major increases in seal depredation and associated economic impacts on Irish fisheries since the 1990's are not unexpected given the substantial recovery of the grey seal population over the same period. Furthermore, the study suggested that effective acoustic deterrent signals deployed from vessels have potential as a practical method to reduce depredation in deep set-net and jigging fisheries. Study results combined with knowledge of seal diving behaviour suggested that seals wait until fish are close to the surface during hauling to remove fish from deep set-nets while depredation is more localised relative to the boat in the case of jigging vessels.

Preliminary field studies were carried out on a cetacean-friendly acoustic deterrent system for seals from fishing operations in 2015. The new smart seal deterrent signal, which was developed by scientists at the Sea Mammal Research Unit (SMRU) in Scotland, produces a startle response in seals rather than an aversion to a very loud noise. In contrast to more traditional seal deterrents used on fish farms, the new signal is transmitted at a sound level which is not harmful to seals even at very close distances. The operating frequencies are at the lower reported auditory range of Bottlenose dolphin, Common dolphin, harbour porpoise, and are considered highly unlikely to cause injury or death to any cetacean. Furthermore the proposed signals have been proven not to affect porpoises (Götz and Janik, 2015). These factors suggest that it is unlikely that these species will be negatively affected by the proposed signal deployment. The cetacean friendly aspect of this device is desirable given the growing network of Special Areas of Conservation (SAC) for cetacean species in Irish waters. Following some promising results during the preliminary studies in 2015, investigations into the effectiveness of the acoustic deterrent device in reducing depredation in jigging and deep gillnet fisheries commenced in 2016.

1.1 Study objectives

The work undertaken to date and the planned on-going effort will meet the objectives outlined in the proposal. This scientifically robust study aims to greatly assist catchers, reduce the economic impact of seal depredation, and facilitate longer term development of measures to reduce seal bycatch. In relation to the new Common Fisheries Policy, the proposed project specifically aims to achieve a more sustainable use of marine biological resources and coexistence with protected predators.

2. Approach and Methodology

The playback system initially consisted of two Lubell 9162 underwater loudspeakers, two Cadence Z9000 power amplifiers, and a Roland R-05 Wave/MP3 recorder (24-bit/96 kHz), all powered by a 12 V lead acid car battery. However, due to a number of issues associated with the loudspeakers malfunctioning, the loudspeakers were subsequently replaced with the newer 916 model. Signals were 200 ms long, extending over 2-3 octave bands within a frequency range of 700 Hz and 1500 Hz. These were played at a source level of approximately 180 dB re 1 Pa (rms) at 1 m.

Previous evidence indicates that the majority of seal depredation occurs close for the surface during hauling within the deep-net hake fishery (Cosgrove *et al*., 2013), and depredation is localised in the case of pollack jigging. To this end, the speakers were deployed at depths of 15 m and 5 m, with a hydrophone lowered to a depth of 10 m to recorder the signals using an Edirol R-09 Wave/MP3 recorder (24-bit/96 kHz).

Any seals above water observed in the vicinity of the vessels were photographed using a digital SLR camera (Canon EOS-IDS) with a 600 mm telephoto auto-focus image stabilising lens (Canon 600 mm f/4L EF IS USM lens). The purpose of the photo identification was to determine from patterns of individual pelage markings if re-sightings of the same seals was occurring. Seal distance from the boat was also recorded using a Bushnell Yardage Pro laser rangefinder (8x36 Quest) operating within a range of 13 – 1189 m. This was done to establish the minimum distance of seals from the boat when the acoustic deterrent device was active.

All trials were conducted under license from the National Parks and Wildlife Service (NPWS). As per the license conditions, the local NPWS conservation ranger was notified of each impending trip prior to the commencement of the activity.

