Marine Mammal Scientific Support Research Programme MMSS/001/11

CSD 6:

Report

Harbour seal decline workshop II

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Sea Mammal Research Unit
Report to
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Hall, A.[1], Duck, C.[1], Hammond, P.[1], Hastie, G.[1], Jones, E.[1], McConnell, B.[1], Morris, C.[1], Onoufriou, J.[1], Pomeroy, P.[1], Thompson, D.[1], Russell, D.[1], Smout, S.[1], Wilson, L.[1], Thompson, P.[2]

[1] Sea Mammal Research Unit, Scottish Oceans Institute, University of St Andrews, St Andrews, Fife KY16 8LB.

[2]Univeristy of Aberdeen, Institute of Biological & Environmental Sciences, University of Aberdeen, Cromarty,IV11 8YL

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Contents

1 Executive summary

The persistent decline in the abundance of harbour seals (*Phoca vitulina*) in some regions of Scotland continues to be of concern. Following a workshop held at the Sea Mammal Research Unit in 2012 (Hall *et al.*, 2012) a number of key potential drivers (particularly the potential causes of the spiral seal lacerations, factors affecting prey availability and the effect of toxins from harmful algae) were highlighted as being priority areas for further research. This led to a second workshop, again hosted by the Sea Mammal Research Unit (SMRU), held in April, 2014 and which is the subject of this report. The main aim of the Workshop was to discuss the main candidate drivers responsible for the sharp decline in harbour seal numbers on the Scottish East Coast, Orkney and Shetland and develop an empirical and statistical research approach for investigating their role in future population trajectories.

The workshop acknowledged that there is a need to rapidly identify any anthropogenic drivers of the decline so that mitigation could be implemented before the situation deteriorates any further.

It was agreed that the most important priority was not just to focus on candidate drivers but to estimate the vital population rates that shape the population trends, namely survival and fecundity rates. This would be critical in furthering our understanding of the most likely causes for the declines, which could be different in different regions and may be due to a combination of drivers. Because some regions are declining but others are stable or increasing, this provides a 'natural experiment' in which vital rates can be compared among areas of decline in abundance and those that are not.

Although the workshop participants did not set any recommendations for future research SMRU made recommendations based on the outcomes of the workshop and the discussions that were had. SMRU will now develop a focused programme of research to seek to establish the key life-cycle factors that appear to be driving the decline in some regions but not in others. This will be based around a minimum of two sites (one in an area with a population decline and another in an area with a stable population). It will include investigation of the potential contribution of grey seals (*Halichoerus grypus*) as competitors for prey and other interactions between the two species, the type and availability of prey in the different regions and the potential impact of exposure to toxins (such as domoic acid and saxitoxin) produced by harmful algal blooms. SMRU will continue to research the issue of spiral seal lacerations to inform revised guidance for developers and to explore potential mitigation options.

2 Introduction

This document summarises the Sea Mammal Research Unit (SMRU) Harbour seal decline workshop held at the University of St Andrews in May 2014. The workshop participants are listed at the end of this report. The purpose of the workshop was to discuss the potential causes of the harbour seal decline that were highlighted by the broad initial workshop held in 2012 (Hall *et al.*, 2012). The outcome of the workshop would then feed into the process of developing a proposal to be submitted to Scottish Government for consideration under the next phase of the Marine Mammal Scientific Support (currently MMSS 001/11) Research Programme. Participants included stakeholder representatives from Scottish Natural Heritage, Marine Scotland, Marine Scotland Science and researchers from SMRU and the University of Aberdeen.

The primary aim of the workshop was to discuss the main candidate drivers responsible for the sharp decline in harbour seal numbers on the Scottish East Coast, Orkney and Shetland and develop an empirical and statistical research approach for investigating their role in future population trajectories.

A previous workshop in 2012 concluded that the most likely candidates of the harbour seal decline are:

- Potential impact of the "corkscrew" seal deaths (this will be the subject of separate discussions).
- Prey related (changes in quality or quantity as a result of various drivers).
- The uptake of marine toxins from harmful algae.

The latter two aspects were the focus of this workshop. In particular, the workshop focused on how the question – 'is the decline a result of increased competition between grey and harbour seals for prey?' - could be tackled.

3 Background presentations

Four background presentations were given at the workshop in order to facilitate the discussion and highlights from these are summarised below. Copies of the presentations are available on request.

a) Phil Hammond gave a presentation on the question of whether the decline is due to competition with grey seals for prey. There is overlap between these sympatric species on land, at sea and that they consume similar prey. But they have very different abundance trends, both within and between regions (Figure 1).

