Marine Mammal Scientific Support Research Programme MMSS/001/11

Addendum to Updated USD 1 & 6 Report 'Current state of knowledge of the extent, causes and population effects of unusual mortality events in Scottish seals'

Preliminary report on predation by adult grey seals on grey seal pups as a possible explanation for corkscrew injury patterns seen in the unexplained seal deaths: addendum

Sea Mammal Research Unit
Report to
Scottish Government

July 2015 [version F2]

Thompson, D.[1], Onoufriou, J.[1], Brownlow, A.[1] & Bishop, A.[3]

1. Sea Mammal Research Unit, Scottish Oceans Institute, University of St Andrews, St Andrews, Fife, KY16 8LB.
2. Scottish Marine Animal Stranding Scheme, Scottish Agricultural College, Inverness
3. University of Durham, Stockton Rd, Durham, DH1 3LE

Editorial Trail

Main Author	Comments	Version	Date
D. Thompson J. Onoufriou A. Brownlow A. Bishop	authors	V1.1	21/1/2015
P Irving	review	V1.2	21/01/2015
Marine Scotland	comments	V2.0	26/04/2015
Authors	response to comments	V3.0	19/06/2015
A. Hall	final editing	VF1	24/07/2015
O. Racu	final copy editing	VF2	15/08/2015

Citation of report

Thompson, D., Onoufriou, J., Brownlow, A. & Bishop, A. (2015) Preliminary report on predation by adult grey seals on grey seal pups as a possible explanation for corkscrew injury patterns seen in the unexplained seal deaths: addendum Sea Mammal Research Unit, University of St Andrews, Report to Scottish Government, no. US1 & 6 addendum, St Andrews, 14pp.

Contents

Preliminary report on predation by adult grey seals on grey seal pups as a possible explanation for corkscrew injury patterns seen in the unexplained seal deaths: addendum

1 Introduction

This is a preliminary report on a sequence of lethal attacks by a male grey seal on recently weaned grey seal pups on the Isle of May in December 2014. The seal's behaviour during a period of intense visual observation between 2nd and 9th December was described, and its subsequent movement pattern to date and describe the initial results from post mortem examination of the dead pups. These observations were discussed in relation to previous corkscrew seal observations at the Isle of May and in relation to recent observations of similar attacks by adult male grey seals on both grey seal pups and harbour seals.

2 Methods

2.1 Visual Observations

The initial predation event was observed and video recorded incidentally during an observation programme setup to monitor the behaviour of specific adult female seals on the grey seal breeding colony at the Isle of May. After the initial observation the adult male was continuously monitored during daylight hours and all subsequent attacks were video recorded.

Time lapse cameras were setup to monitor the seal's behaviour. The time lapse camera set-up comprised two cameras: one focussing on the known location of predation events and the second providing a wider angle of the breeding area where the male was observed to remain. A second time-lapse camera system was set up to continuously monitor the area to the north of the breeding site where corkscrew carcasses had been recovered. In addition, an observer focussed on the study male outside the hours of other fieldwork duties to provide high resolution photographs and video of any witnessed predation events.

2.2 Telemetry

On the 4th December 2014 the adult male was caught and fitted with a GPS/GSM transmitter glued to the fur on the back of his neck. This tag is designed to log GPS locations at 1 hr intervals when the seal is on land and at the start of each inter-dive surfacing event while the seal is at sea. Data are downloaded via the mobile phone network whenever the seal hauls out within reception range of a mobile phone mast. Detailed description of the GPS/GSM telemetry tags is given in MR 5. This transmitter will provide detailed location information on the seal until it falls off during the annual moult in February. In addition, the seal was fitted with a Wildlife Computers SPOT2 ARGOS satellite transmitter attached to a flipper tag on the left hind flipper. This tag will provide low resolution location data for the seal when it is hauled out. This tag will remain attached through the moult and provide a record of the haulout sites used by the seal until the battery fails in summer 2015. Detailed description of the flipper mounted ARGOS telemetry tags is given in Lonergan *et al*., (2012).

