Marine Mammal Research at Wild Salmon Fisheries
Annual Report for 2013

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1 Introduction

Bag-nets and stake-nets are used to catch salmon in Scottish coastal waters; seine nets are typically used in estuarine limits when bag-nets are not permitted. There are, in general, two typical bag-net designs in use in Scotland; these are the single bag-net and the double bag-net (Figure 1). Bag-nets make use of the behaviour of migrating salmon to funnel fish into a trap from which they find it hard to escape. In its construction no mesh size smaller than 90mm or, mono-filament net can be used and its design must not aid the enmeshment of salmon (www.scotland.gov.uk[1]). Furthermore, no fishing is permitted on weekends (18:00 Friday – 06:00 Monday) and the overall duration of fishing season may differ between districts. Enforcement of regulations falls to the District Salmon Fishery Boards (DSFB) and not Marine Scotland Compliance that enforces other marine fisheries in Scotland. Salmon and sea trout landings statistics are obtained from annual returns made by the fisheries to Marine Scotland.

There is a long history of conflict between salmon fisheries and seals due to their belief that seals adversely affect salmon landings (Butler *et al.* 2011). However, work in both the Baltic and Scotland has shown that acoustic seal scaring devices can be effective at reducing the impact caused by seals (Fjälling *et al*. 2006; Harris *et al*. 2014). In addition studies in the Baltic have shown that modification of the design of nets can reduce the effects of seals on salmon catches (Lehtonen & Suuronen 2004; Lunneryd *et al.* 2003). Some Scottish fishermen have also introduced their own modifications such as strengthening areas of the net that are frequently targeted by seals and removing tight corners where fish can be trapped by seals. Others, however, feel that such modifications only reduce catches as salmon are hesitant to enter reinforced areas of bag-nets.

Salmon fisheries may also protect their nets and catches against serious damage from seals by lethal control, and licences to shoot seals are issued under the Marine (Scotland) Act 2010. Licences are considered for coastal nets and inland rod and line fisheries as well as aquaculture, and limits are issued accordingly by Marine Scotland. Licence holders are required to report the numbers of each species removed on a quarterly basis and to make an attempt to recover carcases whenever possible. Post-mortem reports on each recovered carcase are held by the Scottish Rural College (SRUC) Scottish Marine Animal Strandings Scheme (SMASS) and tissue samples made available to benefit a range of scientific studies.

Reported here:

Following on from previous work (Harris *et al.* 2014; Harris 2011; Harris 2012a; Harris 2012b) we provide a progress report on marine mammal research and support for wild salmon fisheries during 2013. The objectives during 2013 were to (1) continue trials of ADD (Acoustic Deterrent Device) use in the Moray Firth, (2) analyse data from the 2012 bag-net modification trial, (3) collect seal gastro-intestinal tracts from shot seals for dietary analysis, and (4) provide support to DSFBs with regard to seal management issues and ADD installations.

[1] http://www.scotland.gov.uk/Publications/2004/11/20316/47367

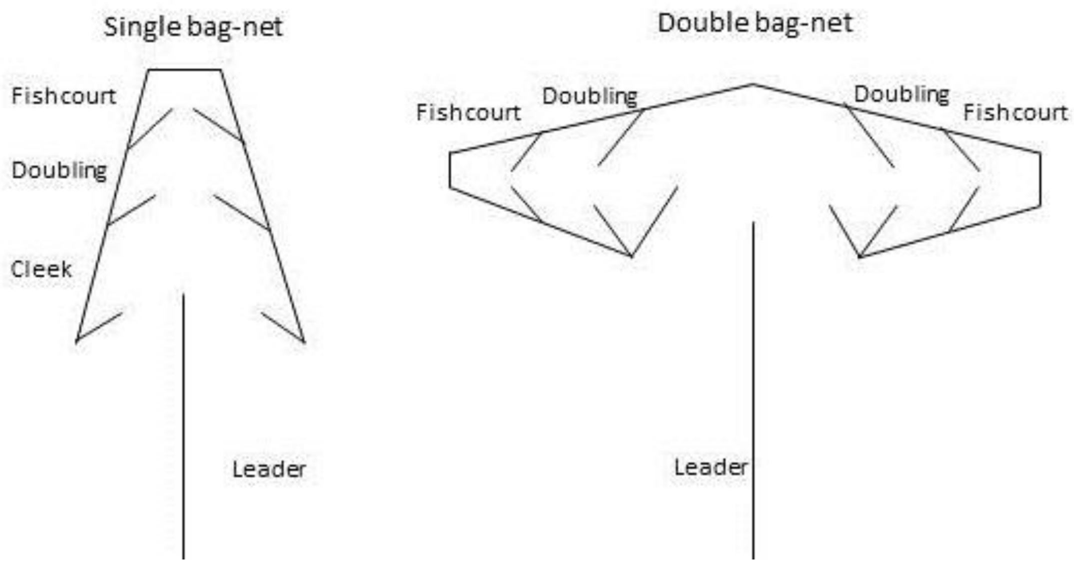

Figure 1. Plan view of a single bag-net and a double bag-net showing the sequence of chambers that make up the salmon trap - cleek, doubling and fish court.

2 Trials of Acoustic Deterrent Devices (ADDs) by Moray Firth salmon bag-nets (2013)

The Sea Mammal Research Unit (SMRU) purchased and installed a land-based, mains-powered Airmar ADD at Crovie (Gamrie Bay), and this represents the first trial of this device by SMRU. The device was maintained by SMRU and trialled in an experimental fashion involving control periods. Usan Salmon Fishery recorded landings and damage information throughout the trial. SMRU carried out land-based observations, collected seal carcases from Usan Salmon Fisheries or removed gastrointestinal tracts (GITs) from some seals where practicable. In addition SMRU maintained two underwater camera systems at two net fishing sites to monitor seal activity at the ADD site and an adjacent net fishing site (without an ADD). The work carried out at Gamrie Bay will be outlined in section 2.1.

In addition, for the fifth year in succession we provided William Paterson & Sons a Lofitech ADD, floating housing and batteries, for use at Portmahomack. The fishery agreed to record information as requested in previous years, and to maintain the device as instructed by SMRU. This work is outlined in section 2.2.

2.1 Usan Salmon Fisheries at Gamrie Bay

Usan Salmon purchased salmon fishing rights along a stretch of coast at Gardenstown, NE Scotland, and began fishing operations in 2012. It is understood that the stretch of coast had not been fished by salmon fishermen for a number of years prior to 2012. During 2012 up to seven nets were set at six locations (Figure 2). A Lofitech ADD in a floating housing was installed at the March net (a double bag-net – site A) and observations were carried out from two locations with fishermen recording landings data from nets at site A and site C.

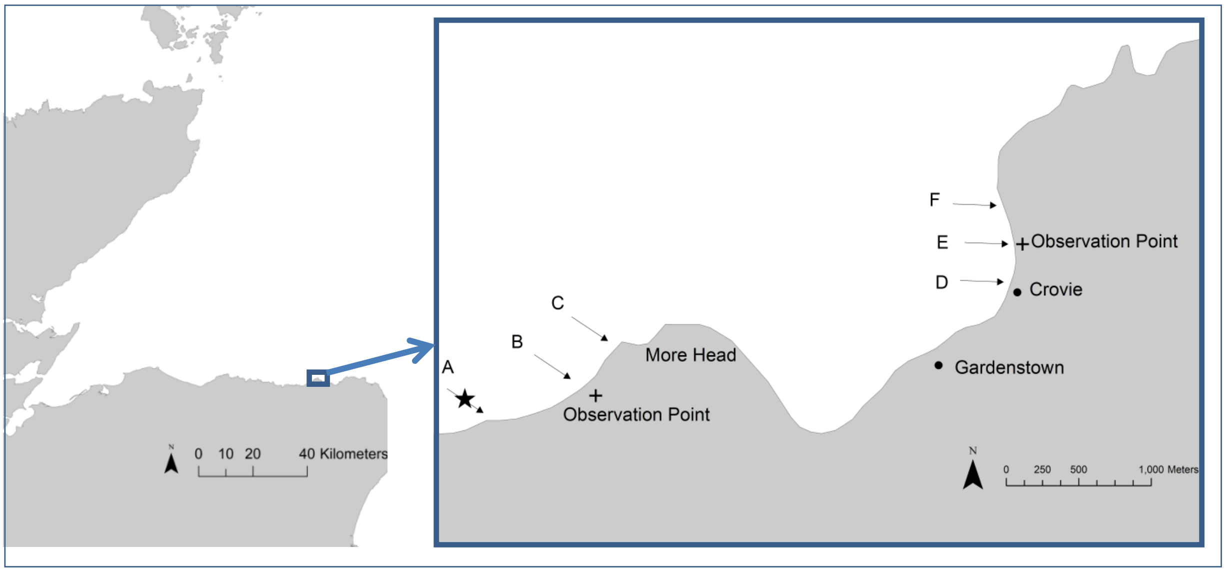

Figure 2. Locations of the observer's position and Usan Salmon Fisheries' salmon net sites at Gamrie Bay 2012: Site A – March net (1 double bag-net with ADD), Site B – Middle nets (2 double bag-nets), Site C – More Head (1 double bag-net), Site D – Crovie (1 single bag-net), Site E - Peter net (1 double bag-net), Site F – Wirren (1 double bag-net)

