# Estimating dispersal and survival of grey seal pups

## Preliminary Report

## to BEIS

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# 1 Introduction

There are stark differences in the regional population trajectories of grey seals (Thomas *et al.* 2019). Evidence from Wales and Southwest England Seal Monitoring Units (SMUs) indicates that the population is increasing (reviewed in Russell and Morris 2020). This is despite an estimated level of bycatch (of young individuals) that exceeds the Potential Biological Removal threshold (PBR). Similarly, estimated bycatch levels in Ireland exceed the precautionary PBR threshold there (Luck *et al.* 2020). Thus, the Irish and southwest UK grey seal populations are likely to be receiving significant immigration. Such immigration would violate the assumption of a closed population that underlies the PBR method. At the other extreme, calculating PBR on the scale of aggregated SMUs (or equivalent; i.e. combining SMUs on the west of the UK and Ireland) is also inappropriate; migration rates between these components of the metapopulation are unknown.

Any substantial net movement into southwest UK and Ireland is most likely to be through pup dispersal. The main potential source of pups is the Western Isles SMU, in which over 15,000 pups are estimated to be born each year (ten times the combined estimate for Wales and Southwest England; Russell *et al.* 2019). The level of pup production in the Western Isles SMU is relatively constant with the population appearing to reach carrying capacity in the mid-1990s (Thomas *et al.* 2019). This is likely driven by density-dependence acting on pups at sea; first year survival (0 to age 1) is estimated to be around 14% (Thomas *et al.* 2019). This estimate is based on the outputs of a population dynamics model which assumes a closed population in the Western Isles, and is informed by abundance data as well as information on grey seals demographic rates (from the UK and elsewhere). However, if there is a considerable degree of emigration, which seems likely given the density-dependent pressures, then this survival rate could be a gross underestimate. It is critical to determine the levels of both emigration and pup survival. Under BEIS contract OESEA-20-122, funds were available for the purchase of 50 bespoke ARGOS tags (made by SMRU Instrumentation) and the associated ARGOS transmission charges for 30 tags. The Met Office funded the upgrade of 20 tags (to include temperature sensors) and their ARGOS transmission charges. Under contract BEIS OESEA-21-131, the tags were deployed on moulted pups on the Monach Islands, Western

Isles. Approximately 12,500 pups are born on these islands each year making it the largest grey seal pupping colony in Europe.

# 2 Methods

### 2.1 Tags

Tags (Figure 1) were developed specifically for this project for two reasons. First, the nature of the key research questions (dispersal and survival) required a relatively high sample size of tags and did not require the detailed at-sea data provided by GPS/GSM tags typically deployed on seals in the UK (Carter *et al.* 2017). Second, the data required could be collected using a smaller tag than is typically used. Thus, SMRU Instrumentation developed a bespoke ARGOS tag with expert input on the optimal hydrodynamic tag shape from Chris Pass (Computational Fluid Dynamics, University of Plymouth). In total 50 ARGOS tags were purchased (less than 20 GPS/GSM tags could have been purchased for the same amount).

### 2.2 Licences and permissions

All capture, handling and other licensed procedures were carried under Home Office project licence (PF84B63DE) under the Animals Scientific Procedures Act. It has been approved by the University of St Andrews Animal Welfare and Ethics Committee (AWEC). Furthermore, the capture of seals was conducted under SMRU's Seal Licence (Research 01/2021/0) from Marine Scotland (as required under the Marine (Scotland) Act 2010). The Monach Islands is a Special Area of Conservation (Monach Islands SAC; of which grey seals are a primary feature). Thus, additional approval (as per SMRU's Marine Scotland Licence) was required. Approval, on the basis of a fieldwork protocol supplied by SMRU, was granted for this specific work by Marine Scotland Licensing. Permission was also gained from the landowner (North Uist Estate Trust).