2.3 Post Mortem examination

Eleven of the 14 pup carcasses were retrieved from the Isle of May and transported to the Scottish Agricultural College in Inverness. Post mortem examinations were carried out by the marine mammal pathology team of the Scottish Marine Animal Strandings Scheme. The damage to the carcasses were assessed using the standard scoring scheme devised for identifying cork screw injuries explained in section USD2 of this project.

3 Results

3.1 Observations of cannibalism by an adult male grey seal

On the 2nd December 2014 an adult male grey seal was seen to approach a weaned grey seal pup on land on the Isle of May. It grabbed the pup by the scruff of the neck and dragged it over 20m to a shallow freshwater pool. The adult then climbed on top of the pup, forced its head under water and held it until its struggles subsided.

The male seal then proceeded to bite the back of the neck and simultaneously pull back with its head while pushing away with his fore flipper. This caused the skin to tear along a length of approximately 20 cm. and caused the blubber layer along the line of the tear to detach from the underlying body musculature (Figure 1). The study male then proceeded to eat the blubber by forcing his lower jaw under the lip of the tear, biting down on the skin and then pulling back from the wound before swallowing. The process of tearing using

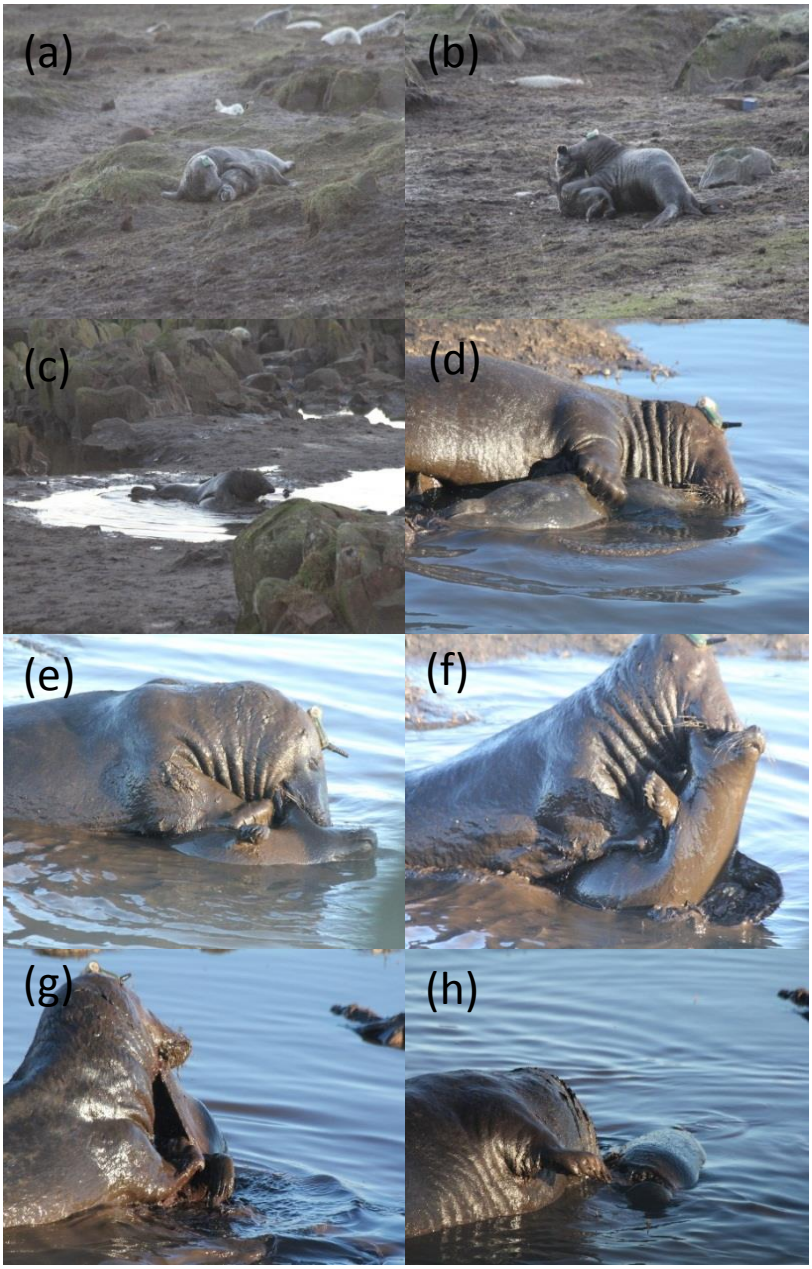

Figure 1. The study male (a) capturing a weaned pup, (b) lifting and dragging the pup towards the freshwater pool, (c) and (d) forcing the pup under the water to subdue it, (e) clamping his jaw around the scruff of the pups neck while locking his fore-flippers to the mid-section, (f) pulling upwards with his jaw while pushing downwards with his fore-flippers, (g) tearing flesh from the carcass which now displays a open wound and (h) resting after feeding on the pup which now displays a spiral laceration or 'corkscrew cut'.

neck muscles levered against the flippers continued intermittently for 41 minutes interspersed with periods of chewing off sections of blubber. Several small sections of blubber and skin became detached and were swallowed whole.

The pup was seen to move independent of the actions of the adult male 12 minutes after being dragged to the pool, indicating that it was still alive and possibly conscious at that point. Severe blood loss would likely have killed the pup shortly after that observation.

