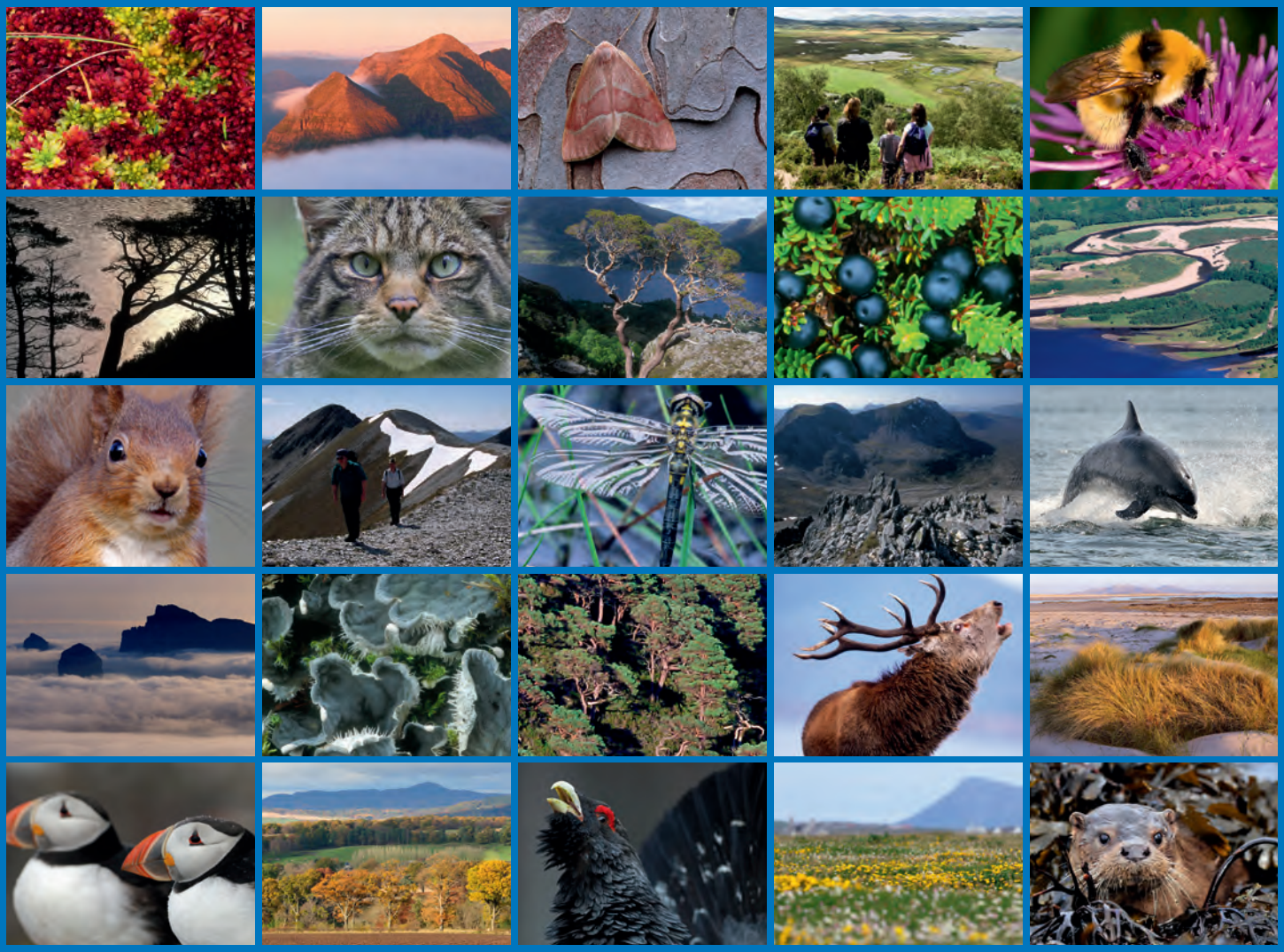
Scottish Natural Heritage
Commissioned Report No. 441

Utilisation of space by grey and harbour seals in the Pentland Firth and Orkney waters



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COMMISSIONED REPORT

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Utilisation of space by grey and harbour seals in the Pentland Firth and Orkney waters

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COMMISSIONED REPORT

Summary

Utilisation of space by grey and harbour seals in the Pentland Firth and Orkney waters

Commissioned Report No. 441
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Background

The Pentland Firth and Orkney waters are important for both grey and harbour seals. Both species are resident, using the area for all aspects of their life cycle. The area is also high in wave and tidal energy and areas in the Pentland Firth and Orkney waters have been leased for both demonstration and commercial renewable energy production projects.

This report aims to assess the potential for overlap between areas around Orkney and the Pentland Firth that are used by seals and those proposed for wave/tidal energy development. In particular, the spatial and temporal overlap between seals and the location of potential renewable energy devices was required.

Main findings

- In 2008, 37% of Orkney grey seal pups were born at colonies close to or within the Pentland Firth.
- Numbers of grey seals hauling out during the summer have not changed particularly in recent years.
- When foraging, adult grey seals routinely move large distances.
- The main overlap between grey seals and areas of high tidal current/potential development appears to be in the Pentland Firth, particularly the area around Stroma, Swona and the Pentland Skerries (which are heavily used for both breeding and hauling out).
- Harbour seal numbers in Orkney declined by 63% between 2001 and 2008. On the north coast of Scotland, they declined by 41% between 1997 and 2008.
- Harbour seal movements are relatively local, and there is less movement between haulout regions than there is for grey seals.
- Costa Head, the licensed area to the west of Rousay, overlaps a corridor that harbour seals use to move to and from a foraging area to the west of Orkney.
- Both seal species use the whole water column when diving.