In 2013 the More Head net site was moved from site C to site C(ii) and the net at site D was moved to the end of the Crovie pier, site D(ii) (refer to Figure 3) and partway through the season a 'new' net site was established at Downie, site G (Figure 3). Fishermen recorded landings data for all sites except Downie and these are presented in section 2.1.1. The Gamrie Bay fishery moved away from using the double bag-nets that were used in 2012 to use mainly single bag-nets in 2013.

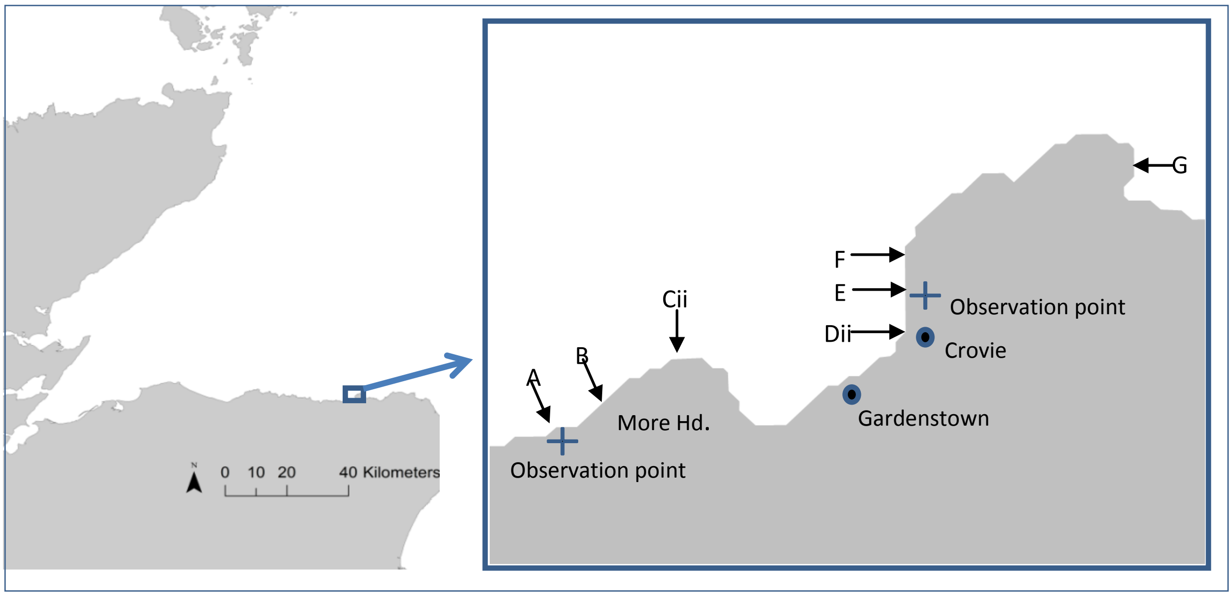

Figure 3. Locations of the observer's position and Usan Salmon Fisheries' salmon net sites at Gamrie Bay 2013: Site A – March net, Site B – Middle net, Site Cii – More Head net & Outrigger, Site Dii – Pier net, Site E - Peter net (with Airmar ADD), Site F – Wirren net, Site G - Downie

During 2013 the Lofitech ADD was not redeployed in this area. Instead, a new device (Airmar) was purchased and installed by SMRU at site E (Peter net). As mains power was available from a nearby residential property and the ADD suppliers were able to produce a device with a 200m transducer cable, the charging and ADD control unit was housed close to the property in a small shed with the transducer cable running out to the net. Not only did this represent the first trial by SMRU of an Airmar device at a bag-net fishery, but also the first bag-net trial involving this land-based deployment method utilising mains power (see section 2.3 for a more detailed description).

The installation of the Airmar device began in April and was completed on 8th May 2013. The device was first switched 'on' on 10th May. The equipment stopped working (producing only weak acoustic signals) on the 15th May and the transducer and cable removed and inspected by SMRU and the ADD supplier on the 17th May. The fault was traced to the device's recharging system and corrected. The transducer and cable were ready for redeployment later that day (17th May), but stormy weather and subsequent storm damage to the double bag-net prevented redeployment of the equipment until 4th June (at which point the double bag-net was replaced with a single bag-net). The ADD was redeployed on its own mooring approximately 4m from the fish court of the Peter net on 5th June.

SMRU observers maintained the ADD during the trial, switching the device 'on' or 'off' for randomised 24hr treatments and carried out land-based observations from two fixed points overlooking site A and site E to record marine mammal sightings (section 2.1.2). They also maintained two underwater camera systems on the Pier net (site Dii) and the Peter net (site E) (section 2.1.3), liaised closely with the salmon fishermen to develop a data recording methodology and to collect or sample shot seal carcasses (section 5).

We hope the ADD will be trialled experimentally for 5 years and a full report will be produced on the effectiveness of the device at this location following the completion of the trial.

2.1.1 Landings data

Usan Salmon Fisheries provided effort, landings and damage data from 9th May to 19th August 2013 from seven nets spread over six sites (sites A, B, Cii, Dii, E & F). Landings data showed that more fish were damaged by seals in May and June compared with July and August. Catches peaked in July with the exception of the Wirren net (site F) when catches were highest in August (Table 1). No seal damaged fish were recorded at the Peter net while the ADD was switched 'on'.

Table 1. Summary of the catch data supplied by Usan Salmon Fisheries for seven nets - number of salmon caught, estimated number of hours of fishing effort, number of salmon caught per hour as catch per unit effort (CPUE) and the number damaged by seals at the net. The * denotes the net with the Airmar ADD please note that the device was not regularly in use until June.

Month	Net	No. Salmo	Effort (hrs)	CPUE	No. damaged
May	March	31	413	0.08	8 (25.8%)
	Mid	15	413	0.04	7 (46.7%)
	More Hd.	48	413	0.12	9 (18.7%)
	Outrigger	18	413	0.04	8 (44.4%)
	Pier	3	96.5	0.03	1 (33.3%)
	Peter*	18	299.5	0.06	3 (16.7%)
	Wirren	27	396	0.07	8 (29.6%)
June	March	104	533.5	0.19	6 (5.8%)
	Mid	109	533.5	0.2	10 (9.2%)
	More Hd.	96	533.5	0.18	6 (6.3%)
	Outrigger	60	533.5	0.11	1 (1.6%)
	Pier	16	413	0.04	0
	Peter*	41	438.5	0.09	0
	Wirren	75	465.5	0.16	3 (4%)
July	March	152	504.7	0.3	1 (0.7%)
	Mid	117	504.7	0.2	1 (0.9%)
	More Hd.	228	504.7	0.45	1 (0.4%)
	Outrigger	68	504.7	0.13	5 (7.3%)
	Pier	39	476	0.08	0
	Peter*	66	476	0.14	0
	Wirren	96	461	0.21	1 (1%)
August	March	107	441.5	0.24	1 (0.9%)
	Mid	73	441.5	0.17	1 (1.4%)
	More Hd.	93	441.5	0.21	2 (2.2%)
	Outrigger	40	441.5	0.09	0
	Pier	34	453.5	0.07	3 (8.8%)
	Peter*	43	453.5	0.09	0
	Wirren	142	513.5	0.27	4 (2.8%)

2.1.2 Land-based observations

Each week observations were carried out at the Peter net (Site E) and the March net (Site A) while nets were fishing (see descriptions of observer positions below). Nets were legally able to fish between 6am on Mondays through to 6pm on Fridays. The purpose of the observations was to record marine mammal activity and environmental conditions as these have both been shown to affect bag-net landings (Harris *et al.* 2014). In an attempt to increase the observers' chances of detecting seal activity and to sample environmental conditions over each day the observation periods were spread out over each day and standardised to 1hr sessions (~5 per day) at the Peter net, and 2hr sessions (~2 per day) at the March net. The difference in session duration for each site was due to the difficulty/time associated with accessing the March net observation site. Sessions were occasionally cut short due to worsening weather conditions. The time of seal surfacing events was recorded and the duration of an encounter was taken from the time of the first to the last surfacing or where 30mins passed between surfacing events the subsequent surfacing was deemed to be a separate encounter. When only one surfacing was recorded then the seal was assumed to be present for one minute. The presence of other marine mammals or basking sharks was also recorded by observers (Table 3, 4 & 6). During daily routine operations (such as managing of the ADD and underwater video systems) the observers recorded additional encounters out with survey times as incidental sightings (Table 4).