However, how to determine whether competition is occurring is difficult. Fundamentally, the prey resources have to be limiting, and consequential effects are density dependent. There are different types of competition: *exploitation* which occurs indirectly through a common limiting resource; *apparent* where two species are preyed upon by the same predator; and *interference* which occurs directly between individuals via aggression. Interference competition could be a factor, if grey seals disrupt the foraging of harbour seals. This could be in addition to exploitation competition for prey resources, resulting in the dominant species out-competing the subordinate. The competitive strength is also a function of population abundance and competitive efficiency and impacts the rate of change in the competing population.

For the prey now to be limiting and for competition now to be a driver of abundance, the prey must have changed in abundance, distribution or size structure or a competitor has increased in abundance. An example of the former is illustrated in Figure 2 showing the total stock biomass of sandeels on the Dogger Bank in the North Sea (a major prey item of both grey and harbour seals) has declined since the 1980s. Similarly there have been radical changes in North Sea cod stocks (Figure 2).

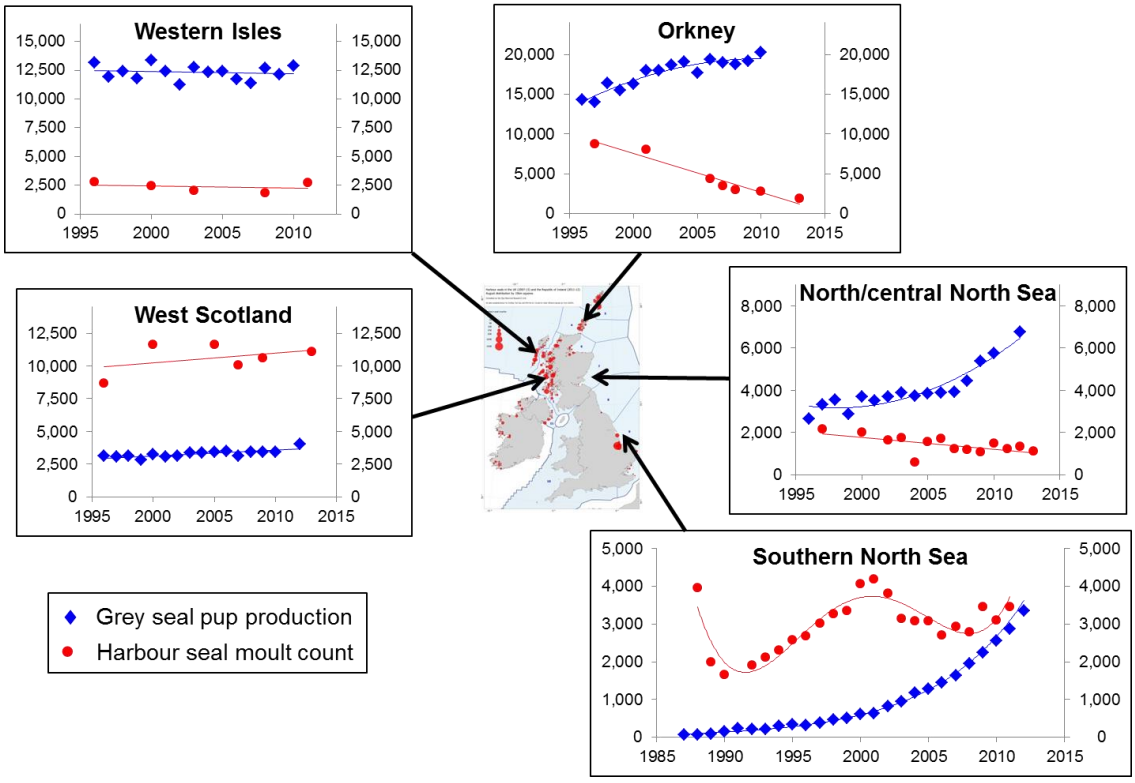

Figure 1. Changes in grey seal pup production and harbour seal moult counts over time.