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1 INTRODUCTION

Orkney is a key UK location for the development of wave and tidal renewable energy technology. Test site facilities for both wave and tidal devices were set up in Orkney in 2006 (by EMEC, the European Marine Energy Centre). More recently the Crown Estate held the first round of a leasing competition for demonstration and commercial project sites in the Pentland Firth and Orkney waters, resulting in 1600 MW of planned projects[1].

The waters around Orkney are also home to large numbers of grey and harbour seals. Of the five main breeding areas of grey seals in the UK, the greatest numbers of pups (43% of the UK total and approximately 15% of the world total) are born at colonies in Orkney (Duck 2009; SCOS 2009). Until 2001, Orkney was the main stronghold for harbour seals in the UK (22%; Lonergan *et al*. 2007). Following declines in populations since 2001, the contribution to the UK total provided by Orkney has fallen considerably, from 22% in 2001 to 12% in 2008 (Duck and Thompson 2009; Lonergan *et al*. 2007).

The work outlined in this report was commissioned by SNH in order to better understand potential interactions between seals and wet renewable energy developments in the Pentland Firth and Orkney waters. Specifically, investigation of the spatial and temporal overlap between seals and potential wet renewable energy device lease areas was required.

The Sea Mammal Research Unit (SMRU) has been collecting data on seal numbers and at-sea behaviour for two decades. We have used existing SMRU survey (of seals hauled out on land) and telemetry (at sea) data to explore the potential for interactions between seals and renewable energy devices in the Pentland Firth and Orkney waters.

For the purposes of this report, we have concentrated on the Pentland Firth and Orkney Strategic Area (PFOSA; enclosed by the 12 nm line; Figure 1). We have also used a narrowed area of search for some aspects of the work (enclosed by the 3nm line; Figure 1). There are 11 proposed wave and tidal development lease areas in the PFOSA (although the lease area to the south of Stroma is not shown in these maps). Special consideration is given to seals from Special Areas of Conservation (SACs) within the PFOSA (Figure 1; Table 1) and from the adjacent grey seal SAC at North Rona, to the west of Orkney.

Both grey and harbour seals are listed in Annex II of the EU Habitats Directive. Member states are required to designate SACs for all Annex II species to aid in maintaining population levels at a favourable conservation status. Within the PFOSA, SACs were designated at Sanday (for harbour seals) and Faray and Holm of Faray (for breeding grey seals) because of their importance for seals.

1.1 SACs for seals in the PFOSA

1.1.1 Faray and Holm of Faray grey seal SAC

Grey seal SAC designation was based on the numbers of pups born at individual breeding colonies. Candidate SACs had to contribute a reasonable proportion of pups to the Scottish annual total and had to be evenly distributed across the

[1] http://www.thecrownestate.co.uk/wave-tidal

geographic range of grey seal breeding colonies in Scotland. Using the most up to date population data available, the largest grey seal breeding colonies (based on pup production estimates) were selected as SACs. There are six grey seal SACs in Scotland: the Treshnish Isles (Strathclyde), the Monach Isles (Outer Hebrides), North Rona (Outer Hebrides), Faray and Holm of Faray (Orkney), the Isle of May (Firth of Forth) and the Berwickshire and North Northumberland Coast (crosses the Border on the east coast).

Faray and Holm of Faray (two uninhabited islands in the northern part of Orkney) support a well established grey seal breeding colony. The seals tend to be found in areas where there is easy access from the shore, and freshwater pools on the islands appear to be particularly important. These islands support the third largest breeding colony in the UK (and fourth largest in the world) and, in 2008, contributed approximately 6% of annual UK pup production.

Although outwith the PFOSA, the grey seal SAC at North Rona is also considered. North Rona is a remote and very exposed island in the North Atlantic 40 miles north-west of the north-west tip of mainland Scotland. Grey seals breed on Fianuis, the northern promontory of the island. Although North Rona supports a significant grey seal breeding colony, contributing approximately 2% of the 2008 UK pup production, the number of pups born on the island has been gradually declining over the past 10-15 years.

1.1.2 Sanday harbour seal SAC

Selection of SACs for harbour seals was primarily based on numbers counted during their annual moult, in August. Additional surveys confirmed that the candidate SACs were also used for breeding. There are eight harbour seal SACs designated in Scotland: Yell Sound Coast and Mousa (Shetland), Sanday (Orkney), Ascrib, Isay and Dunvegan (Skye), Eileanan agus Sgeiran Lios mor (Isles and Skerries of Lismore) and South-East Islay Skerries (Strathclyde), Dornoch Firth and Morrich More (Moray Firth) and the Firth of Tay and Eden Estuary (Tayside and Fife).

Sanday is situated in the north-east of the Orkney archipelago and, up to 2001, supported the largest group of harbour seals at any discrete site in Scotland. The breeding groups, found on intertidal haulout sites that are unevenly distributed around the coast, represent over 4% of the UK population.

1.2 Aims

The aims of this project are:

1. To determine use of land and sea by harbour and grey seals in the PFOSA using existing data
2. To consider the implications for these species of installing marine renewable developments, particularly tidal turbines.