2.1.2.1 Observation position Crovie

Peter net (Crovie): The observer was positioned close to the Peter net at site E (Figure 3), approximately 20m above sea level and positioned near the start of the leader. Site Dii (Pier net) was ~350m to the south and site F (Wirren net) ~225m to the north, seals at these three nets were visible from the Peter net observation position (Figure 3). Peter net observations were carried out between 9th May and 21st August. Harbour seals were rarely seen, during surveys only one harbour seal was sighted passing close to the Peter net while the ADD was 'off', the seal was not thought to have interacted with the net. In addition to sightings made during survey effort we also report incidental sightings made during times outwith survey effort.

Table 2. Summary of grey seal survey data (<80m of a net) from Crovie land-based observations by month, AirMar ADD status and surveys (1 hour duration). Seal presence indicates the number of surveys that grey seals were present at one of the Crovie nets (this as a rate in parenthesis) and the total duration in minutes that grey seals were recorded as present at a net (this as a rate of n of minutes observed). The AirMar ADD was 'on' for only 3 days in May due to a system recharging problem.

Crovie	**ADD status**	**Observations**	**Seal presence**	**Duration (mins)**
May	Off	19	4 (0.21)	23 (0.02)
	On	0	-	-
June	Off	34	8 (0.23)	36 (0.02)
	On	36	0	0
July	Off	43	5 (0.12)	79 (0.03)
	On	38	0	0
August	Off	48	3 (0.06)	37 (0.01)
	On	18	0	0

Table 3. The number of Crovie surveys and number of surveys where bottlenose dolphins (*Tursiops truncatus*), harbour porpoise (*Phocoena phocoena*), basking shark (*Cetorhinus maximus*), minke whale (*Balaenoptera acutorostrata*) or otter (*Lutra lutra*) were present in the area visible to the observer during surveys while the AirMar ADD was 'off' or 'on'.

Crovie	**N. surveys**	**Dolphins**	**Porpoise**	**Shark**	**Whale**	**Otter**
Off	144	4	3	1	1	0
On	92	0	0	0	0	0

Table 4. Summary of 2013 incidental sightings (outwith survey effort) made by the authors from Crovie village of grey seals (*Halichoerus grypus*), harbour seals (*Phoca vitulina*), bottlenose dolphins (*Tursiops truncatus*), harbour porpoise (*Phocoena phocoena*), basking shark (*Cetorhinus maximus*), minke whale (*Balaenoptera acutorostrata*) or otter (*Lutra lutra*) while the AirMar ADD was 'off' or 'on'.

Crovie	**Grey**	**Harbour**	**Dolphin**	**Porpoise**	**Shark**	**Whale**	**Otter**
Off	12	2	5	1	2	1	0
On	3	1	3	0	0	0	1

The closest range at which these species were recorded from the AirMar ADD during an 'on' treatment was: bottlenose dolphins ~200m, otter ~200m, grey seal ~130m and harbour seal ~170m.

2.1.2.2 Observation position More Head

March net (More Head): The observer was positioned above the Middle nets in 2012 (Figure 2) and above the March net in 2013 (Figure 3) at an altitude of approximately 100m above sea level and set back from the start of the March leader net by approximately 180m. This site required an area around the nets to be regularly scanned with x10 binoculars. One advantage of this site, due to the height above sea level coupled with the water clarity, meant that seals at the March net site could be followed underwater for entire dives as they patrolled around and inside nets in search of prey. These sightings provide support to land-based observations and underwater video from other sites that have shown that seals frequently enter nets in search of prey. The netting site to the north east was the middle net (site B) and at approximately 650m from the March net, made it possible to see seals at this net. However, the More Head net site had been moved further eastwards in 2013 and at approximately 1500m from the March net, seals at the More Head net were too far away to be reliably detected from the observation position. The ADD on the Peter net at Crovie was approximately 4 km from the March net. March net observations were carried out between the 3rd July and the 16th August.

Table 5. Summary of grey seal data (<80m of a net) from the More Head land-based observations by month, surveys were 2 hours in duration unless weather conditions deteriorated. Seal presence indicates the number of surveys that grey seals were present at either the March or Middle net (this as a rate in parenthesis) and the total duration in minutes that grey seals were recorded as present at a net (this as a rate of n of minutes observed).

More Head (March)	Observations	Seal presence	Duration (mins)
July	36 surveys (71 hours)	5 (0.14)	66 (0.02)
August	22 surveys (44 hours)	10 (0.45)	182 (0.07)

Table 6. The number of More Head surveys and number of surveys where bottlenose dolphins (*Tursiops truncatus*), harbour porpoise (*Phocoena phocoena*), basking shark (*Cetorhinus maximus*), minke whale (*Balaenoptera acutorostrata*) or otter (*Lutra lutra*) were present in the area visible to the observer during surveys.

N. surveys	Dolphins	Porpoise	Shark	Whale	Otter
58	8	1	2	0	1

2.1.3 Underwater video footage

Underwater video footage was collected at Crovie during July and August in the 2013 fishing season at the Pier net and Peter net; during July and August these nets were single bag-nets (Figure 1). The fishing method at these sites required three nets to rotate between the two sites, which enabled one net to be brought ashore to be cleaned while the other two fished. Due to the difficulty of removing and installing camera systems we fitted each net with three cameras and these remained on the nets during the study. The cameras were placed in the entrance to the doubling (Figure 1) of each net to detect seals entering this area. The time of seal sightings on the video and any behavioural notes was recorded, the duration of an encounter was taken from the time of the first sighting to the last or where 30mins past between sightings the subsequent sighting was deemed to be a separate encounter, where only one sighting was recorded then the seal was assumed to be present for one minute. This protocol follows that of the land-based observations in section 2.1.2. Cables were routed back to housings containing a hard-drive and 100 amp-hour gel battery (Haze Battery Co.) which were attached to the bridle of the net close to the cleek pole in a floating waterproof container (Peliproducts.co.uk). Cameras typically recorded from 03:00 to 23:00 each day during July and 04:00 to 22:00 during August. The floating containers that housed the hard-drives and batteries were recovered at the end of each week, or if bad weather was forecast, to recover data and recharge batteries.

At Crovie in 2013 a total of 665 hours of underwater video footage was collected and reviewed (437 hours from the Peter net and 228 hours from the Pier net). Only grey seals were detected on the video and this was confined to the Peter net - no seal activity was noted from the Pier net video. Seal sightings on the cameras were pooled into ten distinct visits, all visits occurred during ADD 'off' treatments and seven out of the ten encounters occurred either before 6am or after 9pm. A summary of the Peter net video is provided in Table 7.

Table 7. Underwater video footage collected from the Peter net - the number of occasions seals were present in the net and the cumulative total time seals were present. The hourly presence rate is shown in parenthesis.

Crovie: Peter net	ADD status	Footage (hrs)	Seal presence	Duration (mins)
July	OFF	169	5 (0.03)	22
	ON	76	0	0
August	OFF	124	5 (0.04)	14
	ON	68	0	0

Seal detection: underwater video versus land-based observations

While underwater video was recording, land-based observations recorded five separate seal encounters where at least one seal was present. Two of these encounters corresponded with underwater video footage of seals either inside or passing under the net. In addition, underwater video detected one additional seal encounter that was not detected by the land-based observer.

The three occasions where no seal was detected on the video appears to stem from occasions where seals either interacted with the net out with the range of the cameras, for example on one occasion a seal spent 25 minutes in the vicinity of the net and was seen to remove a salmon enmeshed in the leader yet was not detected on any of the cameras in the doubling (Figure 1). Alternatively seals may simply pass close to the net without interacting with it.