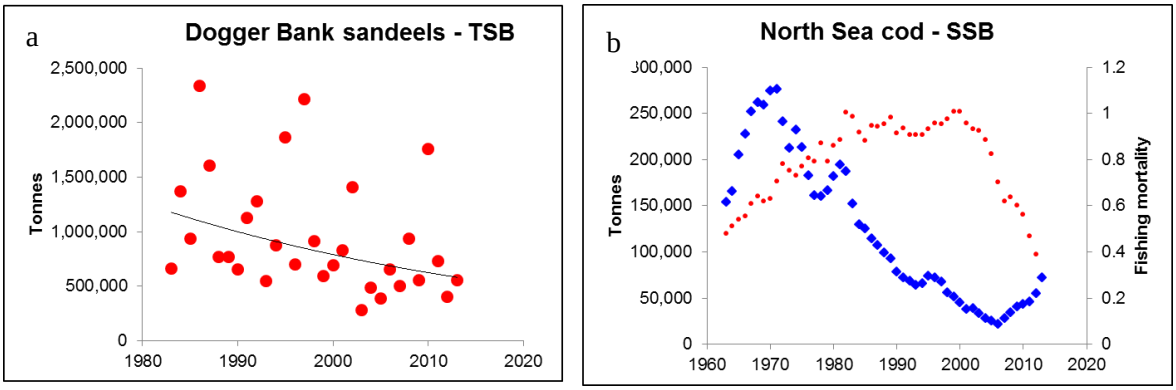

Figure 2. Changes in Total Stock Biomass (TSB) of (a) sandeels on Dogger Bank and (b) Standing Stock Biomass of North Sea cod over time. The blue dots in b) show the tonnes of fish and the red dots the proportional fishing mortality.

In response to competition, a reduction in growth and body condition in the out-competed species, changes in foraging effort and thus possible reduced fecundity and/or reduced survival resulting in a reduction in population size would be expected. But even if there are these changes it is difficult to be sure that they are a consequence of competition. The best approach would be to carry out a manipulative experiment but that is not possible for marine mammals. But there is the opportunity to take advantage of the variation in features and population trajectories for the two species in different areas. If competition is occurring changes at the individual level (growth, body condition, foraging and diet) and in the vital population rates (reduced fecundity and survival) would be expected. Therefore, by focusing on areas of contrast, existing data could be analysed and field studies to measure key parameters, such as fecundity and survival rates, diet, foraging strategies and seal activity budgets, toxin uptake and health condition could be carried out.

b) Ailsa Hall gave a presentation showing some initial analysis of harbour seal body condition data and nutritional stress measures from clinical chemistry data and then presented some initial results from the MASTS funded biotoxin PhD study currently being undertaken by Silje Kristin Jensen. Preliminary trials, using an individual-based model framework already developed for investigating effects of domoic acid exposure on California sea lion populations do indicate that toxin levels found in the harbour seal prey on the east coast are high enough to cause mortality and a population decline. Refinement of the risk assessment approach is currently being undertaken but the early indications are that they may be a factor in the observed decline in some regions (Jensen *et al*., 2015).

c) Paul Thompson provided a presentation on drivers, through either bottom-up or top-down ecosystem effects. Important population parameters to investigate include individual condition, phenology, juvenile growth, body size, fecundity, survival and population structure. Population age structures may have changed which may give further clues as to the importance of various proximate factors. For example, observations in the Moray Firth suggest the number of juveniles has declined. In addition, other factors such as parasite-mediated competition should be investigated. Both species are secondary hosts to a number of different macroparasites, most of which are host-adapted. However, if a parasite jumps to a new secondary host because of changes in exposure, through perhaps consumption of novel primary host prey, it may cause morbidity and increased mortality.

d) Finally, Sophie Smout and Marjolaine Caillat discussed the population modelling aspects of their current work, which is developing a robust model framework for determining both ultimate and proximate drivers of population change for harbour seals. A model framework has been developed for the Moray Firth and has the potential to be used in other areas where data on adult moult counts and pup counts are available. Covariates of interest (such as shooting, prey availability, toxin exposure, boat traffic, etc.) can be incorporated into the model to estimate the effects of each where time-series data for the covariates are available over a time scale that matches the seal population data (1996 – present). It would also be possible to make inferences from such models based on a simulation approach. For example, "what would be the population-level outcome if X seals were removed from the population due to biotoxin poisoning each year?"

4 Analytical frameworks

There are various approaches that could be taken to integrate the empirical data and determine statistically whether any of the ultimate factors or covariates are likely to be driving population change. These would include continued development of state-space modelling, currently implemented for the Moray Firth only, and an individual-based modelling approach. It was recognised that model development would need to be carried out in parallel to the empirical studies to ensure that the data could be analysed efficiently once sufficient had been collected.

5 Discussion of empirical approach

The workshop discussed the criteria for choosing specific study sites around the Scottish coast which would allow for regional contrasts in, for example, survival, fecundity, prey availability, condition, movements and toxin exposure. This would include regions where harbour seal populations show contrasting population trajectories and where grey seal numbers are also changing. In addition such sites need to be accessible. The selection criteria discussed are listed in detail below (Table 1) and the suggested regions for focused studies are shown in Table 2.