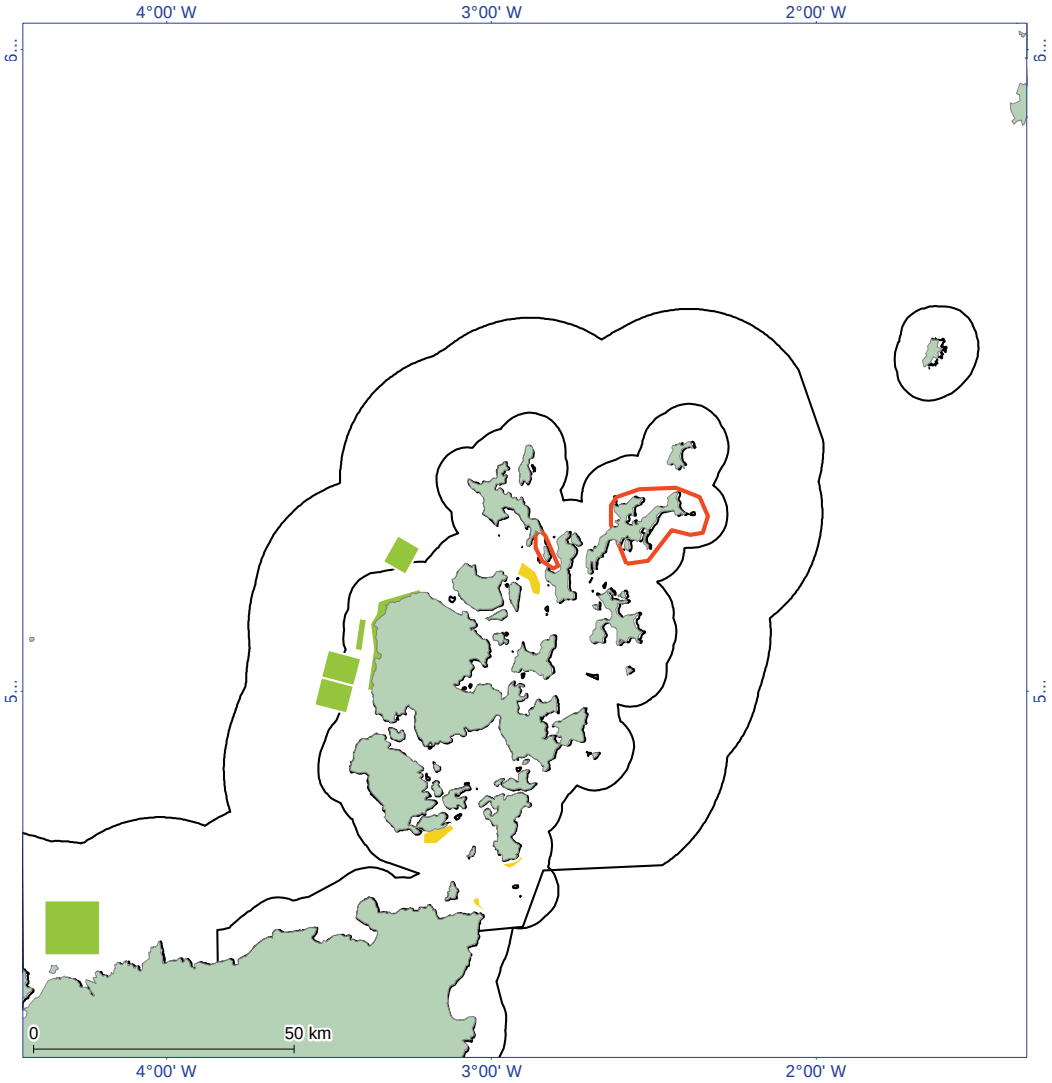

Figure 1. Areas of interest in the Pentland Firth and Orkney waters. The PFOSA is shown by the outer (12nm) line. The narrowed area of interest is shown by the inner (3nm) line. Locations of development lease areas for wave (green) and tidal (yellow) are shown. The local SACs for both grey and harbour seals are also shown (red line).

2 METHODS

2.1 Monitoring seal populations

SMRU's seal surveys enable the Natural Environment Research Council (NERC) to fulfil its statutory obligation under the Conservation of Seals Act, 1970 and the Marine (Scotland) Act 2010, to provide the Scottish Government and Defra with scientific advice related to the management of seal populations. An essential component of this advice is information on the size and distribution of grey and harbour seal populations.

2.1.1 Estimating grey seal pup production

Every year, between September and December, SMRU conducts aerial surveys of the 60 main grey seal breeding colonies around Scotland. Normally, these main breeding colonies are surveyed between four and six times during the breeding season (at approximately 10 to 12 day intervals) but a number of smaller, or more difficult to survey, colonies are surveyed three times during the breeding season. Approximately 40 additional colonies are surveyed once during the breeding season, on a two to four year rotation.

SMRU's grey seal pup surveys are carried out using a light, twin-engine survey-modified aircraft. A large-format camera is mounted in the floor and takes high resolution images of the areas used by breeding seals. Large-format film (96 x 126mm) is currently used but this is due to be replaced by a high-resolution digital system in the near future. Surveys are flown at a height of 1,100 to 1,200 feet (350 to 365m) and images cover an area on the ground of approximately 300 x 200m. Overlapping transects are flown over large colonies to ensure that all areas used by breeding seals are covered and areas of overlap on adjacent frames are excluded prior to counting. Pups are categorised into two age classes and are counted from images magnified in a microfiche reader.

Grey seals start to breed on the west coast first and colonies in the Inner and Outer Hebrides may be surveyed as early as mid September, whereas colonies in Orkney and the North Sea may not be first surveyed until late October. With suitable weather and light levels, it takes between four and five days to survey all of the routinely monitored breeding colonies. Routine searches are also made for new colonies around the coast of Scotland.

Some colonies are not surveyed by air but from the ground. SNH routinely undertake ground surveys of colonies in Shetland and at South Ronaldsay in Orkney. Occasionally, aerial surveys of some colonies (e.g. Helmsdale and Fast Castle) are supplemented with ground counts.

The grey seal pup surveys and subsequent image processing is extremely labour intensive and requires approximately four to five man-months each year to complete.

SMRU reports pup production for the whole of the UK annually through the Special Committee on Seals (SCOS), which formulates scientific advice on matters related to the management of seal populations to government on behalf of NERC. "SCOS reports" are available to the general public via the SCOS section of the SMRU website[2].