After 41 minutes of continuous tugging at the carcass and eating blubber and small strips of skin the male fell asleep, resting on the carcass. The entire process from start of the attack to the male discarding the carcass was video recorded. When he later moved out of the pool, the pup carcass was retrieved and transported back to the mainland for necropsy. The attack left the carcass with a severe rotational wound similar to those described as corkscrew wounds (Figure 2).

Figure 2. A recently weaned grey seal pup found on the Isle of May in December 2014. The spiral laceration wound had been inflicted by an adult male grey seal.

The male seal was continuously monitored during daylight hours until he left the island on the 8th December. Over the next six days he was observed catching four more weaned pups on land. He dragged them back to the same freshwater pool and killed each pup using the same method, inflicting similar wounds in each case and in each case ate a quantity of blubber (Figure 1). All of these events were video recorded.

In addition, over the same period a further three pup carcasses with similar wounds were retrieved from the same freshwater pool after having been killed during the night. Although the cannibalism events were not directly observed in these cases the same adult male was seen resting in or near the pool next to the carcass on each occasion and no other adult seals were seen in that pool over the entire study period.

Over the 11 day period from 28th November to 9th December an additional six pup carcasses were retrieved from tide pools and the beach of Kirkhaven (Figure 3), a tidal channel adjacent to the freshwater pools. Four of these had similar wounds while two had been killed by severe injuries to the front of the skull. Table 1 presents details of the locations and timings of carcass discoveries.

Preliminary report on predation by adult grey seals on grey seal pups as a possible explanation for corkscrew injury patterns seen in the unexplained seal deaths: addendum

Table 1. Locations and timings of carcass discoveries.

ID Number	Date found	Location	Witnessed	Retrieved
1	28/11/2014	Kirkhaven	FALSE	TRUE
2	02/12/2014	Loan (Dead Pool)	TRUE	TRUE
3	03/12/2014	Loan - (Second Pool)	FALSE	TRUE
4	03/12/2014	Loan (Dead Pool)	TRUE	TRUE
5	03/12/2014	Loan (Dead Pool)	FALSE	TRUE
6	03/12/2014	Kirkhaven	FALSE	TRUE
7	03/12/2014	Kirkhaven	FALSE	TRUE
8	03/12/2014	Kirkhaven	FALSE	TRUE
9	03/12/2014	Kirkhaven	FALSE	TRUE
10	04/12/2014	Loan (Dead Pool)	TRUE	TRUE
11	05/12/2014	Loan (Dead Pool)	TRUE	TRUE
12	07/12/2014	Loan (Dead Pool)	FALSE	FALSE
13	08/12/2014	Loan (Second Pool)	TRUE	FALSE
14	09/12/2014	Kirkhaven	FALSE	FALSE