Table 1. Selection criteria for study sites.

Selection criteria	**Comments**
Previous data	Historical data are available for some harbour seal haulout sites, particularly in the Moray Firth, Orkney, Skye, Islay and the Firth of Forth/Tay
Relatively closed population	This is unlikely to be achieved except at very few sites. Use existing telemetry data to estimate site usage.
Both moult and pupping occur	The study sites should be regions where animals both moult and breed
Strategic interest	E.g. SACs, proximity of renewable development (this may bring in confounding factors such as disturbance).

Table 2. Suggested regions in the UK.

Regions	**Population trends**	
	Harbour seal	**Grey seal**
West coast	Increasing / steady	Pup production and summer counts both steady
Pentland Firth / Orkney	Decreasing	Pup production increasing, summer counts steady
Moray Firth	Steady	Pup production increasing, summer counts steady
Tay	Decreasing	Firth of Forth pup production increasing, summer counts steady
Wash	Steady	Pup production and summer counts both increasing

The workshop discussed the general data requirements to calculate key population proximate parameters (fecundity and survival using for example, a mark-recapture photo-id approach) and also the covariate data that would be required to assess ultimate factors (for example, body condition through photogrammetry, prey consumption and toxin exposure from scat analysis). Table 3 shows the various tasks at the regional level that would ideally be included in a study. These were not prioritised at the workshop and resources required to carry out each one were not estimated. Table 4 then lists the required covariates. In a future project it may be necessary to stagger some of the work regionally, by starting year, in order to be able to carry out the study within the resources and vessels available.

Table 3. Regional tasks required for addressing drivers of population change in Scottish harbour seals. Candidate list of tasks. F_a = age class fecundity; S_a= age class survival; S_{pup} = pup survival; M = movement (immigration/emigration).

Tasks	**Annual input**	**Primary output**	**Model**	**Duration (y)**[1]	**Comments**
Population dynamics model (PDM); new Agent based model (ABM)	Pup count Moult count – aerial surveys	Population size and trajectory. Sensitivity of population to change in F_a, S_a	State space	5+	These approaches are needed to investigate the combined effects of different population drivers.
Photo ID (PID)	Regional photo surveys	F_a, S_a	Mark recapture	2+	Land, boat or Unmanned aerial vehicle– based – proof of concept trials currently underway Also informs PDM priors
Pup telemetry (PT)	E.g. SPOT tags[2]	S_{pup}, M_{pup}	Statistical model		Also informs site extent for other tasks
Live captures (LC)	Annual, all ages – collect mass, morphometrics, blood, blubber, skin, teeth	Condition, toxins, Pregnancy, Juvenile growth, Asymptotic body size		1+	Avoid periods of rapid change (pupping/moult) => target season April/May
Remote condition (RC)	Regular photo surveys	Condition, Population age structure?			UAV-based morphometrics Proof of concept trials currently underway
Carcass recovery (CR)	Carcass n – preferably >10/region/y	Cause of death, condition, toxin uptake		1+	Establish high recovery effort Don't know if reduced condition would be cause or effect
Adult female telemetry (CAP)	Examine existing, 10 GSM/GPS/region/y	$M_{ad\ fem}$ $S_{ad\ fem}$		1+	1. Map foraging-pupping regions 2. Identify foraging sites 3. Inform photo recapture effort 4. Identification of closed population study sites (see PID) 5. Duration must extend from foraging to pupping (Apr/May)

[1] How long would it take to collect sufficient data
[2] Hanson, *et al*., (2013)

Table 4. Individual and group covariates to be collected at and around study sites.

Covariate Type	Covariates	Method
Harbour seal		
individual	Condition, pregnancy, toxin exposure, parasites, disease, age, sex	Live captures
group	Diet	Scat collection (sex and species id using DNA)
	Harbour seal density and distribution	Usage maps – update regionally using existing telemetry data and pup and moult data from PDM
Environmental		
	Grey seal abundance/distribution	Spring, harbour seal moult and harbour seal pupping photographic surveys Usage maps – update regionally using existing telemetry data and pup production data from autumn surveys and moult data from PDM
	Grey seal diet	Scat collection
	Killer whale predation	Observations (opportunistic) Carcass recovery
	Biotoxins	SAMS surveillance data from phytoplankton monitoring project Toxin tracking (SPATT) bags for water concentrations Prey collection
	Prey field	Literature (e.g. ICES), Local fishery offices Bespoke local surveys
	Disturbance	Shipping (AIS), Distance from tourism Camera monitoring
	Trauma	Carcass recovery from CR about
	Shooting	MSS records

6 Conclusion

The conclusion and outcome of the workshop was an agreement that this general approach was the most appropriate to investigate the causes of the decline in Scottish harbour seals, and to take this forward and refine it into a specific project proposal as required for the next phase of the MMSS programme.