[2] http://www.smru.st-andrews.ac.uk/pageset.aspx?psr=411

2.1.2 Estimating harbour and grey seal numbers in August

Population surveys of harbour seals are not carried out during their breeding season but during their annual moult, in August. Unlike grey seals, harbour seals tend to disperse to breed and, in the UK, pups are born in their first adult coat having moulted their white coat (lanugo) while in the uterus. Pups are frequently born below the high water mark and, necessarily, are able to swim with their mothers on the next incoming tide. Because pups are inconspicuous, are very widely dispersed along the coast and may be swimming with their mothers, surveys are carried out at a different time in the harbour seal annual cycle, during their annual moult in August. When moulting, harbour seals do aggregate to a certain extent and tend to spend longer out of the water to facilitate the rapid growth of their new coat.

Where seals haul out onto sandbanks and are relatively easy to locate, surveys are normally carried out using a fixed-wing aircraft and hand-held oblique digital photography. Where they haul out onto rocky and seaweedy shores and are well camouflaged, they are surveyed by helicopter using a thermal imaging camera. This system allows rapid survey of extensive areas of coastline as seals can usually be detected at distances of up to 3km.

Both harbour and grey seals are counted in August surveys and high-resolution digital images of most groups of seals are taken to confirm species identity and the number of seals in each group. This is an expensive survey method and, as a result, the whole of Scotland is surveyed approximately only once every five years. Areas of particular interest or importance may be surveyed more frequently, depending on the availability of resources.

To maximise the numbers of seals on shore and to minimise the effects of environmental conditions on haulout behaviour, surveys are restricted to:

- within two hours before and after the time of local low tide
- between approximately 12:00 and 17:30 local time
- days without persistent or moderate to heavy rainfall

To ensure seals are not disturbed from their haulout sites, helicopter and fixed-wing surveys are carried out at an altitude of between 180 to 250m (600 to 800 feet) and at a distance of approximately 500m off shore. The thermal image is recorded onto a digital video recorder. The number of seals in each group and the group's location are recorded onto 1:50,000 maps. Digital still images are taken of most groups of seals. These images are later used to correct counts made in real time and to confirm the species of seal.

2.1.3 Surveys in Orkney and around the Pentland Firth

Surveys of grey seal breeding colonies have been carried out annually since the 1960s[3]. August surveys of harbour seals in Orkney have been carried out in 1993, 1997, 2001, 2006, 2007 and 2008, with a partial survey in August 2009. The north coast of Scotland, between Duncansby Head and just west of Scotland's Haven was also surveyed in these years (but not in 2009). The remainder of the Scottish coast was surveyed in its entirety in August 1997 and 2005 (Fraserburgh to Cape Wrath) and partially in 2007 (Fraserburgh to Nairn) and 2008 (Findhorn to Cape Wrath).

[3] It is unknown whether these surveys will continue on an annual basis in future.

Surveys of seals in the Moray Firth, between Findhorn and Helmsdale, are carried out annually between June and July (harbour seal breeding season) and in August (moult).

2.2 Telemetry

The bulk of the data presented here were provided by the **SMRU Argos tag**[4] (Satellite Relay Data Logger or SRDL) and the more recent **SMRU GSM/GPS phone tag**[5]. The Argos tags relay data via the Argos satellite system. However the data flow bottleneck of the satellite system results in only a *sample* of all data stored for transmission being successfully relayed. Of relevance here is the fact that not all haulout records[6] are relayed. Also, Argos locations may have errors from tens of metres to tens of kilometres. The SMRU GSM/GPS phone tag collects GPS quality locations (up to c. 50 per day, cf only c. 6 per day with Argos). These, and *complete* sets of high quality dive and haulout records, are stored and relayed through the mobile phone system.

Haulout records are derived from the wet/dry sensors on the tag and are important in helping define the standard unit of subsequent analysis – the trip.

Two other types of Argos tag made by Wildlife Computers (WC)[7] have been used for specific studies. Whilst they do not relay detailed individual dive and haulout information, they are cheaper and thus a greater number of seals can be tagged. The **WC Argos Spot tag** produces track data, but only rudimentary haulout information. The **WC Argos Flipper tag** produces more detailed haulout information, but, because they are attached to the flipper, seldom provide locations at sea.

2.2.1 Seal catching and device attachment

Seals are captured on or around their haulout sites using a variety of methods. Individual seals may be caught ashore by

1. rush-and-grab technique using hand-held hoop nets
2. rapid deployment of a seine net
3. static tangle nets
4. submerged barrier nets released remotely

All activity relating to catching and working with seals in the UK is licensed by the Home Office in accordance with the Animals (Scientific Procedures) Act 1986.

The primary method of tag attachment is by gluing the tag with rapid setting epoxy resin onto the fur on the dorsal neck region. The tag will certainly detach during the annual moult (grey: Jan-Mar; harbour: Aug-Sept). However typical tag deployment for grey and harbour seals is seldom greater than six months. Miniature flipper tags (see **WC Argos Flipper tag** above) overcome this moult attachment barrier. Their necessary small size requires them to be very energy efficient and therefore they are duty-cycled to transmit only small amounts of information. Also, they only provide locations when the seal is hauled out.

[4] http://www.smru.st-andrews.ac.uk/Instrumentation/pageset.aspx?psr=286
[5] http://www.smru.st-andrews.ac.uk/Instrumentation/pageset.aspx?psr=287
[6] A typical tag haulout definition is: Start= > 10mins continuous dry, End = > 40s continuous wet.
[7] http://www.wildlifecomputers.com/Products.aspx?ID=-1

2.2.2 Post processing

Argos-derived location fixes are prone to large errors and so the tracks are smoothed with a GAMM smoother (R package gampath by Mike Lonergan, SMRU). However there still may be residual error remaining.

Tracks are categorised into *trips* from haulout sites. A trip is defined as the period when a seal is (say) > 1 km from a haulout for (say) 1 hour. A trip ends when the seal next hauls out on land. The absence of individual haulout bout information from the two types of WC tags means that tracks from these tags have not been categorised into trips.