Figure 3 shows the locations at which the 14 pup carcasses were recovered, together with the GPS logged locations of the adult male seal between 4th and 9th December. The locations of the eight pups found in the pool have been displaced slightly to the left and spaced out to ease interpretation. All eight carcasses in the pool are assessed to have been killed by the same adult male seal. The six carcasses found to the north were not seen to be killed by that male. However, the first one was found on the beach of Kirkhaven on 28th November, four days before the first observed predation event and the last was found on the morning of 9th December having been killed during the previous night. The male left the left the island on the night of the 8th December. All six carcasses were found within 90m of the killing pool and all but one were found in the water on the route that the male would have followed when moving to and from the water. The most distant carcass (number 6 in Figure 3) to the north of Kirkhaven was found on the 3rd December and was estimated to have been dead for 3 or 4 days. This and the carcass found on the beach the 28th November (number 1 in Figure 3) pre-date the first sighting of the adult male. However, neither site was under observation and it is clearly possible that the adult male was in that area at that time.

A series of intensive searches were carried out of all accessible points of the Isle of May between 3rd and 9th December. In addition the normal research programme on the Isle of May means that ad hoc surveys had been carried out prior to the predation observations specifically to look for evidence of any corkscrew lacerations. No other traumatically injured carcasses were found.

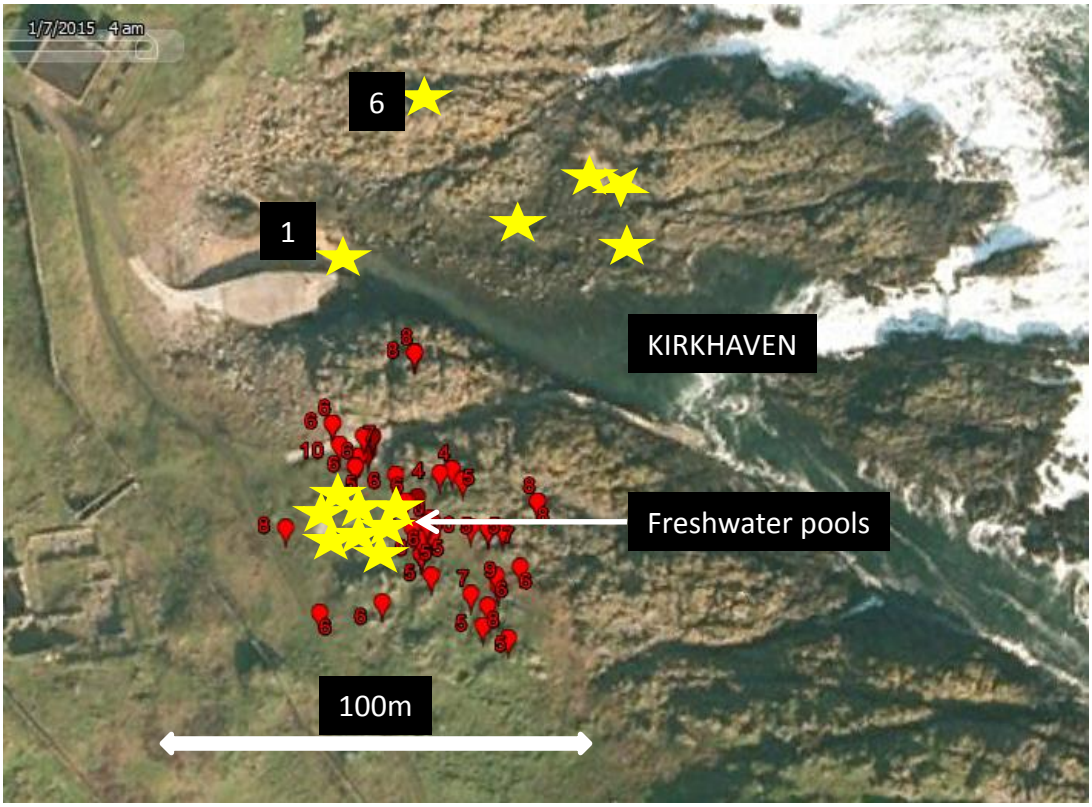

Figure 3. Carcass recovery locations (yellow stars) together with the GPS logged locations of the adult male seal between 4th and 9th December (red markers). The locations of the eight pups found in the pool have been displaced slightly to the left and spaced out to ease interpretation.

3.2 Previous cases on the Isle of May

The Isle of May has been a hotspot for corkscrew injuries with multiple strandings recorded in 2010, 2012, 2013 and 2014. Until 2014 all carcass locations had been on the beach, in the sea or in tide pools. Of the 37 corkscrew injured carcasses on the Isle of May all bar three had been reported in the water, in or close to Kirkhaven. The exceptions were one seal floating offshore at the south end of the island approximately 400m away and two found in 2013 in a tide pool at the north end of the island approximately 900m away. In addition, in 2012, a different adult male grey seal was seen attempting to kill two pups and was also seen eating a corkscrew seal, assumed at that time to be a scavenging event.

3.3 Description of initial pathology

The carcasses of 11 of the 14 traumatically injured pups found between the 28/11/2014 and 5/12/2014 were retrieved and transported to the SAC for post mortem examination, Three carcasses of seals killed on the 7th and 8th December could not be recovered from the Isle of May, but photographs of these were inspected (Figure 2).