2.2 Jigging Fishery, southwest coast

Two inshore vessels participated in the study based out of Ventry, Co. Kerry: Vessel 1 (Deep Cove, Registration number T133), an 8.73 m vessel consisting of 4.21 Gross Tones (GT) and a 68.24 KW engine output; Vessel 2 (Kate Marie, Registration number S13), an 11.3 m vessel of 8.59 GT and an engine output of 83 KW. Both vessels were under the same ownership and each contained 5 DNG jigging machines targeting pollack at depths of 30 – 90 m. Targets of 10 days were set at the outset of the project. An observer was assigned to each vessel, with Vessel 1 deploying the device for the initial 5 days (experimental boat) and Vessel 2 acting as the "control" boat. The device was then switched to Vessel 2 which became the "experimental" boat with Vessel 1 acting as the "control" for the final 5 days so as to reduce potential biases attributed to observer error and vessel noise.

The two loudspeakers were deployed over the opposite side of the vessel to where the jigging machines were used to avoid entanglement. Signal deployment (playback) was alternated on and off between independent fishing events (i.e. drifts) in one day so that each event was not affected by the previous event. A detailed data collection program outlined methods for recording landed and depredated fish, fishing location and operation details, and playback experiment details (sound file nos. etc.). A standardised approach to classify seal damage (see Cosgrove *et al*., 2013) was used. When possible, seal behaviour/response to the device was observed and documented e.g. distance seals maintained from the vessel during playback, swimming direction, head above/below water etc. Prior to the commencement of playback, a visual survey effort of 10 minutes around the experimental vessel for marine mammals was undertaken. As a precaution, if cetaceans were observed with a 10 m range of the underwater loudspeaker before the device was switched on, playback was suspended until the animals were clear of the area. The behaviour of any cetaceans observed in the vicinity of the vessels during after playback was initiated was also recorded.

2.3 Gillnetter Fishery, west/southwest coast

One offshore vessel based out of Dingle, Co. Kerry is currently participating in the study. The 23.65 m vessel (Atlantic fisher, Registration number T116) weighs 176 GT with an engine output of 309.59 KW. This fishery targets hake using deep-set gillnets in depths from 44 to 194 m, with each set approximately 2.4 miles long and operated using a Spencer Carter NHO-10 hauler. Targets of approximately 24 days (4 x 6 trips) were set at the outset of the project.

Similar to the procedure on the jigging vessel, playback signals are alternated between each fishing event (i.e. hauls). The two loudspeakers are deployed slightly astern of and at the opposite site to the hauler to avoid entanglement in the fishing gear. Both are attached to a derrick which is then lowered mechanically from the wheel house during playback experiments and withdrawn when the vessel is moving to minimise the potential of cables getting caught in the engine propeller. The hydrophone is lowered to a depth of 10 m and is positioned aft of the hauler with all playback experiments recorded. All details on catch, incidents of depredation, fishing operations, playback, and marine mammal behaviour were recorded in the same manner as with the jigging fishery. Similarly, a visual survey for cetaceans was conducted prior to commencing of playback.

2.4. Statistical analysis

To analyse any potential effect of playback of the acoustic deterrent device on the fish catch and depredation rates a negative binomial generalised linear model (GLM), using the R package MASS, was chosen as the most appropriate model for the data. Each drift was treated as a single observation of fishing effort and the number of fish caught in each drift was treated as the response variable. A total of 10 predictors (Table 1) were included in the global model. Using the dredge function of the MuMin package in R, all possible models using different combinations of predictors, were created. All models within 2 AICc of the optimal model were then averaged to provide a model that best described the data.

Table 1: Predictors used in the negative binomial GLM of fish caught per fishing effort (drift)

Predictor	**Description**
Playback of ADD	Playback of ADD on or off
Drift duration	Duration of the drift in minutes
Number of jiggers	Number of jigging machines active during the drift
Depth	Sea depth (m) during drift
Drift speed	Speed (knots) at which the boat drifted
Number of seals present	Number of seals sighted around boat during drift
Sea state	Sea state during drift based on Douglas sea scale
Date	Date of drift
Vessel	Vessel used
Drift sequence	The sequential order of the drift in that day. I.e. whether it was the 1st, 2nd, 3rd etc. drift on a given day

3. Results

Playback trails onboard the jigging vessels commenced in June 2016 (Table 2). These trips were conducted along the southwest coast of Ireland (Figure 2) when weather was optimal, requiring a sea swell of no greater than 2 m. Due to malfunctioning of the loudspeakers, seal acoustic deterrent trials onboard the gillnetter vessel were deferred until August 2016 (Table 2). Fishing onboard this offshore vessel was primarily conducted off the southwest coast with 6 playback experiments carried out off the west coast of Ireland (Figure 2).