We emphasise in this report the track and count *data* without combining the two types of data into usage maps. There are two reasons for this approach. First, the scale of interest is too fine for the currently available usage map algorithms. Second, whilst usage maps do produce uncertainty surfaces, we feel that the raw data are better at emphasising the lack of telemetry data from certain haulout sites within the PFOSA.

2.2.3 Dive and swim speed patterns

SMRU Argos and GSM/GPS data loggers collect *individual* dive information. Each dive record includes dive duration, subsequent surface duration, a dive depth profile through time and the maximum depth. We consider here the subset of dives recorded in Deployments 1 (grey seals) and 3 (harbour seals) that occurred within the 3nm Orkney zone as representative of the behaviour likely to be found in the vicinity of wet renewable devices. We include only dives that were greater than 5 m depth, longer than 30 s. This resulted in 22,012 grey seal dives and 44,156 harbour seal dives. Each dive was assigned a value for the local water depth.

Three dive metrics are calculated. The *maximum dive depth* and the *dive duration* statistics are self explanatory. *Time at surface* is calculated on an individual dive basis as the percentage of time spent at the *surface* prior to a dive divided by this time plus the time spent in the next *dive*. It thus excludes time spent hauled out.

Speed values were based on the rate of two-dimensional movement between locations fixes. This introduces two biases. First, the greater the interval between successive fixes the greater the likelihood that the seal did not travel in a straight line between these fixes. Thus there is a tendency to *under-estimate* the real average speeds. However, when successive fixes are close in time or space the error in each of the fixes tends to *over-estimate* the distance between them and thus the real speed of the seal. Thus the speed values presented here should be taken as a general guide rather than being definitive.

3 RESULTS

3.1 Monitoring seal populations

3.1.1 Grey seal pup production in Orkney and around the Pentland Firth

Individual grey seal breeding colonies are numbered (1-28; Table 1 and Table 2) or labelled (A-E; Table 3) and their locations are shown in Figure 2 and Figure 3, the latter with a higher resolution around Orkney and the Pentland Firth. Pup production at breeding colonies in Orkney has been monitored almost continuously since the early 1960s.

The numbers of grey seal pups born at breeding colonies in Orkney between 1998 and 2008 are provided in Table 1 (original Orkney colonies) and Table 2 (newer Orkney colonies). Table 3 shows the numbers of pups born at colonies on the north and north-east mainland coast of Scotland. In 2008, 7,000 pups (37% of the Orkney total or 17% of the Scottish total) were born at Orkney colonies close to, or within the Pentland Firth (colonies highlighted in bold in Table 1 and Table 2). An additional 1,655 pups were born at colonies on the north and north-east mainland coast of Scotland, of which 300 (18%) were born at the colony at Duncansby Head and 1,100 (66%) along the coast between Helmsdale and Duncansby Head.

The grey seal breeding colonies listed in Table 1, Table 2 and Table 3 are the main colonies in the area. There are likely to be a number of small breeding colonies that are not included e.g. the south coast of Walls and the west coast of Hoy. There are other colonies from which seals are very likely to move outside the breeding season into or through the Pentland Firth including most of those in the Outer Hebrides, Shetland and along the east coast of Scotland and England.

3.1.2 Harbour and grey seal numbers in Orkney and around the Pentland Firth from August aerial surveys

The distribution of harbour seals between Rattray Head and Cape Wrath, including Orkney, from aerial surveys carried out in the Augusts of 2007 and 2008 is shown in Figure 4. A more detailed view of harbour seal distribution in Orkney and around the Pentland Firth from August 2008 is shown in Figure 5. Harbour seal numbers in Orkney and on the Scottish north coast declined dramatically between 2001 and 2008 (Lonergan *et al*. 2007; Duck and Thompson 2009). The cause(s) of this decline are not yet known.

The main moulting sites for harbour seals around the Pentland Firth are around Gills Bay by Thurso, the south-western tip of Stroma and around Scapa Flow in Orkney, in particular on Switha, Flotta, Cava, South Fara, Barrel of Butter and in Widewall Bay on South Ronaldsay. There are also large haulout groups on the north tip of Hoy and in the Bay of Ireland, just east of Stromness (Figure 5). To the south, the closest groups are south of Helmsdale, around Brora, at Loch Fleet and in the inner Moray Firth round to Findhorn (Figure 4).

In the most recent count, in August 2008, **754** harbour seals, 26% of the Orkney total (**2,867**), were counted south of the Brough of Birsay and the east side of the northern most Churchill Barrier, including Stroma. In 2001, the last count before the decline, **2,593** harbour seals were counted in the same area, 33% of the Orkney total (**7,752**). The 2008 count for the southern part of Orkney was 70% lower than the 2001 count.

Numbers of harbour seals on the north coast of Scotland, between Duncansby Head and Strathy Point, have also declined but not as severely. In August 2008, there were **83** harbour seals, mainly around Gills Bay, compared with **141** in 1997 and **101** in 2005.

Grey seal distribution during the summer months is very different to their distribution during their breeding season. The numbers of grey seals on shore are recorded during SMRU's August harbour seal surveys. In contrast to declining harbour seal numbers, grey seal numbers have not changed particularly in recent years. Grey seal distribution, from surveys in 2007 and 2008 between Rattray Head and Cape Wrath including Orkney, is shown in Figure 6 with a more detailed view of Orkney and the Pentland Firth in Figure 7. The islands and coasts in and around the Pentland Firth are heavily used by grey seals during the summer months, although their numbers can vary greatly from day to day. The most heavily used areas include the Pentland Skerries, Swona, Stroma, the south-west coast of Hoy, Flotta, Holm Sound (east of Lamb Holm), Copinsay, Bay of Skaill and the Scottish mainland coast between Duncansby Head and Dunnet Head (Figure 7). In August 2008, there were **2,390** grey seals between the Brough of Birsay and the east side of the northern-most Churchill Barrier, 30% of the Orkney total (**8,021**). There were an additional **66** grey seals on the north Scottish coast between Duncansby Head and Strathy Point, **460** on the Helmsdale coast between Dornoch and Duncansby Head and **278** between Strathy Point and Cape Wrath (Figure 6).