Necropsies were carried out on all 11 recovered carcasses. Each carcass was examined for gross pathological features and then scored using the agreed, weighted scoring system used to identify corkscrew lesions in previous necropsies (Thompson *et al*., 2014).

3.3.1 Cause of death

Only one of the seals recovered from the freshwater pool was found to have significant amounts of muddy water in the lungs and was deemed likely to have drowned. The absence of mud or sediment in the lungs of the other five pup carcasses recovered from the freshwater pools means that drowning was not likely to have been the cause of death. Rapid absorption of sea water in the lungs is typical of drowning in sea water, so

the absence of water in the lung does not rule out drowning as the cause of death for the six pup carcasses found on the beach or in tide pools.

All eleven cases had extensive traumatic injuries including severe crush injuries to the front of the skull and/or large deep lacerations and detachment of skin and blubber layers that would have led to severe blood loss. The resulting shock was identified as the most likely cause of death in any cases that had not drowned.

3.3.2 Pathological features of lacerated seal pups

Table 2 summarises the gross pathology observed in the 11 carcasses.

Two of the carcasses were intact with the exception of severe trauma to the front of the skull. Both had significant proportion of the facial bones missing and/or broken. In both cases the facial and skull injuries and associated blood loss with resulting shock were assessed to be the likely cause of death. The patterns of injuries, including apparent canine puncture wounds in the skull were compared to the dentition of a male grey seal skull. In each case the injuries were consistent with crushing bite wounds by an adult male grey seal.

The remaining nine carcasses all had a characteristic wound consisting of a smooth edged cut that started at the head and spiralled around the body (Figure 2). In all cases the resulting strip of skin and blubber was detached from the underlying tissue. The wound was identified as the cause of death in all cases for which a detailed post mortem examination was carried out. Post-mortem examinations revealed no evidence of any underlying disease or disability and the pups were all assessed to have been alive and healthy when the injuries were sustained. In five of the cases this was confirmed by visual observation of the entire predation event.

The wound patterns were similar to those identified as corkscrew injuries in previous breeding seasons at the Isle of May and appear to be the same as those observed in both grey seal pups and harbour seal adults necropsied in Norfolk (RSPCA and AHVLA), throughout Scotland (SRUC) and Northern Ireland (AFBI). Necropsy findings from all three areas were presented in Bexton *et al.* (2012) and are summarised in Table 1 of USD 1& 6. For comparison the same table has been used to present the necropsy results from the 11 recovered carcasses from the Isle of May this year.