Table 2: Summary of effort to date

	Jigger	**Gillnetter**
Start date/End date	June 2016/October 2016	August 2016/On-going
N. target days	10	24
No. days effort	10	6
No. of vessels	2	1
No. of drifts/hauls	236	18
No. hauls device deployed	95	9

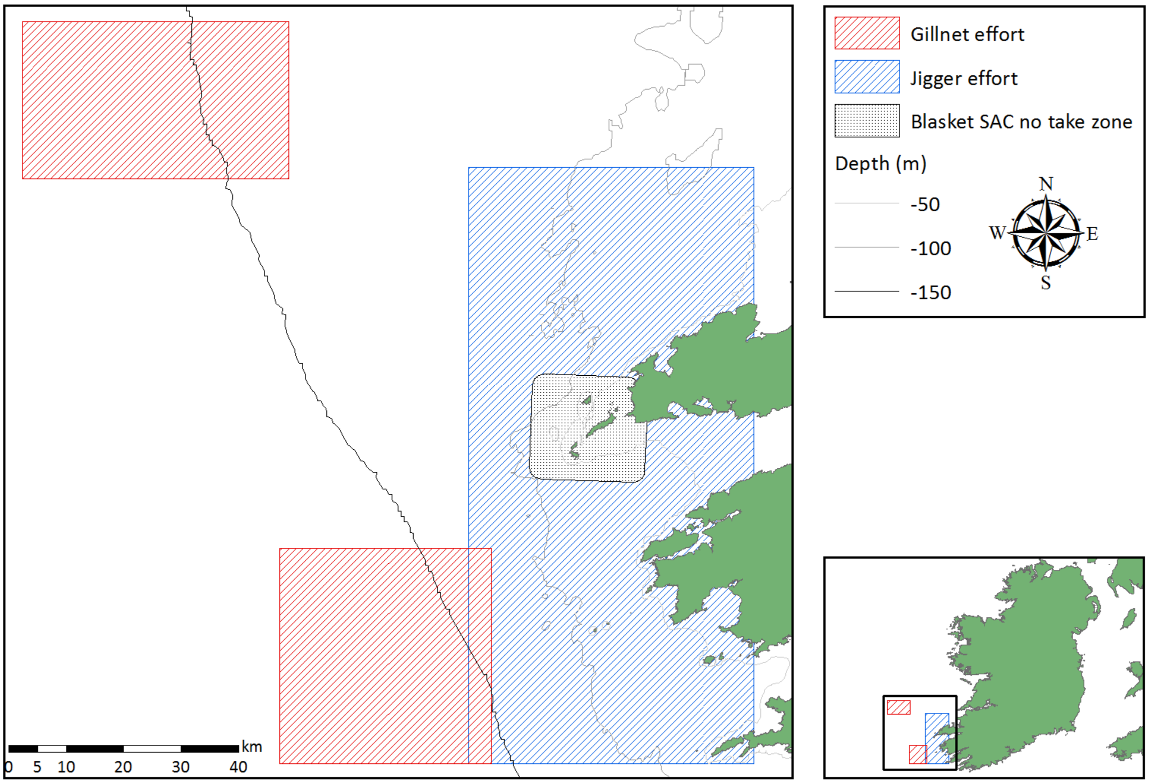

Figure 2: Map of Ireland indicating areas off the southwest and west coast where seal acoustic deterrent playback trials were conducted

3.1 *Jigging Fishery, southwest coast*

3.1.1 Distribution of effort

A total of 236 drifts were observed on board both jigging vessels over 10 days (Table 3), with the acoustic deterrent device deployed during 95 drifts. The discrepancy between the number of drifts with playback 'On' and 'Off' is due to a number of short drifts (< 10 mins) when the skippers were less inclined to deploy the device due to time constraints. Additionally, days when the speakers malfunctioned resulted in the experimental vessel carrying out drifts with the device "off".

Table 3: Number of drifts observed on board each vessel with acoustic deterrents deployed (playback on) and not deployed (playback off).