Grey seals haul out during the summer to rest between foraging trips. The most heavily and frequently used haul-out sites, particularly the Pentland Skerries, Copinsay, south-west Hoy and the coast around Swona and Stroma, are likely to reflect proximity to productive foraging areas.

Table 1. Pup production estimates for grey seal colonies in Orkney. Colonies in **bold** are in or close to the Pentland Firth.

YEAR	Muckle Green Holm	Little Green Holm	Little Linga	Holms of Spurness	Point of Spurness	Linga Holm	Holm of Huip	Holm of Faray	Faray	Rusk Holm	Sweyn Holm & Gairsay	Grass Holm	**Swona**	**Pentland Skerry**	Auskerry	**Switha**	**Stroma**	Calf of Eday	**Copinsay**	Stronsay	TOTAL for these islands
Colony code	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
1998	883	442	842	429		2583	1323	1675	2166	272	405	61	**1032**	**69**	123	**430**	**784**	499	**1914**	299	16231
1999	790	438	632	449		2390	1240	1399	2152	220	505	40	**957**	**62**	44	**449**	**686**	567	**1962**	271	15253
2000	898	367	704	419		2890	1347	1293	2061	191	482	22	**1005**	**60**	54	**474**	**826**	456	**2082**	362	15993
2001	1000	427	723	482		3156	1402	1291	2168	239	563	26	**1077**	**55**	58	**441**	**1019**	556	**2540**	300	17523
2002	914	373	704	442		3125	1190	1252	1955	194	486	22	**1304**	**64**	85	**446**	**1296**	612	**2403**	301	17168
2003	809	390	678	487	(10)	3240	1123	1387	2038	224	545	21	**1210**	**45**	66	**495**	**1283**	816	**2270**	359	17486
2004	736	367	692	462	(27)	3833	1284	1168	1953	169	507	17	**1159**	**54**	79	**524**	**1260**	769	**2307**	457	17797
2005	731	337	650	459	(34)	3291	1112	1110	1723	127	491	11	**1144**	**50**	144	**494**	**1331**	631	**2332**	545	16713
2006	691	277	745	449	(21)	3838	1233	1309	1839	185	500	8	**1115**	**45**	90	**553**	**1458**	649	**2385**	535	17904
2007	716	261	575	431	(8)	3832	1085	1251	2064	158	511	7	**1210**	**39**	140	**506**	**1509**	529	**2454**	521	17799
2008	658	271	649	384	(17)	3962	999	1007	1781	137	501	6	**1285**	**39**	160	**573**	**1397**	541	**2384**	547	17281

N.B. Pup numbers from the Point of Spurness are not included in the Orkney totals because this small colony is surveyed less intensively than the others listed.

Table 2. Pup production estimates for newer grey seal breeding colonies in Orkney. Colonies in **bold** are in or close to the Pentland Firth.

YEAR	Calf of Flotta	South Fara	North Flotta	South Westray	Stronsay Rothiesholm	Sule Skerry	South Ronaldsay	Hoy	Orkney Total
Colony code	21	22	23	24	25	26	27	28	
1998	**121***					15*			16367
1999	**110***	**92***				7*			15462
2000	**154***	**134***				7*			16288
2001	**250***	**155***				10*			17938
2002	**204**	**226**				10*	**344**		17952
2003	**178**	**242**	**213**	114		19	**400**		18652
2004	**226**	**257**	**239**	109		13*	**482**		19123
2005	**173**	**216**	**322**	114	71	35			17644
2006	**205**	**235**	**397**	107	97	30	**357**		19332
2007	**185**	**201**	**404**	119	89		**155**[1]		18952
2008	**201**	**236**	**403**	84	69	18*	**349**	**124***	18765

* Single counts only

[1]Incomplete count for South Ronaldsay in 2007

Table 3. Pup production estimates for grey seal breeding colonies on the far north and north-east coast of Scotland. Colonies in **bold** are in or close to the Pentland Firth.

YEAR	Loch Eriboll	Eilean nan Ron	Duncansby Head	Wick – Dunbeath	Berriedale-Helmsdale	Helmsdale Total	Total
Colony code	A	B	C	D	E	C+D+E	A-E
1998	649	262					911
1999							
2000	670	235					905
2001							
2002	675	275					950
2003	707	259					966
2004	561	256					817
2005	702	175	**336**		**690**	1026	1903
2006	524	177	**441**	**184**	**659**	1284	1985
2007	503	127	**360**	**121**	**720**	1201	1831
2008	450	107	**292**	**144**	**662**	1098	1655