In all nine cases with lacerations there was some removal of blubber, in four of these substantial amounts of blubber had been chewed away. In one case a significant amount of muscle tissue had been removed. In all cases the chewing of the blubber produced damage which in previous cases had been assumed to be post mortem damage resembling short tears in the tissue that were assumed to be beak marks from avian scavengers such as gulls or crows.

Table 2. Summarised Necropsy results from 11 grey seal pups killed on the Isle of May between 28/11/2014 and 09/12/2014.

1.	Continuous helical skin laceration originating at the head and spiralling down the body (corkscrew wound)	9 (82%)
2.	Skin and blubber sheared from the underlying fascia with connective tissue attachments torn caudo-laterally	9 (82%)
3.	Scapular attachments to the axial skeleton severed and the fore flipper partially de-gloved	9 (82%)
4.	Wound edge smooth and perpendicular or angled slightly caudally to the axis of the body, with hairs immediately adjacent to the wound uncut	9 (82%)
5.	Bruising, notably to the neck, thoracic inlet, and/or sternum consistent with blunt trauma to the chest area	0 (0%)
6.	Animals in good physical condition with adequate blubber reserves	11 (100%)
7.	Absence of any additional significant gross pathological changes indicative of underlying disease or injury	11 (100%)
11.	No significant tissue loss associated with wounds	2 (18%)
12.	Lesions to the head, including slice wounds on the muzzle or skull fractures with lesion orientation consistent with a frontal impact	4 (36%)

The nine carcasses with lacerations were all assessed against the standardised scoring scheme. In all nine cases the score was 15 or greater which represents the upper 75th percentile of the carcasses previously identified as corkscrew injuries.

A detailed analysis of the pathology data including histopathology of tissue samples from the wound site is underway and the results will be circulated as soon as they become available.

3.4 Subsequent behaviour

The GPS/GSM transmitter provided hourly location records for the study male while he was on the Isle of May (Figure 3) which show that he concentrated his time in a small area in and around the fresh water pools in which he was seen to kill and eat pups. He left the Isle of May on the evening of the 8th December and apparently swam due west away from the island. No locations were recorded as he entered the water and the first position fix at sea, which was 30 minutes after the last position fix on the island, put him 1.7km to the east. Over the next five days he swam on a constant heading of 080^{o} at an average speed over the ground of 1.1m.s.$^{-1}$ to an area west of Jutland where he spent three days diving to the sea bed before swimming on a constant heading to a set of sandbanks and small islands off the coast of Sylt and Amrun islands in Germany (Figure 4). For the next 20 days the seal remained close to shore, spending the majority of his time in very shallow water within a few metres of the beach (Figure 5). During that time he made only one short excursion out to sea, and made few dives below 10m depth. The area covered by the map contains one of the two established grey seal breeding sites in Germany and the sand banks hold several harbour seal haulout sites.

Preliminary report on predation by adult grey seals on grey seal pups as a possible explanation for corkscrew injury patterns seen in the unexplained seal deaths: addendum

Figure 4. Swimming track of the adult male grey seal between leaving the Isle of May on 8/12/2014 and arriving at Sylt in Germany on 20/12/2014.

Figure 5. Swimming track of the adult male grey seal in the waters around Sylt and Amrun Islands, Germany between 20/12/2014 and 9/1/2015.