	Playback		
Vessel	**On**	**Off**	**Total**
Vessel 1	36	91	127
Vessel 2	59	50	109
Total	95	141	236

3.1.2 Total fish catches

Twelve fish in total were depredated by seals, making up 0.46% of the total catch (Table 4). This includes damage to fish and hidden losses (where a seal removes an entire fish from the line). Hidden losses were recorded when the jigging machine registered a fish on the line but after a sharp tug (presumably the seal removing the fish) the line came up empty. Though the numbers of depredated fish were extremely low, depredation was higher when playback was off, i.e. when no deterrent was deployed, where no fish were recorded depredated. This was consistent across total numbers of fish depredated, percentage of fish depredated, and mean number of fish depredated per drift, but depredation events were too rare for any sophisticated statistical analysis.

Table 4: The number of fish caught by both vessels and the number of fish depredated by seals (including hidden losses) when playback of acoustic deterrent was on and off

Playback	**Total fish**	**Mean (± se) fish per drift**	**Total fish depredated**	**% total fish depredated**	**Mean (± se) fish depredated per drift**
On	902	9.49 (± 1.20)	0	0.00	0.00 (± 0.00)
Off	1712	12.14 (± 1.82)	12	0.70	0.09 (± 0.04)

3.1.3 Number of drifts attacked by seals

Fishermen are more likely to terminate a drift once seals begin depredating the lines due to an increased chance that depredation will continue for the duration of the drift or that seals may scare fish away. Therefore, the number of drifts depredated by seals as opposed to the number of fish damaged was examined as an alternative measure of depredation. Results indicate the rate of depredation is slightly higher, with 10 of 248 drifts (4.0%) affected. No drifts were depredated when the device was emitting the playback signal (Table 5).

Table 5: Number of drifts where depredation occurred when playback of acoustic deterrent was on and off.

Playback	No. drifts	Drifts depredated	% drifts depredated
On	95	0	0.0
Off	141	7	5.0

3.1.4 Seal numbers

Seals were observed from the experimental vessel more frequently when the device was not playing. A seal was sighted near the experimental vessel once when the device was on and five times when the device was off. Of these 6 drifts during which a seal was sighted, only 3 were depredated. No drifts were depredated when the device was playing.

3.1.5 Statistical analysis

Based on the negative binomial GLM, playback of the device had no significant effect on the catch, and was not retained in models. All other predictors were retained. Predictors that had a significant effect on catch were drift duration ($p<0.001$), depth ($p<0.01$), number of active jigging machines ($p<0.05$), drift speed ($p<0.05$), and sea state ($p<0.05$). The summary output of the catch model is highlighted in Table 6.

Table 2: Summary output of model-averaged catch model with total number of fish caught per drift as the response variable.

Coefficients	Estimate	Std. Error	Adjusted SE	z value	Pr(>|z|)
(Intercept)	1.654e+01	3.328e+01	3.333e+01	0.496	0.6197
Depth	1.038e-02	3.387e-03	3.406e-03	3.049	0.0023 **
Drift speed	4.388e-01	2.143e-01	2.156e-01	2.036	0.0418 *
Duration	2.750e-02	2.754e-03	2.769e-03	9.934	<2e-16 ***
No. jiggers	2.843e-01	1.173e-01	1.178e-01	2.413	0.0158 *
No. seals	7.402e-01	4.419e-01	4.444e-01	1.666	0.0958 .
Sea state	1.949e-01	8.700e-02	8.747e-02	2.228	0.0259 *
Date	-3.891e-08	2.377e-08	2.387e-08	1.630	0.1030
Vessel (Kate_Marie)	-1.590e-01	1.475e-01	1.483e-01	1.072	0.2837
Drift sequence	-1.358e-02	1.599e-02	1.609e-02	0.845	0.3984

3.2 *Gillnet Fishery, west/southwest coast*

3.2.1 Effort, fish catches and fish damage

To date, 1 trip (6 days) of a planned 4 trip (24 day) trial period have been covered. Out of a total of 18 hauls, playback experiments were conducted for 10 hauls with 4 fish in total depredated (Table 6). Greater quantities of fish were caught when the deterrent device was off although this coincided with a larger number of the catch being damaged by seals.