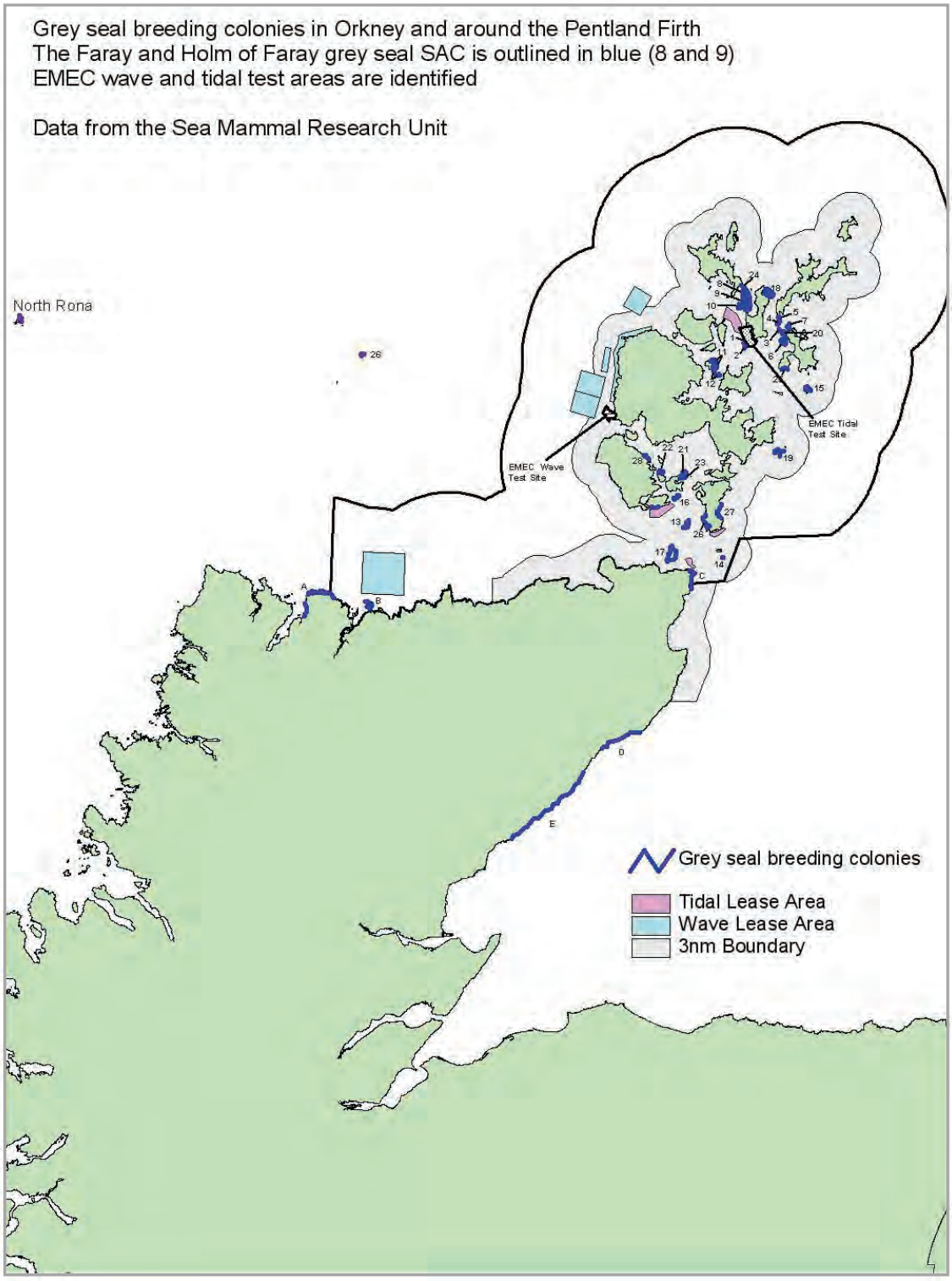

Figure 2. Grey seal breeding colonies between Rattray Head and Cape Wrath, including Orkney (for colony codes, see data from Table 1 to Table 3). The PFOSA is shown as the black line. Lease areas for wave (turquoise) and tidal (pink) development are also shown as is the Faray and Holm of Faray grey seal SAC (blue line, colonies 8 and 9).