### 2.3 Fieldwork Protocol

Grey seal pups are born covered in a white fur (lanugo) which they moult off by around 23 days after birth (Russell *et al.* 2015 and references therein). The pups are weaned from their mothers at about 18 days (Pomeroy & Fedak 1999) and then undergo a post-weaning fast until leaving the colony to go on their first foraging trip around 30-40 days old birth (Russell *et al.* 2015 and references therein). Pup mortality rate on colonies varies but the vast majority of

mortality occurs in whitecoats (pre moult) rather than in moulted pups (post moult; Quaggiotto *et al*. 2018). In terms of survival estimates, our aim here was to be able to estimate rates after leaving the colony (post-leaving survival). Only moulted pups were tagged; tags cannot be deployed on whitecoats. To maximise the degree to which pup tagged represented the wider colony, fieldwork was planned to coincide with the presence of moulted pups that had been born during the peak of the season. It was critical to a non-bias sample of moulted pups, whilst rejecting pups from the study which were unlikely to survive to leaving the colony. To facilitate this, the protocol was for a visual health check to be conducted followed by comprehensive hands-on whole body inspection for overt signs of ill health; examination of integument, attitude, locomotion, posture, respiration and a check of mouth, nose, eyes and ears. To minimise disturbance to the colony as a whole (which is densest on the beaches), all tagging was conducted outwith the main colony (inland). As weaned pups typically move away from the dense breeding areas it is unlikely that this would have led to a bias in the sample of pups being tagged.

***Figure 1.*** *Picture of a tagged pup on the Monach Islands (2021)*

**2.4 Fieldwork**

Fieldwork was conducted between the 31st of October and 3rd of November 2021. A local tour operator, Uist Sea Tours (Lochboisdale), was used to transfer to and from the island. The 13 m RIB used allowed transfer of the team and equipment in one trip each way and effected

a beach landing and offload/pick up without incident. Once on the island the team stayed in the Old Schoolhouse (managed by Trust for Heisgeir).

To avoid any unnecessary disturbance, target pups were first assessed without capture, for both moult status and health. One moulted pup with a visibly swollen face was rejected after the visual inspections. Potential study pups were caught with a pup bag and immediately sedated. The whole body health assessment (see above) resulted in the rejection of two more pups due to overt evidence of disease. Of the 50 individuals tagged (Appendix 1), 27 were females and 23 male. The mean mass of the females was 40.2 kg (range: 27.0 – 53.0) and males 40.4 (range: 29.8 – 55.6). Although, mass at weaning is correlated with post-leaving survival (Hall *et al.* 2001), these masses represent different stages of the post-weaning fast and thus should be considered in that context. Mean length (nose to tail) was 103 and 108 cm for females and males respectively (ranges: 94-110 and 101 – 117). Finally, mean axial girth was 92 and 91 cm for females and males respectively (ranges: 80 - 105; 79 - 111). The tags were attached to the fur at the back of the neck (using superglue) and will fall off by the end of the annual moult in Spring 2023. Each pup was marked with a unique flipper tattoo. Biological samples were taken from captured pups for four additional projects: (1) Influenza A prevalence in grey seals (led by Divya Ventakesh, University of Oxford); (2) Rates of anti-microbial resistance genes in seals (led by Kimberley Bennet, University of Abertay); (3) Genetic differentiation in grey seals; (4) BioGenome Project. All capture, handling, and sampling was conducted under Licence (see 2.2)

### 2.5 Tag data

The tags transmitted data on location via Argos satellites when the seals were hauled out. Movement type, resident or emigrant, was assigned on the basis of the pups' final location. Pups whose last known location was within the Western Isles/West Scotland Seal Monitoring Units (SMUs) were termed residents. Emigrants were those whose final location was in other SMUs or countries (Ireland).

## 4 Results

Of 50 tags deployed, 49 went to sea, one pup appeared to never leave the Monach Isles and thus likely died on the breeding colony. The other tags sent data for up to seven months. In total, 30% of pups stayed within the West Scotland & Western Isles SMUs; c. 5 % went north

(Orkney), and c. 65 % went south (Ireland and Southwest England). For one pup, for which the last location is listed in Table 1 as Ireland, there was one additional location in Nova Scotia, Canada. The inter-location interval and the data transmitted did not indicate the location was an error. However, the battery was very low at the point of last contact, and thus the tag did not transmit any further data making it impossible to confirm that this was a genuine position.