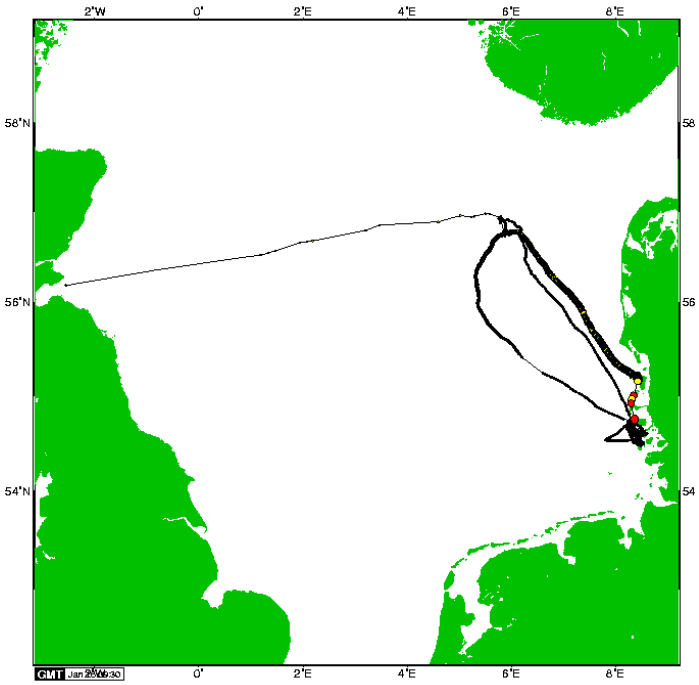

Figure 6 Swimming track of the adult male grey seal during entire period from 8/12/2014 to 15/1/2015

The seal left the Sylt area on the 9th January and made a 6 day trip to the same apparent foraging site off Denmark where he spent time on his trip from the Isle of May. As of now (16/1/2015) the seal has returned to the haulout sites between Sylt and Amrun Islands.

The seal's current location is approximately 800km from the breeding site on the Isle of May but is only 40km form the island of Helgoland where an adult male grey seal was observed killing and eating harbour seals during summer 2013 and 2014 (van Neer *et al*., 2015) (Figure 6).

4 Discussion

4.1 Wound patterns

The wound patterns seen on the grey seal pups at the Isle of May clearly resembled those that have been recorded as corkscrew wounds on previous grey and harbour seal cases in Scotland. When tested against the standardised scoring system 12 out of the 14 pups identified as being killed by an adult male grey seal score in the top category for corkscrew injuries. This clearly suggests that a proportion of the cases previously identified as the result of interactions with propellers were in fact due to grey seal predation.

4.2 Previous Isle of May cases

The locations of the carcasses on the Isle of May in 2014 were similar to those recorded in previous years and the injury patterns were similar. It is therefore highly likely that the same mechanism, i.e. grey seal predation is responsible for all the recorded corkscrew mortalities identified at the Isle of May since 2010.

4.3 Other observations of grey seal predation behaviour

Apparently coincidentally there have been recent observations of an adult grey seal killing and eating a grey seal pup in Orkney in November 2014 and a series of observations of an adult male grey seal killing and eating young harbour seals on and around the island of Helgoland, Germany (van Neer *et al*., 2015). Previous observations of a different adult male grey seal apparently scavenging a corkscrew seal carcass at the Isle of May in 2012 and that same individual attacking two seal pups in what were interpreted as simple aggression should be re-assessed in light of the recent observations.

There are photographs of the males seals involved in predation at the Isle of May, Orkney and Helgoland in 2014. Unfortunately the fur of the Isle of May animal was covered in oil and mud throughout the observation period and it is not possible to confirm that it either is or is not the same seal in the different locations.

The telemetry tracks show that the seal from the Isle of May swam directly to a grey seal breeding site in Germany, relatively close to the island of Helgoland where a male grey seal was recorded killing and eating harbour seals. It seems unlikely that these are the same seal but we cannot rule this out at present.

4.4 Wider geographical implications

In previous reports (Bexton *et al.*, 2012; Thompson *et al.*, 2010; Thompson *et al*., 2014) we have argued convincingly that the wounds identified on grey seal pups and harbour seal adults in Scotland are probably the result of the same mechanism. The nature of the wounds, the stereotypical patterns of injuries and timing of events strongly suggests that a similar mechanism is responsible for the majority of reported corkscrew mortalities in UK waters, including those seen in Norfolk and Strangford Narrows. If the same argument holds here, the implication would be that a proportion of the cork screw injuries to seals observed throughout the UK are likely to have been due to grey seal predation events.