Altering the range at which seals are categorised by land-based observers as 'at the net' from 80m to say 40m may not improve the accuracy of correctly determining those seals that are interacting with the nets, as most known net specialist seals usually surface at greater distances from the net, possibly to avoid being detected by man. Alternatively relying on observer experience to subjectively assess whether a seal is interacting with the net may also be tricky in many situations and is open to considerable effects when different observers are used. Incorporating photo-identification with land-based observations may represent the most informative method of land-based observations as seals that habitually return to the net site can be identified and distinguished from transients. Without improving or changing the distribution of underwater surveillance, seals attacking fish or disrupting the passage of fish in other areas may be missed. Vice versa, land-based observations may also miss seals at the net, especially when sea state or light conditions are poor or the observation position is not ideal.

Land-based observations can produce a wealth of other information such as faults with the nets, general seal activity in the study area out with the nets, environmental conditions and the sightings of non-target species although many may be overcome through equipment such as weather stations and acoustic monitoring equipment. Both land-based observers and underwater surveillance have their merits and their resulting data need to be considered with their faults/biases.

2.1.4 Discussion

Seal activity at Crovie was generally low. Neither land-based observations or underwater video detected seal activity at the Peter net while the ADD was 'on' although seal presence was recorded on twenty occasions while the ADD was 'off'. No seal damaged fish were recorded when the ADD was 'on'. While the ADD was 'off' three fish were recorded as seal damaged and observers recorded a seal removing an additional salmon from the Peter net leader. Sightings of cetaceans, basking sharks and otters were too low for any meaningful analysis on the effect of the ADD on presence, however sightings of bottlenose dolphin as close as 200m from the AirMar ADD during 'on' treatments suggest that this device does not completely exclude this species.

Seal activity at the More Head observation site was comparable to Crovie seal activity during July (while the ADD was off), however during August seal activity was greatest at the March observation site.

A preliminary investigation of the Peter net landings data collected during the ADD trial (i.e. June onwards) suggested that there was no difference in landings between ADD 'on' treatments and ADD 'off' treatments. This result was not surprising given the low number of seal sightings during the trial.

2.2 Portmahomack (2013)

William Paterson & Sons has the right to fish for salmon along a section of coastline near Portmahomack on the Tarbat Ness Peninsula in Easter Ross. The fishery has operated one double-bag net here for over 10 years (Figure 4). The salmon fishery was provided with a Lofitech ADD to be used at this site for the fifth year in succession (Harris *et al*. (2014), Harris (2011, 2012b). The fishery agreed to maintain the ADD; regularly check battery voltage, recover the ADD for recharging when battery voltage fell below 11.5v and regularly check the ADD cable, mooring lines and transducer. In addition fishermen were expected to record landings, seal damage, fishing effort, seal sightings and ADD status ('on' or 'off') on forms provided by SMRU. SMRU also provided fishermen with predator damage guidance notes to avoid all fish damage being incorrectly apportioned to seals.

Following a review of the use of ADDs at salmon bag nets, it was recommended that all nets using SMRU ADDs should have the size of the 'door' into the fish-court of the net reduced to prevent seals frequently seen at nets from entering and potentially becoming trapped in the net and therefore unable to escape the intense sound pressure levels generated by ADDs. William Paterson & Sons made these changes before the start of the 2013 fishing season.

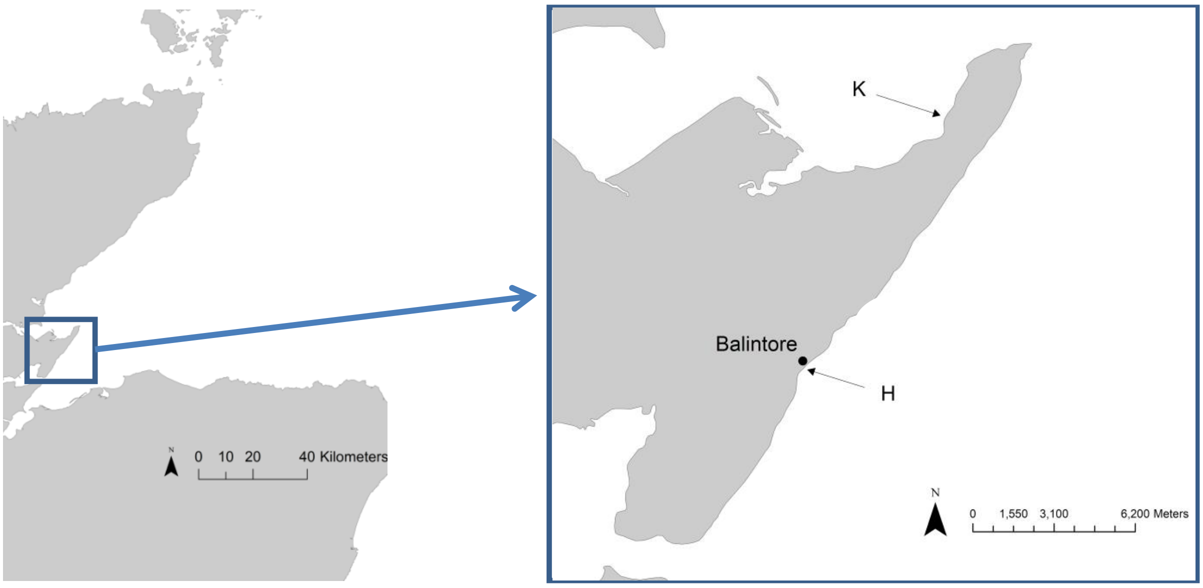

Figure 4. Locations of two bag-net sites: Sites H (Balintore) and K (Portmahomack) were run by William Paterson & Sons

2.2.1 Landings data

William Paterson & Sons requested that their landings not be presented explicitly but as an index of catch. The fishermen recorded the requested information from 9th July 2013 to 21st August 2013 (approx. 31 days of fishing effort). A preliminary summary of these data is provided below

Table 3. The number of days when the ADD was "on" and "off", the percentage of the landings damaged at the net by seals, the undamaged catch per unit effort (UCPUE) for this site and the proportion of hauls when seals were seen by fishers, when the ADD was 'off' and 'on'.

Site	ADD status	Days	Landings damaged	Index of UCPUE	Proportion of hauls with seal presence
Portmahomack	Off	11	17%	0.83	0.2
Portmahomack	On	27	17%	1.17	0.2

2.2.2 Discussion

Although the data are presented relative to ADD status ('on' or 'off)' the "on"/"off" periods were not distributed in a randomised fashion and 'off' treatments were simply the result of the device not being deployed by the fishermen until the second week of the season and the need for the fishermen to remove the device for recharging. As a result, a direct comparison between 'on' and ‘off’ would be unwise. However, from these results it is clear that unlike the previous four years, seal damage to fish during the 2013 season was often encountered by fishermen during ‘on’ treatments as well as ‘off’ treatments when seals were seen at the net.

Understanding exactly what happened and whether the device was functioning correctly is a priority for 2014.

2.3 ADD housing development

The Lofitech ADD has been shown to be an effective seal deterrent in this fishery in previous years (2009-2012). However, these devices were not designed to be used at salmon bag-nets and therefore we were presented with the challenge of how to deploy and power devices at bag-net sites in a way that would be affordable and practical to net fishermen.

Floating deployment – This method utilised a modified peli-case to house the manufacturers’ electronics and an additional power supply (lead-acid gel batteries). The buoyancy of this housing was sufficient to float its contents close to a bag-net and it was attached to one of the mooring lines of the bag-net. Unfortunately during 2012 two of the three ADDs failed during periods of stormy weather when either the transducer cable broke or the transducer cable gland broke. Before the start of the 2013 season we therefore replaced the housing glands to a more robust design and ensured that transducer cables were fitted with strain relief to prevent these failures from reoccurring. In addition modifications were made to the ADDs’ electronics case to further improve its water-proofing in the event that the peli-case flooded.

No problems were encountered with this deployment method in 2013. However, the inability of the system to be completely submerged for long periods and the durability of the housing mean that, although suitable for testing purposes, this method is probably not suited to long-term commercial use.