Table 6: The number of hauls depredated by seals and the quantities of fish both landed and depredated when playback of the acoustic deterrent was on and off.

Playback	No. of hauls	No. hauls depredated	Landed fish boxes	No. fish depredated
On	10	3	118	4
Off	8	6	124	40

3.2.2 Seal numbers

Similar to the jigging trials, seals were observed more frequently when the device was not playing. While playback was on seals were observed 12 times over the course of 4 hauls at distances ranging between approximately 40 – 200 m away from the vessel. It should be noted that these may have been repeat sightings of the same seal.

3.3 *Cetacean sightings*

No cetaceans were observed over the course of the gillnetting trip. Cetaceans were frequently seen during the jigging trips however they were only observed while the vessels were in transit.

A standalone trial day aboard the jigger took place prior to June 2016 (not included in data results). On this day over 70 common dolphins approached the experimental vessel over the course of 3 separate drifts while the device was on. The dolphins swam directly to and under the vessel, initially appearing curious as to the source of the sound. They then remained in the vicinity (less than 20 m from the vessel) for the duration of the drifts displaying milling and playing behaviour. A humpback whale was also observed on the same day during a playback “on” drift, although this was sighted over 500 m away and it is unlikely the acoustic signal strength would have propagated that distance.

4. Discussion

Within the pollack jigging fishery, results indicate that the acoustic deterrent device does not have adverse effects on the overall landed catch. Very little overall depredation occurred over the course of trips on board the jigging vessels regardless of whether the acoustic device was on or not. However, given that no drifts or fish were depredated when playback was on, this would indicate that the startle signal may be deterring seals during fishing operations.

Preliminary results from the offshore hake fishery are encouraging. Though 30% of hauls were depredated while playback trials were on, the overall amount of depredated fish was very low at just four fish in total. Furthermore, subsequent to the trip the loudspeakers were replaced with a newer model as the older model was found to be malfunctioning. It may be that the source level was below optimal level and could explain why three hauls were depredated. Alternatively, if a seal is deaf or has impaired hearing (possibly due to old age), the startle response may not be activated. These reasons may explain the sightings of seals less than 200 meters from the vessel when the device was on. However, given the low sample size to date further experimental trials are necessary to conclusively determine that the deterrent device significantly reduces depredation.

Due to a series of logistical issues encompassing; adverse weather conditions hindering the deployment of the device; the ability of the jigging vessels to fish; and the malfunctioning of the initial loudspeaker model, the end date of the project has unavoidably been pushed out. However, issues such as bad weather are expected problems that have to be overcome and while the matter of the loudspeaker was unanticipated, the newer model has been proven to function optimally during the final three jigging trips.

To conclude, the fieldwork undertaken to date and subsequent preliminary analysis show promise that the acoustic deterrent device tested in this study has the potential to significantly reduce the economic impact of seal-induce damage to fishery catches. Alongside mitigating against seal depredation within the Irish fishing sector, the continued experimentation and final results produced should therefore facilitate longer term development of of measures to reduce seal bycatch and ultimately achieve a more sustainable use of marine biological resources and coexistence with protected predators.

Acknowledgements

We would like to thank the skippers and crew of the vessels participating in the study; Eoin Firtéar (owner of Deep Cove and Kate Marie), Breandán Johnson, Ciarán Ó Lúing, Míchéal Grummell, Adam Flannery, Muiris Firtéar, Tom Kennedy (owner of Atlantic Fisher), and John O'Connor (skipper). This work was funded by the Irish Government and part-financed by the European Union through the EMFF Operational Programme 2014 – 2020 under the BIM sustainable fisheries scheme.

References

Cosgrove, R., Cronin, M., Reid, D., Gosch, M., Sheridan, M., Chopin, N., and Jessopp, M. 2013. Seal depredation and bycatch in set net fisheries in Irish waters. *Fisheries Resource Series* Vol. 10

Götz, T., and V. M. Janik. 2015. Target-specific acoustic predator deterrence in the marine environment. *Animal Conservation*, 18, 1, 102-111.