4.5 Implications for propeller interaction hypothesis

The identification of ship propellers as the most likely cause of these injuries was based to some extent on the conclusion that these wounds could not be inflicted by any known predator of seals. Attempts to reproduce the wounds using clamps to mimic a predator's jaws and hoists to provide traction did not produce tearing wounds similar to the corkscrew wounds. Skin and the underlying blubber layers could only be torn with the application of severe tension forces in excess of 200kg to sections where tear wounds had already been started. However, in all cases they produced only rough irregular wound patterns that would not have scored highly on the marking scheme. As a consequence of these observations and the extremely neat smooth edge and consistent path of the wounds we excluded the possibility of predator damage.

However, we now have clear, incontrovertible observations of a sequence of these events in one of the "hotspots" of cork screw seal strandings. The wounds can be and in some circumstances are being inflicted during these unexpected predation events by adult male grey seals. The mechanisms by which the carcasses tear in such a stereotypical fashion are not known and require further investigation.

Propeller interactions were proposed as the most likely cause on the basis of arguments presented in the Thompson *et al*., (2014). A series of scale model trials described in the USD 2 report (Onoufriou & Thompson, 2014) demonstrated that such mechanisms can produce these types of wounds. Vessels with such mechanisms have been identified as potential causes in some of the observed events. It would be premature to assume that the interactions with propellers are not responsible for any of the observed corkscrew injuries, but the observations of predation could explain many, if not most of the observed mortalities.

5 Summary

- At least one adult male grey seal at Isle of May caught and killed at least 14 grey seal pups.
- At least 12 of these pups were partially eaten.
- A different adult male grey seal was seen attempting to kill two pups and seen eating a corkscrew seal in 2012.
- A different adult grey seal seen killing and eating a grey seal pup in Orkney.
- At least one adult grey seal seen killing and eating harbour seals at Helgoland in 2013 and 2014.
- The Isle of May study seal has moved directly to one of the two grey seal breeding sites in Germany, approximately 40 km from Helgoland.

The observed wound patterns cover all of the wound types seen on corkscrew seal carcasses.

Using the scoring system most of the 11 post-mortemed carcasses scored highly and all except 2 were confirmed as spiral laceration cases, others had been killed by bites to the face and front of the skull.

6 References

Bexton, S., Thompson, D., Brownlow, A., Barley, J., Milne, R. & Bidewell, C. (2012) Unusual mortality of pinnipeds in the United Kingdom associated with helical (corkscrew) injuries of anthropogenic origin. *Aquatic Mammals,* **38,** 229-240

Lonergan,M., Duck,C.D., Moss,S., Morris,C. & Thompson,D. (2012) Rescaling of aerial survey data with information from small numbers of telemetry tags to estimate the size of a declining harbour seal population. *Aquatic Conservation,* **23**, 135-144.

Onoufriou, J. & Thompson, D (2014) Testing the hypothetical link between shipping and unexplained seal deaths: Final report. Sea Mammal Research Unit, University of St Andrews, Report to Scottish Government, no. USD 2, St Andrews, 31pp.

van Neer, A., Jensen, L.F. & Siebert, U. (2014) Grey seal (*Halichoerus grypus*) predation on harbour seals (*Phoca vitulina*) on the island of Helgoland, Germany. *Journal of Sea Research*, **97**, 1–4

Thompson, D., Bexton, S., Brownlow, A., Wood, D., Patterson, A., Pye, K., Lonergan, M. & Milne, R. (2010) Report on recent seal mortalities in UK waters caused by extensive lacerations. Report to Scottish Government, Sea Mammal Research Unit, University of St Andrews, St Andrews, October 2010.

Thompson, D., Onoufriou, J., Culloch, R; Milne, R. (2014) Current state of knowledge of the extent, causes and population effects of unusual mortality events in Scottish seals. Sea Mammal Research Unit, University of St Andrews, Report to Scottish Government, no. USD1 & 6, St Andrews, 22pp.