Sub-surface deployment - We investigated options for an entirely sub-surface deployment method with interchangeable battery pack using housings of high density plastics. To build housings we utilised SMRU plastic welding expertise and a prototype housing was built and was moored in the sea near St. Andrews at a maximum depth of approximately 2m to test durability. However, a small leak caused the trial to be abandoned and an improved method of controlling for weld performance is currently being investigated. Although it seems possible to build housings in plastic, the connectors and number of housing units required to enable a system of interchangeable battery packs to be utilised and the number of batteries that would be needed make this a technically demanding and likely expensive option for salmon fishermen.

Land-based deployment – A land-based deployment method was utilised in Crovie in 2013 as the land-based housing site was within 200m of the net and the ADD supplier was able to produce cable lengths of up to approximately 200m. The ADD was housed with a battery bank and charger in a purpose built shed near a residential property in Crovie where mains power was available. The transducer cable was protected and bolted to the rocky foreshore and then weighted and routed to the net along the seabed. The cable and transducer were then attached to the net, however, following a storm it was decided to attach the transducer to its own mooring so that if the net moved (e.g. in a storm) it wouldn't risk damaging the transducer cable. The final 20m of the transducer cable were floated to avoid the cable snagging on the seabed with the rise and fall of the tide.

The success of this deployment method suggests that, whenever possible, ADDs should be housed on land and cable/transducer extended out to the net. Although mains power was available for this trial, it would not be a necessity. For example, if a land-based site is available and accessible (by vehicle) within 200m of the net then a housing for the ADD and batteries could be established. This would be preferable to attempting to house electronics and batteries in the sea.

Power – At the majority of bag-net fishing sites 'mains' power is not available and therefore batteries need to be recharged on site or regularly replaced with charged ones. However this latter option often sees lead-acid batteries being deeply discharged before being recharged (lead-acid batteries only withstand ~30% depth of discharge before life expectancy is greatly reduced). Fishermen would therefore need to purchase new batteries after a relatively short period resulting in a considerable cost in the long-term. Not replacing the batteries may reduce the effectiveness of ADDs as ageing batteries struggle to hold their charge. Regularly having to recover heavy batteries from the sea for recharging is not seen by fishermen as a practicable long-term solution. Producing seal scarers that require less power is achievable and should be seen by manufactures as a priority if they expect their equipment to be run from batteries in remote areas.

Recharging on site requires the need for recharging systems such as solar panels or wind generators and these should be investigated wherever possible. An alternative would be to use a type of lithium battery pack that can handle deep discharges and therefore a longer battery life expectancy. The large initial outlay for lithium might put fishermen off this option, even though the theoretical performance suggests that the long-term costs would be little different from those of lead-acid batteries. The weight-saving advantages of lithium should also be noted given the considerable difficulties associated with regularly changing heavy lead-acid batteries.

Utilising fishery resources – The best way forward possibly lies with the salmon fisheries as they will often have unused resources they can call upon to house ADDs, such as small boats that could be modified to enable them to withstand mooring in open water. There are many deployment methods which salmon bag-net fishers could utilise to enable ADDs to be used at net fishing sites. The choice over which method to employ will likely be driven by location, on site skills and the financial implications.

3 Bag-net modification trial at Balintore (2012)

In an attempt to mitigate the effects of seals on salmon landings, Usan Salmon Fisheries have made a number of modifications to salmon bag-nets which are believed to reduce the number of seal damaged fish being landed and improve catches by making it harder for seals to remove fish – an improvement on the traditional salmon bag-net. To scientifically test the effectiveness of these modifications, SMRU trialled a modified net (Usan design) against a traditional Scottish bag-net (unmodified) at the Balintore fishery.

In 2012 William Paterson & Sons Ltd. agreed to help assess the effectiveness of the Usan modifications by agreeing to modify one net following the Usan design and by providing a site off Balintore (site H – Figure 4) to fish the two nets in a paired trial, where modified and traditional nets could be fished side by side.

Single bag-nets (including the modified net) were fished at these locations from 2nd July to 24th August 2012. One net was modified (Figure 5), the other nets (control nets) were of traditional design using 2mm twisted nylon, minimum stretched mesh size of 90mm and the opening to the inner chamber consisted of a number of openings each measuring approximately 60cms by 15cms, framed with rope. The traditional design will deform to allow a seal to pass through (Figure 6). The modified net was a traditional net with changes to the inner chamber that prevented seals entering the inner chamber and also made it harder for seals to trap salmon in tight corners. Changes included:

- Replacement of the rope framed entrance with 8mm stainless steel bars welded into 6 rectangular shapes each measuring 43cms by 15cms (Figure 5 & Figure 7)
- Heavier net material to prevent seals breaking the net and to increase the difficulty for seals to take fish through the net meshes (2mm twisted nylon increased to 4mm braided nylon) (Figure 5).
- Traditional nets typically have a larger mesh size for the floor, this was reduced in the modified net to the industry minimum (90mm);
- Tight corners within the inner chamber were closed off to reduce the chance of fish being cornered by seals (Figure 5)

The modified single bag-net was fished in an experimental trial alongside an unmodified 'traditional' single bag-net of the same dimensions (control net). The modified net and one control net were fitted with cameras to monitor the frequency of seals and salmon entering both modified and unmodified chambers of the nets (Figure 8 & 9). The two nets were set approximately 250m apart. When the nets with cameras became fouled they were brought ashore to be cleaned. At this time an unmodified net (without cameras) replaced the dirty nets to keep the sites fishing while the nets with cameras were cleaned. The cleaned modified and unmodified nets with cameras were then returned to the alternative location in an attempt to control for any particular site fishing better than the other.

Net fishermen recorded the number of fish caught, the amount of seal damage (referring to the guidelines and a catalogue of reference images provided by SMRU) on specifically designed forms. Dedicated land based observations of the two nets were also carried out regularly to record environmental data and marine mammal activity in the area.

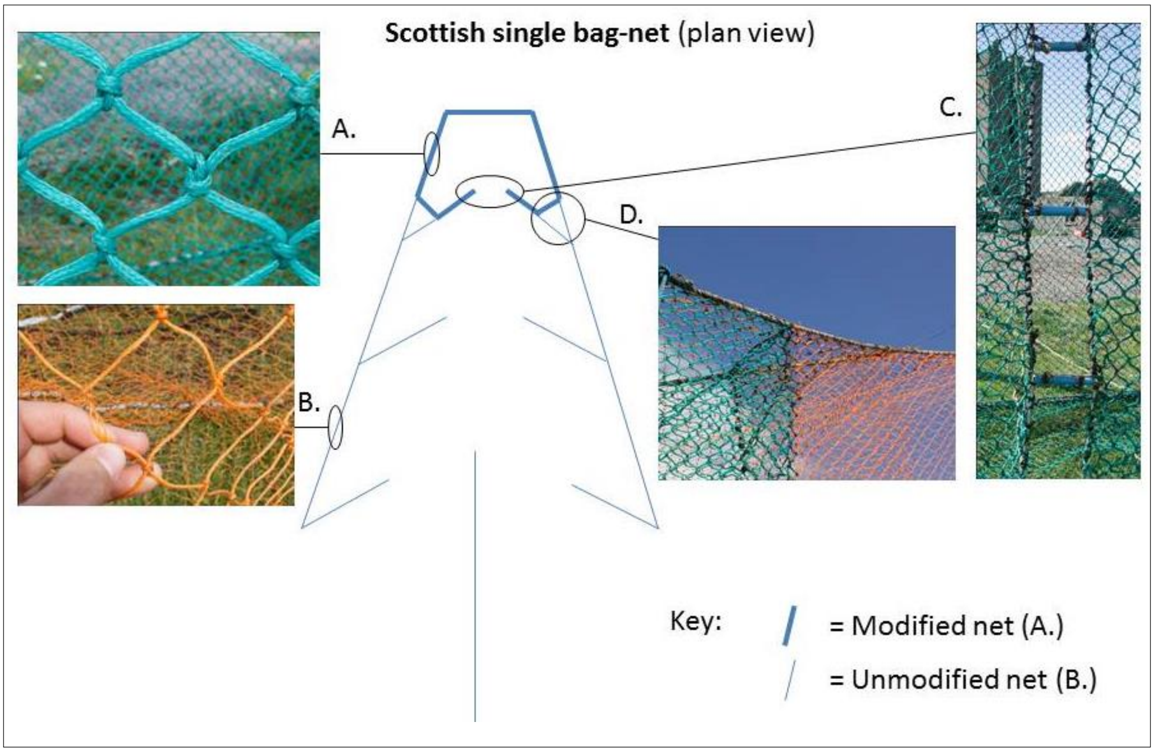

Figure 5. Scottish single bag-net showing modified inner chamber. A=modified sections (4mm braided nylon), B=unmodified sections (2mm twisted nylon), C=steel frame reinforcing door to inner chamber, D=tight corners in the inner chamber are closed off.