Two tagged pups were found dead; both in Ireland. One was sighted on a beach; and the other was caught in a cray fish net (reported by the fisher). Unfortunately, the bodies could not be recovered.

Table 1. The area in which the final location from the tags was transmitted, by sex. The minimum percentage of pups still alive by the end of each month is shown by area

| | Sex (n) | | Minimum still alive (%) | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Area/SMU** | **Female** | **Male** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** |
| Western Isles/West Scotland | 10 | 5 | 87 | 53 | 47 | 20 | 20 | 13 |
| North Coast & Orkney | 0 | 3 | 100 | 100 | 100 | 67 | 0 | 0 |
| Ireland | 16 | 13 | 100 | 86 | 48 | 24 | 17 | 0 |
| Southwest England | 1 | 1 | 100 | 100 | 50 | 50 | 50 | 50 |
| Total | 27 | 22 | 96 | 78 | 51 | 27 | 18 | 6 |

# 5 Discussion

The tags only transmitted data when individuals were hauled out. This allowed long range movements to be examined. Critically, the data showed that the majority of pups tagged did not remain resident, and instead travelled south to Ireland, with some moving further to Southwest England. The battery life of the tags was variable, and it was not possible to distinguish end of the tag life from pup death. Nevertheless, based on the data transmitted, there was no evidence that one strategy (resident or emigrant) was associated with a higher mortality (Table 1). Although mortality in the first month was limited to those still in Western Isles/West Scotland, this would be expected given the limited time available to move. Thereafter, the minimum percentage still alive was similar between the two areas with the highest sample size (West Scotland/Western Isles, and Ireland).

In terms of net movements, although it is possible that some pups classed here as migrants may return to West Scotland/Western Isles, it seems likely that the net movement of pups

south would remain at least as high as the 31 individuals suggest. Indeed, once in Ireland, only one tagged individual subsequently hauled out in Scotland (Inner Hebrides) before returning to Ireland. There was an indication of continued southern movements in many pups with the first haul out in north or Northern Ireland before moving south down the west coast of Ireland. For a conservative pup survival on the Monach Isles (before leaving for sea) of 80%, these findings suggest around 6,000 pups from the Monach Isles moved south to Ireland/southwest UK after the 2021 breeding season. If the movements are representative of grey seals born at other sites in the Western Isles and West Scotland (which has also appeared to reach carrying capacity), the number of pups from Scotland moving into the waters surrounding Ireland and Southwest UK would be nearer 10,000. The latest combined pup production estimates for Ireland, Wales and southwest England are around 5,350. Production estimates for Ireland are from 2012, and production was increasing, and thus this value may be an underestimate. However, even if pup production was higher and 5,350 was the number surviving to leave the colony, it would still result in Scottish pups in Ireland/southwest UK matching the number of pups born in the area or outnumbering them by 2:1. The former ratio would apply if movements of the tagged pups were representative of the Monach Isles as a whole and the latter if representative of wider West Scotland/Western Isles. It should be noted that although pup production estimates of 5,350 includes pup production estimates from Wales and eastern Ireland, no tagged pups from the Monach Isles hauled out in either.

Grey seal pups typically exhibit an exploratory phase during which they conduct particularly long trips to sea, both in terms of duration and extent (Carter *et al.* 2017). The degree this phase is mediated by foraging conditions is unknown though it seems likely pups would cease exploration once suitable foraging areas were discovered. Pups in different areas, Scottish coast of North Sea vs Wales, showed stark differences in the trip duration and the temporal pattern therein. However, there are so many differences between the areas, including population dynamics and geography, it is not possible to disentangle the potential reasons for the difference.

If pups do cease exploration once suitable foraging areas are found then the high level of emigration would, at least in part, be driven by the seals encountering relatively poor foraging conditions in their natal region. This may mean that the pups arriving in Ireland were in relatively poor condition, and thus may have higher mortality than pups born in the area. The implications of these preliminary findings for the PBR estimates for the Ireland and southwest UK are unclear although they demonstrate that the assumption of a closed population that underpins PBR is violated. Thus, in theory, the number of individuals that can be safely taken, estimated via PBR or other means, could potentially be increased to take into account the immigration. However, as well as uncertainty surrounding the number of immigrants (see above) there are multiple, potentially interacting, factors that complicate any such revision including: the proportion of immigrants that would return to Scotland to breed; to what degree the population estimate used in the PBR already includes immigrants; the age at which individuals are most likely to be bycaught; the background survival rate of immigrants; the extent to which pup survival is mediated by density dependence; and how the allowable take should be allocated between the SMUs/countries in the southwest area.