The workshop acknowledged that there is a need to rapidly identify any anthropogenic drivers of the decline so that mitigation could be implemented before the situation deteriorates further.

Recommendations and priorities were not discussed during the one day workshop. However, SMRU have, based on the outcome of the workshop and the discussions, listed a set of recommendations and priorities for future work in this area.

SMRU will now develop a focused programme of research to seek to establish the key life-cycle factors that appear to be driving the decline in some regions but not in others. This will be based around a minimum of two sites (one in an area with population decline and another in an area with stable population). It will

include investigation of the potential contribution of grey seals as competitors for prey and other interactions between the two species, the type and availability of prey in the different regions and the potential impact of exposure to toxins (such as domoic acid and saxitoxin) produced by harmful algal blooms.

SMRU will continue to research the issue of spiral seal lacerations to inform revised guidance for developers and to explore potential mitigation options.

6.1 SMRU Priorities

- A population dynamics and/or agent-based model framework should be constructed in order to ensure empirical data are collected in the most appropriate way for robust and relevant statistical analysis. This will ensure the question of whether survival or fecundity is truly different between regions can indeed be addressed at the end of the study.
- Regional individual-based, mark-recapture studies should be carried out (using photo-id or other appropriate methods) to estimate fecundity and survival (with associated uncertainty) over at least 3 years (preferably 5, as the estimates are for the periods between the years so for example, 3 years would result in 2 survival and fecundity estimates). This would provide a fundamental understanding of how much the underlying vital rates for the various populations differ among the regions. For populations to be declining either the birth or death rate (or both) is being affected. By determining which of these rates the drivers are primarily acting upon, it will be possible to distinguish between the various potential causal factors that have been identified.
- Carcass recovery has to be prioritised since only the survivors in the population are currently being seen. Close cooperation with the current SMASS team will enable carcasses to be identified, sampled and where possible post mortemed which will narrow down the age and sex classes being washed ashore and whether trauma deaths predominate in a given region. Differences between live and dead animals (for example in terms of condition or uptake of toxins) could also be investigated.
- Where photographs are collected from the air, particularly using unmanned aerial vehicles, body condition of individual animals on haulouts could be determined using photogrammetry methods currently being developed and again compared among regions with different population trajectories.
- Live captures of females and subadults in particular would allow the investigation of differences in the health of animals in the various regions; to compare pregnancy status, age, growth rates, body and health condition, toxin uptake and diet. These trips could be combined with collection of faeces from haulout sites for toxin determination and diet comparison.
- The combination of health assessments and the deployment of telemetry devices (using a simple, relatively cheap telemetry tag that will establish haulout location and duration only) with photo-id will enable a subset of the population to be followed in more detail. This will establish haulout patterns (for example, do animals use the same sites for moult and pupping?), enable the probability of recapture for any photo-id work to be estimated, as knowing if animals have moved, but are still alive, is key to distinguishing between apparent and true survival. It would also allow the fate of a subset of known individuals through the spring to the pupping season to be followed. These individuals could then be targeted for re-capture by photo-id to determine if they had given birth to a live pup.

7 References

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8 Appendix

Elaine Tait	Marine Scotland
Ian Walker	Marine Scotland
Oana Racu	Marine Scotland
John Baxter	Scottish Natural Heritage
Kate Brookes	Marine Scotland
Eunice Pinn	Joint Nature Conservation Committee
Paul Thompson	University of Aberdeen
Dave Thompson	Sea Mammal Research Unit
Bernie McConnell	Sea Mammal Research Unit
Paddy Pomeroy	Sea Mammal Research Unit
Callan Duck	Sea Mammal Research Unit
Chris Morris	Sea Mammal Research Unit
Gordon Hastie	Sea Mammal Research Unit
Joseph Onoufriou	Sea Mammal Research Unit
Marjolaine Caillat	Sea Mammal Research Unit
Esther Jones	Sea Mammal Research Unit
Debbie Russell	Sea Mammal Research Unit
Lindsay Wilson	Sea Mammal Research Unit
Sophie Smout	Sea Mammal Research Unit
Philip Hammond	Sea Mammal Research Unit
Ailsa Hall	Sea Mammal Research Unit