Figure 6. The entrance to the inner chamber of an unmodified salmon bag-net illustrating the size and non-ridged nature of the entrance

Figure 7. A close-up view of the entrance to the inner chamber of a modified salmon bag-net illustrating the size and ridged steel framed entrance

Figure 8. One of 8 underwater video cameras positioned within nets to monitor the frequency of seals and salmon entering modified and unmodified chambers of both control and modified nets

3.1 Fishing periods

The fishing periods for each location and net pairing were not evenly distributed with the modified net fished for longer off the harbour and the traditional net fished for longer in the bay (Table 4 & Table 5).

Table 4. The dates and location of the modified net with the number of days fished

Modified net		
Location	**Dates**	**Days**
Harbour	2nd July – 13th July	10
Bay	23rd July – 31st July	7
Harbour	8th Aug – 24th August	10

Table 5. The dates and location of the traditional net with the number of days fished

Traditional (control) net		
Location	**Dates**	**Days**
Bay	3rd July – 20th July	13
Harbour	16th July – 8th August	18
Bay	31st July – 17th August	13

3.2 Underwater video

The modified and traditional net both had a camera system attached, each consisting of four underwater cameras and cables mounted to each net. These recorded images continuously when external power supplies and hard-drives were moored in a floating housing close to the net.

Cameras were placed in the openings (doors) to the doubling and the fish court of both nets (Figure 9). We used the footage to count the number of times seals and salmon entered/left these chambers of the net and the number of whole salmon that seals removed through these openings. The aim was to assess the frequency that seals use nets and also assess the effects that the modifications had on the catchability of salmon that entered the doubling. This was to try to address the concern that salmon would be hesitant to enter the inner chamber of the modified net.

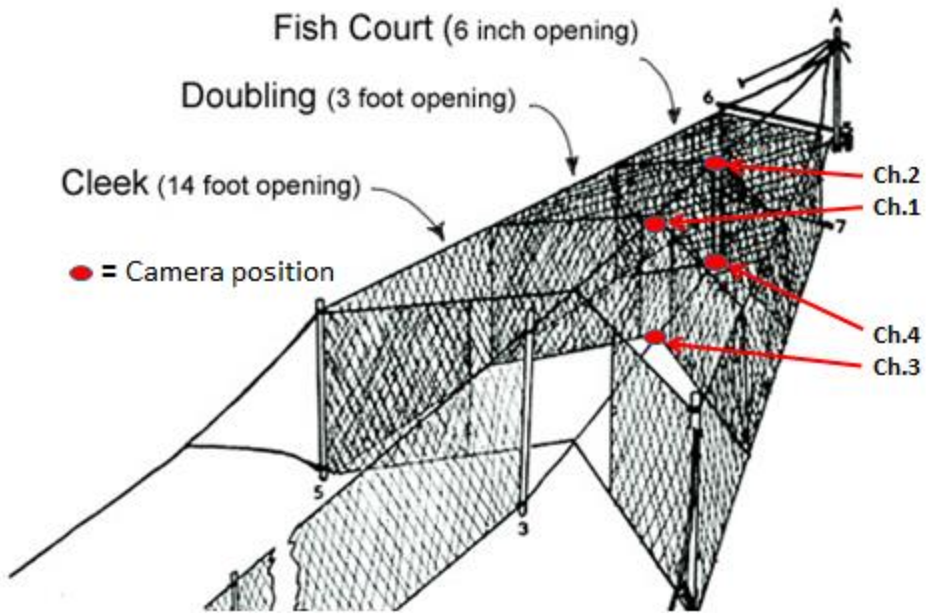

Figure 9. A traditional Scottish single bag-net with the position of its four cameras (Ch.1, 2, 3 & 4) in the openings into the doubling and the fish court.

A total of 236 hours of underwater video effort was collected from the two underwater camera systems (118 hrs per net). This was less than was anticipated due to poor weather conditions and the amount of time nets (with cameras) were removed for cleaning. From this video footage fish and seal activity has been extracted.

In clear cases of fish entering the net (generally single fish or fish entering as a single group), where fish did not swim back out of the net, the fish were timed passing between the doubling-door and the fish-court door. Fish were found to spend considerably longer in the doubling of the modified net than the traditional (Table 6).

The proportion of fish 'escaping' from the net was taken from the total observed during the 118hrs of video. The term 'escape' is used, although it is not possible to say whether fish leaving via the bag-net doors escaped or re-entered the net later. Certainly the timings of fish leaving the doubling in relation to subsequent sightings of fish entering the doubling make it plausible that a large proportion of fish that 'escape' the doubling are in fact turned back by the outer parts of the net (cleek and leader) and subsequently re-enter the doubling. The difference in the proportion of fish 'escaping' the doubling of the modified net compared to the traditional net (Table 6) would indicate an even stronger signal than is suggested below, with fish in the modified net spending considerably more time in the outer parts of the modified net than the traditional net.

Table 6. The average time fish spent in the doubling before entering the fish-court of the modified and traditional nets, and the proportion of doubling entries that swam back out of the doubling and the proportion of fish-court entries that swam back out of the fish-court.

Net type	Average	Min	Max	Proportion of doubling entries that 'escaped' via doubling-door	Proportion of fish-court entries that 'escaped' via fish-court door
Modified	3:20	8 sec	8:40	65%	0
Traditional	0:44	4 sec	3:30	28%	4%

Table 7. The number of times seals were observed passing under the net or entering the doubling and/or the fish-court. The numbers in parenthesis refer to the number of occasions that seals entering the net captured salmonid prey

Net type	No. hrs. of video	Seal passing beneath net	Seal entering doubling	Seal entering fish court
Modified	118	271	117 (7)	0 (0)
Traditional	118	225	121 (2)	33 (10)

In terms of seal movement patterns a single seal may pass under or enter a net several times during one dive and therefore it may have been more informative to simply register presence / absence in a unit of time (e.g., 10min periods). The data exists to go back and do this at a later stage if required. Regardless, seals were regularly recorded passing under and also entering the two nets. The large difference in the number of occasions that seals entered the net and the number of occasions that seals were seen leaving with salmonid prey was likely due to an absence of salmon in the net rather than an inability of seals to successfully capture them. When a seal entered a chamber of the net that held a salmonid (n=19 occasions) the seal took less than 15 seconds to capture and remove the fish from the chamber.

3.3 Landings

Table 8 provides a summary of the information recorded by net fishermen for the two net fishing sites involved in the net modification trial. Although the undamaged catch in the modified net is larger than the traditional net, the proportion of damaged fish is also larger.

Table 8. Landings as an index of the undamaged salmon and grilse landed per unit effort (UCPUE) along with details of the nets, number of days where at least one haul of the net was made and proportion of damaged fish in the net

Net type	Location	No. of days	Catch damaged	UCPUE index
Modified	Bay	7	3%	1.4
Modified	Harbour	20	16%	1.2
Traditional	Bay	26	4%	0.5
Traditional	Harbour	18	12%	0.9
Modified	**Combined**	**27**	**12%**	**1.2**
Traditional	**Combined**	**44**	**8.5%**	**0.7**

3.4 Land-based observations

Land-based observations were carried out by a dedicated observer from a site overlooking both nets. Approximately 4 hours of observations, split into 1 hour periods, were spread out over each day (early morning, morning, afternoon and evening) to assess the number of seals in the vicinity of nets and to record fishing conditions at regular intervals, as these variables have both been shown to affect landings (Harris *et al*. 2014).