Grey seals demonstrate a degree of natal philopatry, returning to the colony or area in which they are born to breed (Pomeroy, Twiss and Redman 2000). The impact of pup emigration on natal philopatry is unknown though the rapid increases in pup production in southeast England indicates that, to a degree, grey seals recruit into populations in which they forage. The population trajectory for the west of Scotland (SMUs 2 and 3) is stable suggesting a first-year survival of around 14%. If the emigrating pups do not recruit in Scotland then they are, in the population model, assumed to have died (doomed surplus).

PBR relies on a population estimate and the intrinsic growth rate of the species. In most SMUs, the August counts (scaled to 20th percentile of population estimates) are used to set the PBR – these counts would, to a degree, include the surviving pups born the previous year and juveniles. Indeed, they are essentially an indicator of the number of seals foraging in the area; some individuals breed and forage in different regions, presumably driven by breeding site fidelity and foraging conditions (Russell et al. 2013).

In SMUs for which there are no reliable August counts, a scalar from estimated pup production is used – this would not explicitly include non-recruited immigrants – the scalar is derived from other SMUs and thus implicitly their age-structure. If bycatch is primarily of young individuals (< 1 year old), then potentially a large proportion of these bycaught individuals could be immigrants which would not have featured in either method of estimating abundance for PBR.

The level of immigration also calls into question the background survival rate of pups in Ireland and Southwest UK– Thomas *et al.* (2019) estimated pup survival to be c. 48% for an unconstrained population. The increasing abundance in the southwest area, especially given the level of bycatch, suggested that the population was not yet at carrying capacity and is likely to subject to limited density dependent constraints. However, the number of pups immigrating will likely increase competition, and the indication that they continued to the move south once in the area, may mean prey availability was limiting. If this was the case, there may be a degree of density dependence acting on pup survival resulting in a smaller net increase in abundance as a result of immigration than the estimated numbers of immigrants from western Scotland would suggest.

No tagged individuals hauled out in Wales or the east coast of Ireland. It is unknown the degree to which tagged pups would have continued to move and the proportion that may have eventually go there. However, if the levels of immigration were resulting in increased levels of density dependence, then pups born in the area may also be more likely to move to find favourable foraging patches and thus may have moved into the areas tagged animal did not.

It is important to note that most of the issues relating to “safe take” are not restricted to PBR and thus for alternative, potentially more appropriate methods, these uncertainties would need to be resolved or incorporated. A further deployment of 25 tags, which will provide locational data at sea, is planned. As well as increasing our understanding of movements at sea and adding to the sample size from 2021, the resulting data will be used to estimate relative survival rates of resident pups versus those that emigrate. However, other questions such as the relative survival of immigrating pups versus those born in the southwest area will remain. A genetic study on grey seal on the structure of the European metapopulation is nearing conclusion (Steinmetz *et al.* In Prep). That study will provide the necessary context to

additional work that is required to compare genetic samples from bycaught seals with those from the Monach Isles.