3.5 Statistical analysis

Landings information from the fishermen and information from the land-based observer on seal presence at the nets, along with the weather data collected by the observer, were analysed to test whether there was a difference in landings between the modified and traditional net. We fitted a poisson generalised estimating equation (GEE) where the response variable was undamaged catch per unit effort (UCPUE). We could only include catch data from hauls when observational data were collected while the net was fishing, and we only included data from periods when both nets were deployed simultaneously. This sub-setting resulted in n=130 hauls. Candidate explanatory variables that were included were day since start of trial, site (bay or harbour), net design (modified or traditional), sea state, wind speed, wind direction, time of day (day or night) and presence of seals within 80m. All variables, with the exception of day and wind speed, were included in the model as factors. The Beaufort scale was used for sea state and wind speed was estimated by the observer in mph. Wind direction was characterised by four states – cross-shore, offshore, onshore and variable. Night was characterised by the time from the last haul of the day to the first haul the following day (approximately 2100 to 0600). The model was fitted using the dredge function in R which evaluates all possible variable combinations and ranks models according to QIC. The GEE approach was adopted because after fitting a quasipoisson generalised linear model (GLM) we found significant temporal autocorrelation ($p<0.001$) remaining in the model residuals. The temporal autocorrelation was found to decline to close to zero after 1 day and therefore we included a 1-day blocking unit in the generalised estimating equation. GEEs can be used to estimate the parameters of a GLM when the correlation between outcomes is unknown and they are robust to mis-specification of the variance structure.

Results:

The highest ranked model with the lowest QIC retained site, net design, wind direction, presence of seals within 80m and sea state. This supported net fishermen's observations that landings were affected by wind direction and sea state at this site, with light onshore winds and calm seas producing the best catches. The delta QIC between the 1st and 2nd best model was 2.09, and there was three times as much support for the best model compared to the 2nd best model (weights =0.44 and 0.16 respectively). There was a significant difference in UCPUE between the two sites (p=0.03) with the harbour site having a higher UCPUE than the bay site (Table 9, Figure 10). There was a significant difference between the two net designs (p=0.006) with the modified net having a higher UCPUE than the traditional net (Table 9, Figure 10). The UCPUE was significantly lower in the presence of seals (p=0.02) (Table 9, Figure 10). In terms of weather, the UCPUE declined as sea state increased (p<0.001) with few fish being landed during sea states 3 and 4, and low UCPUE when wind direction was offshore compared to the other directions and highest when wind direction was variable (p<0.001) (Table 9, Figure 10).

Table 9. Coefficients and P-values for the factors retained in the best-fitting GEE fitted to undamaged catch per unit effort data. The coefficients for each factor level are relative to the baseline state for each factor. The baseline state for site is *"bay"*, for net is "modified", for sea-state is "1", for presence of seals is "0" and for wind direction is "Cross-shore". The P-value relates to the significance of the factor as a whole, not to each level, and is determined by an Analysis of Variance (χ^2 values given from ANOVA fitted following GEE). The P-value for the intercept term is from the GEE output.

Factor	**Coefficient**	**χ^2 value**	**P-value**
Intercept	-1.405		<0.001
Site (harbour)	0.523	4.5	0.03
Net design (traditional)	-0.35	7.6	0.006
Presence of seals (1)	-0.725	5.5	0.02
Sea state 2	-0.315	76.4	<0.001
Sea state 3	-1.526		
Sea state 4	-3.759		
Offshore wind	-1.025	72.8	<0.001
Onshore wind	0.834		
Variable wind	1.142		

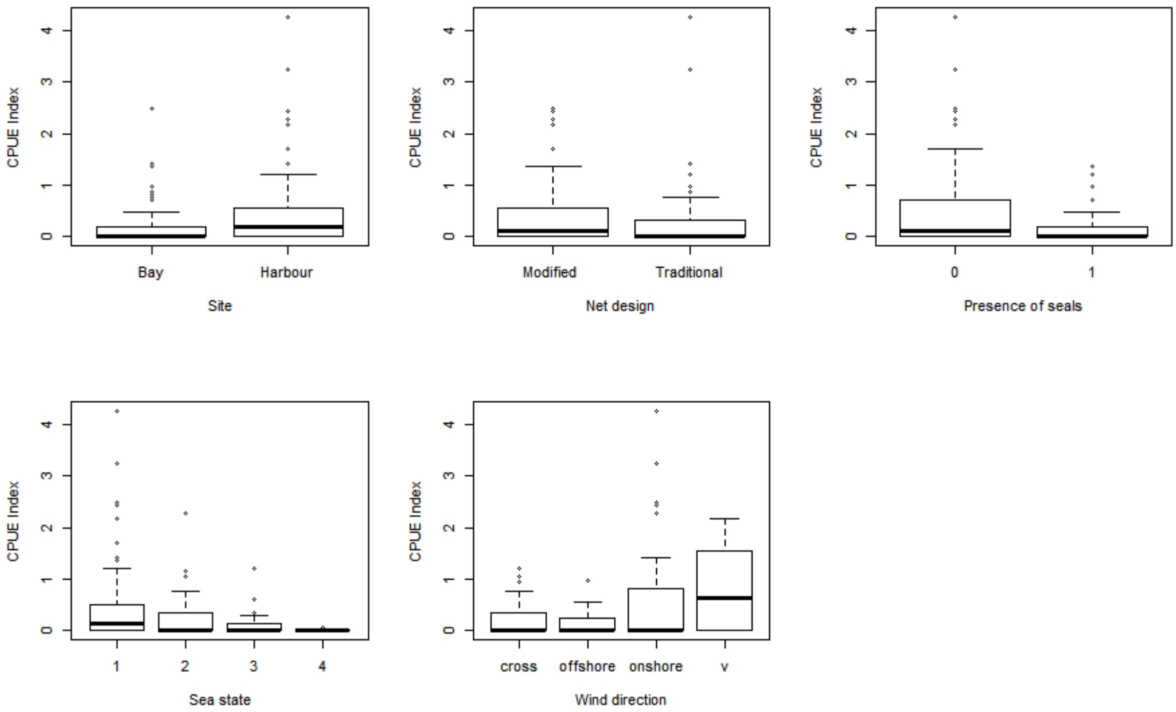

Figure 10. An index of undamaged CPUE against each of the five significant explanatory variables, site, net design, presence of seals, sea state and wind direction. The UCPUE has been converted to a relative index of UCPUE.

3.6 Perceptions of net fishers involved in the net trial

During the net fishing season the fishermen involved in this trial expressed concerns about the weight of the modified net and its increased bulk associated with the thicker twine and steel door. Fishermen also felt the meshes trapped their fingers more easily. An unexpected advantage of the new mesh was that it stayed cleaner for longer (algae appeared to take longer to bond with the new net material). Overall fishermen involved in the research felt that closing off tight corners within the net was a good idea. However, the added thickness of the net material and the weight of the steel door were not welcome modifications. The regular occurrence of damaged fish in the modified net suggested that improvements to the net design still needed to be made to prevent seals damaging fish in the fish court.

3.7 Summary of the bag-net modification trial

Despite the fishermen's perceptions and that a higher proportion of damaged fish were landed from the modified net, the number of undamaged salmon landed per unit effort was significantly larger in the modified net than the traditional net regardless of location, suggesting that the modified net was more effective at producing saleable salmon than the traditional net.

The underwater video footage from the two nets confirms that seals frequently enter nets in pursuit of salmon. Seals were able to access all areas of the traditional net and this may be the reason that fewer damaged fish were recorded and fewer fish landed, as fish were removed from the fish court whole. Seals were unable to enter the fish court of the modified net although salmon took longer to enter the fish court and this allowed seals the opportunity to depredate fish from the doubling of the modified net.

Improving the design of the fish court opening to reduce the time fish spend in the doubling of the modified net and preventing seals damaging fish already in the fish-court should be the next step in mitigating the effects of seals on bag-nets.

4 District Salmon Fishery Board (DSFB) support

During this reporting period the project has provided support to a number of District Salmon Fishery Boards regarding seal presence in the rivers Tay, Ythan, Dee and Clyde. This has primarily involved site visits, attendance at meetings, providing advice on monitoring seal usage in rivers, and providing advice on the deployment of non-lethal methods in rivers (seal-scarers in most cases). Details of the interactions and collaborations with each river DSFB can be found in Appendix 1.

5 Seal diet

Salmon fisheries are able to protect fisheries from serious damage from seals by applying for a licence to shoot a limited number of seals under the Marine (Scotland) Act 2010. As part of the conditions of this licence, fisheries are requested to make an effort to recover seal carcases and make them available for collection by the Scottish Marine Animal Strandings Scheme (SMASS) or SMRU. During 2013 six shot seals were sampled from bag-net fisheries or river fisheries (Table 10). Details of these events are provided below. Carcases were either sampled on site or transported to SRUC for necropsy where gastro-intestinal tracts (GITs) were removed. All GITs were processed by SMRU to make an assessment of the feeding habits of recovered seals, results can be found at (www.smru.st-andrews.ac.uk[2]).