# 4 Acknowledgements

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# 5 Appendix

- ***Table 1: Tag deployments.*** Details of the individuals tagged

| Date | Sex | ID | ARGOS Tag | Mass (kg) | Length (cm) | Girth (cm) |
|---|---|---|---|---|---|---|
| 31/10/2021 | Female | E011 | 20086 | 44.3 | 104 | 97 |
| 31/10/2021 | Female | E012 | 20090 | 29.6 | 97 | 80 |
| 31/10/2021 | Male | E013 | 20078 | 48.4 | 117 | 98 |
| 31/10/2021 | Male | E014 | 20075 | 37.2 | 104 | 86 |
| 31/10/2021 | Female | E015 | 20092 | 42.8 | 105 | 95 |
| 31/10/2021 | Male | E016 | 20095 | 36.4 | 104 | 88 |
| 31/10/2021 | Female | E017 | 20087 | 42 | 105 | 94 |
| 31/10/2021 | Male | E018 | 20094 | 40.6 | 107 | 92 |
| 31/10/2021 | Female | E019 | 20079 | 37.6 | 103 | 91 |
| 31/10/2021 | Male | E020 | 20074 | 35 | 104 | 87 |
| 01/11/2021 | Male | E021 | 20083 | 40.8 | 108 | 91 |
| 01/11/2021 | Female | E022 | 20113 | 38.2 | 106 | 88 |
| 01/11/2021 | Male | E023 | 20070 | 44.8 | 110 | 96 |
| 01/11/2021 | Female | E024 | 20108 | 42.2 | 106 | 94 |
| 01/11/2021 | Female | E025 | 20097 | 45.4 | 106 | 94 |
| 01/11/2021 | Male | E027 | 20109 | 45.6 | 112 | 97 |
| 01/11/2021 | Female | E028 | 20099 | 41.8 | 100 | 95 |
| 01/11/2021 | Female | E029 | 20116 | 38.6 | 104 | 92 |
| 01/11/2021 | Male | E030 | 20117 | 35.8 | 110 | 87 |
| 01/11/2021 | Female | E031 | 20110 | 51.6 | 110 | 101 |
| 01/11/2021 | Female | E032 | 20072 | 48.8 | 105 | 98 |
| 01/11/2021 | Female | E033 | 20112 | 36.8 | 102 | 93 |
| 01/11/2021 | Male | E034 | 20101 | 48 | 112 | 100 |
| 01/11/2021 | Female | E035 | 20096 | 46.8 | 110 | 101 |
| 01/11/2021 | Male | E036 | 20073 | 42.2 | 111 | 88 |
| 02/11/2021 | Male | E037 | 20105 | 39.2 | 110 | 88 |
| 02/11/2021 | Female | E038 | 20071 | 43.4 | 108 | 96 |
| 02/11/2021 | Female | E039 | 20089 | 34.4 | 101 | 84 |
| 02/11/2021 | Male | E040 | 20077 | 40.2 | 109 | 92 |
| 02/11/2021 | Female | E041 | 20103 | 38.6 | 101 | 91 |
| 02/11/2021 | Female | E042 | 20107 | 38.8 | 104 | 90 |
| 02/11/2021 | Female | E043 | 20085 | 42.4 | 103 | 93 |
| 02/11/2021 | Male | E044 | 20111 | 38.8 | 108 | 89 |
| 02/11/2021 | Male | E045 | 20084 | 34 | 107 | 83 |
| 02/11/2021 | Female | E046 | 20102 | 37.4 | 104 | 91 |
| 02/11/2021 | Female | E047 | 20080 | 39.4 | 105 | 90 |
| 02/11/2021 | Male | E048 | 20119 | 45 | 112 | 96 |
| 02/11/2021 | Male | E049 | 20088 | 32.2 | 101 | 85 |
| 02/11/2021 | Male | E050 | 20106 | 40 | 105 | 94 |
| 02/11/2021 | Female | E051 | 20100 | 53 | 109 | 105 |
| 03/11/2021 | Female | E052 | 20081 | 28.8 | 98 | 80 |
| 03/11/2021 | Female | E053 | 20118 | 34 | 95 | 88 |
| 03/11/2021 | Female | E054 | 20076 | 44.6 | 104 | 99 |
| 03/11/2021 | Male | E055 | 20093 | 37.8 | 104 | 89 |
| 03/11/2021 | Male | E056 | 20098 | 29.8 | 103 | 79 |
| 03/11/2021 | Male | E057 | 20104 | 38.8 | 104 | 91 |
| 03/11/2021 | Female | E058 | 20082 | 36 | 101 | 90 |
| 03/11/2021 | Male | E059 | 20115 | 43 | 110 | 95 |
| 03/11/2021 | Male | E060 | 20114 | 55.6 | 114 | 111 |
| 03/11/2021 | Female | E061 | 20091 | 27 | 94 | 80 |