Table 10. Location details of those seals shot in 2013 that were sampled and those providing assistance with recovery, transporting and sampling of each carcase.

Species	Category	Zone	Location	Recovered	Transported	Sampled
Grey	Net	East coast	Montrose	Usan	SMRU	SRUC
Grey	Net	East coast	Montrose	SMRU	Council	SMRU
Grey	Net	Moray Firth	Gamrie	Usan	SMRU	SRUC
Grey	Net	Moray Firth	Gamrie	SMRU	left on site	SMRU
Grey	Net	Moray Firth	Gamrie	SMRU	left on site	SMRU
Harbour	River	North Coast	River Naver	DSFB	DSFB	SRUC

[2] http://www.smru.st-andrews.ac.uk/pageset.aspx?psr=152

6 Publications and presentations

Five presentations on this work were made during 2013:

Wester Ross Fisheries Trust April 2013, Scourie

Moray Firth Seal Management Plan event October 2013, Inverness

Salmon Net Fishing Association of Scotland's AGM October 2013, Dunkeld

Marine Scotland meeting November 2013, Edinburgh

Crovie Preservation Society November 2013, Crovie

Two peer-reviewed publications have resulted from this project during the last reporting period:

Foster *et al.* (2013) Infection due to *Mycobacterium avium* subsp. *avium* in a free-ranging common seal (*Phoca vitulina*) in Scotland. Journal of Wildlife Diseases, DOI: 10.7589/2012-07-178 (publication resulting directly from SMRU carcass recovery work as part of the Moray Firth Seal Management Plan)

Harris *et al.* (2014) The effectiveness of a seal scarer at a wild salmon net fishery. ICES Journal of Marine Science, DOI: 10.1093/icesjms/fst216

7 Acknowledgments

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Appendix 1

A1.1 River Tay DSFB

Following communications between Marine Scotland and the Tay DSFB, the latter expressed an interest in pursuing non-lethal options for excluding seals from the river Tay. A site visit and meeting were planned and SMRU attended the meeting held at the river near Scone Palace on 30th May 2013. SMRU provided information on the state of the harbour seal population and the use and effectiveness of seal scarers in other salmon rivers.

It was in agreement that the next steps should be to begin recording seal sightings at this site (near Scone Palace) and to issue the ghillie with a camera (including 300mm lens) to help document seal sightings. Images would confirm seal species and potentially provide information on the number of seals using the stretch of river. SMRU provided recording forms and information leaflets. The Tay DSFB agreed to proceed down this route and keep SMRU informed of their results before making attempts to install an acoustic barrier.

A1.2 River Ythan

In 2006 SMRU was contacted by the Ythan river bailiff who raised concerns over the increase in seal numbers hauled out near Newburgh and the effects this might be having on the salmonid stocks and the rod and line fishing within the river. Following this initial contact, a site visit was made by SMRU and recording forms / notebooks and disposable cameras were provided with the aim of gathering information on the frequency of seal sightings at different locations in the river, the frequency of seals seen with salmonid prey and the frequency of rod caught seal damaged fish. No information and no cameras were ever returned.

In 2010 a meeting was convened by The Ythan District Salmon Fishery Board (YDSFB) who had invited SMRU to attend and speak about their work on the freshwater seal – salmon interactions project and to provide suggestions of what could be done in the Ythan Estuary to reduce the impact of seals on the salmon fisheries. Those attending included; Aberdeen University, Udny and Dudwick Estate (riparian proprietors), Members of the Newburgh Angling Club, SNH (Forvie NNR Owners/Managers) and members of the public. The Meeting was chaired by the Clerk of YDSFB.

At the meeting it was decided that a collaborative project was needed and that the board would initiate this. The DSFB did not request any further involvement from SMRU. However, following the meeting SMRU remained in close contact with SNH Forvie site managers who agreed to collect seal haul-out counts and scat samples. This work is still being carried out and has generated a considerable collection of grey seal scat samples and seal haul out counts, a proportion of the scat samples have been processed as part of a large scale study investigating the diets of seals across Scotland. There remain a large number of unprocessed samples and sub-samples from processed scats that could be analysed for the presence of salmonid DNA.

The 2010 meeting also seems to have been successful in generating a number of undergraduate student projects for Aberdeen University. These have looked at various issues surrounding the seal-angler conflict on the Ythan estuary. In one project an Airmar seal scarer was supplied on a trial basis by Mohn Aqua Ltd. and was fitted to a fishing boat using the estuary. The device was used in an experimental fashion. Results suggested that when the device was 'on' it was effective at keeping seals away from the fishing boat and that the device appeared to have a greater effect on seals if it was used in a reactive deployment method (i.e. the device was only switched 'on' when a seal was seen approaching the boat), this appeared to cause the greatest level of avoidance by seals.

In 2013 following contact between the Udny Estate Fishery and Aberdeen councillor Rob Merson a meeting was held at the Ythan Golf Club on 1st March 2013. Present at the meeting were representatives from SMRU, Marine Scotland, Marine Scotland Science, Aberdeen University, Usan Salmon Fisheries, SNH and other local stakeholders.

At the request of Udny Estate Fishery, a second meeting was held at Ocean lab on 15th July 2013. Present at the meeting were representatives from SNH, Aberdeen Council, Mohn Aqua Ltd., SMRU, Aberdeen University and local fishery stakeholders. At the meeting SMRU proposed possible methods for trialling the effectiveness of an ADD barrier in the estuary. It was stressed that although SMRU were keen to be involved and provide advice at each stage of the project it was important to find a 'local champion' to oversee and run the project.

In August 2013 SMRU provided Udny Estate Fishery with approximately 120m lead-line (weighted rope) to span across the main channel of the estuary to assess the holding characteristics and tidal forces that may be exerted on a transducer cable spanning the estuary. This work was carried out by the fishery and the lead-line was be monitored.

It is anticipated that Udny Estate Fishery, and more specifically the Ythan DSFB, will make more use of the knowledge and expertise at SMRU by involving SMRU at the decision making stages when it comes to the design of an experiment to evaluate the effectiveness of an ADD barrier. To date the process has been led by Udny Fishery and we hope that the board will now call on the assistances of SMRU to help move this project forward.

A1.3 River Dee DSFB

SMRU have provided four site visits to the river Dee and provided information over the phone or by email on four occasions.

The Dee DSFB have contributed staff time and reimbursed SMRU mileage costs.

In overview, a single Lofitech was purchased and installed by the Dee DSFB following advice from Lofitech AS and powered by lead-acid battery. This information did not align with the advice provided by SMRU. Previous SMRU studies and experience suggested that a single Lofitech device was unlikely to create an effective barrier in a large river and that battery operated devices may be less effective than 'mains' powered devices. This is because ADDs that do not have an automatic shut-down capability when voltage reaches a pre-set level may continue to produce reduced sound pressure levels that may increase the rate at which seals habituate and subsequently ignore the sound.

Dee DSFB experience confirmed that battery voltages were difficult to maintain. The occurrence of seal sightings upstream of the ADD in the river Dee generated impetus to install a second device and to power both devices with 'mains' power. However a choice to power devices with a power converter meant that for a substantial period of time both devices were underpowered. During this period seals were seen passing the ADDs. Difficulties maintaining the sound projectors in the right orientation may also have reduced the sound levels received by seals in the river.

In December 2013 the DSFB made the decision to change from using the voltage converter to using lead-acid batteries on constant charge from a mains supply. The DSFB agreed to carry out standardised river surveys for seals above and below the ADD barrier site and SMRU would provide a small level of support and advice.

During 2013 there has been a very good level of communication between SMRU and the Dee DSFB employees that indicate the potential for the development of a good collaborative project on the Dee. It is not possible to comment on the effectiveness of ADDs in the Dee as yet, however, the observations of seals regularly passing the ADDs suggest a failure to produce an effective barrier. This lack of success may in part be attributed to the difficulties associated with what is still a relatively novel deployment for ADDs. As such these installations may come with a steep learning curve for their installers and that even ADD manufacturers appear overly optimistic about the capabilities of these devices in terms of both their power requirements and also the effective range of devices. Through the close communication with river workers we have been able to gain further valuable knowledge on the installation of ADDs in rivers.

A1.4 River Clyde

Communication was received from the River Clyde's Fishing Association specifically about the effectiveness of seal scarers in rivers and the practicalities over installations. SMRU provided the requested information. No further contact was received from the River Clyde's Fishing Association.