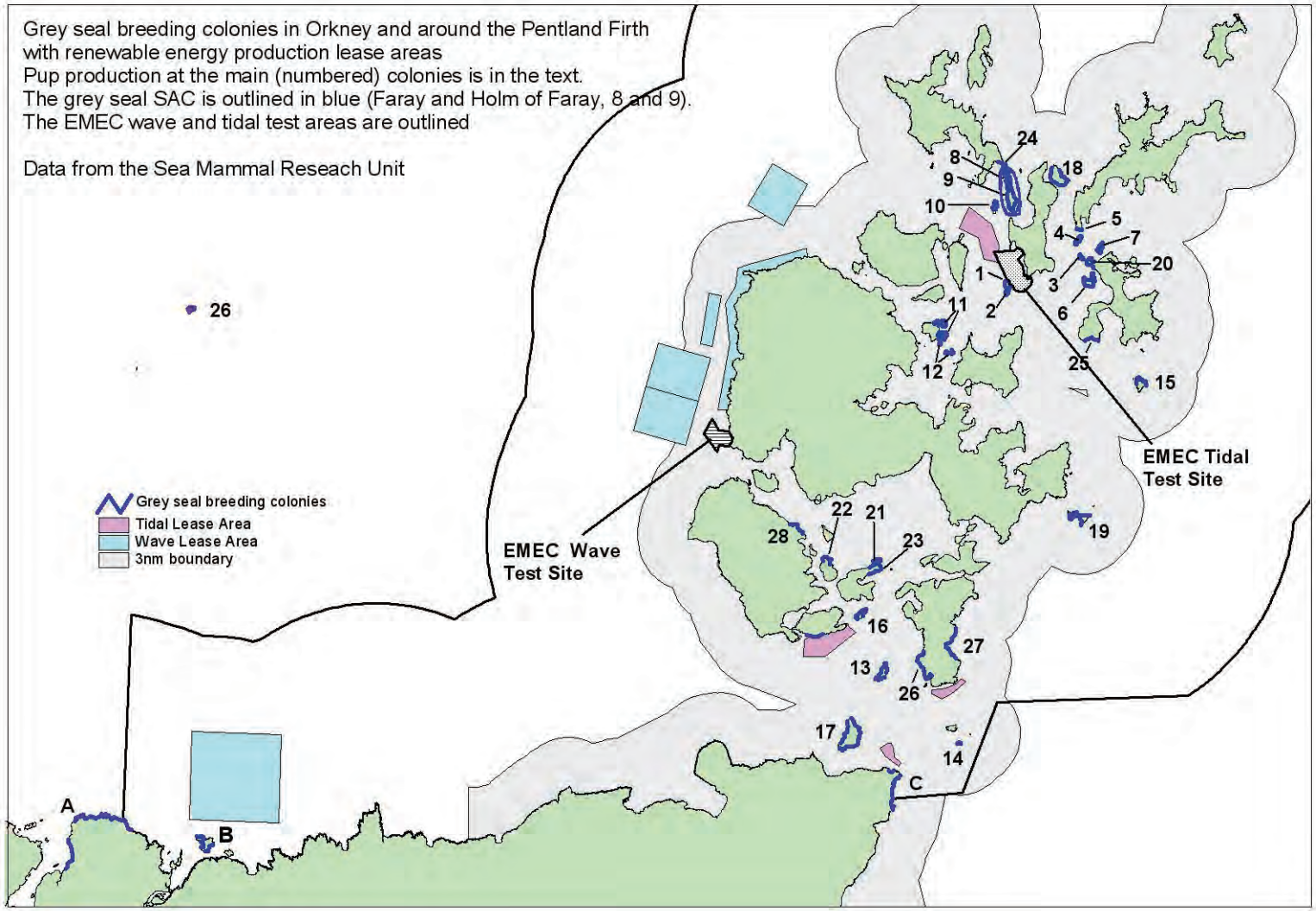

Figure 3. Grey seal breeding colonies in Orkney and around the Pentland Firth (for colony codes, see data from Table 1 to Table 3). The PFOSA is shown as the black line. Lease areas for wave (turquoise) and tidal (pink) development are also shown as is the Faray and Holm of Faray grey seal SAC (blue line, colonies 8 and 9). This figure shows the same information as the previous one but is magnified to show the Orkney region in more detail.

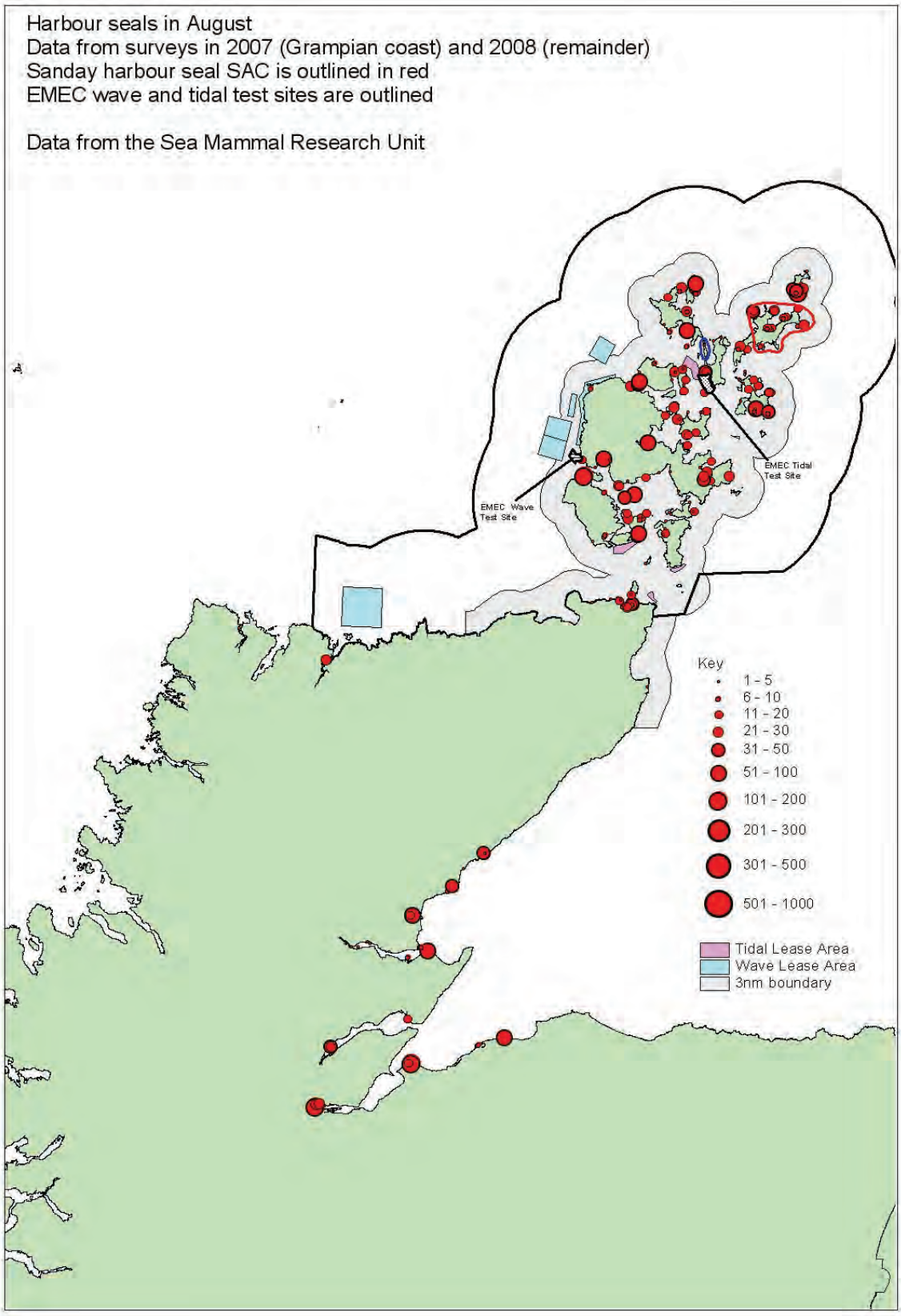

Figure 4. Harbour seal distribution between Rattray Head and Cape Wrath, including Orkney, in August 2007 and August 2008 in relation to the approximate locations of wave and tidal development lease areas. The Sanday harbour seal SAC is outlined in red.

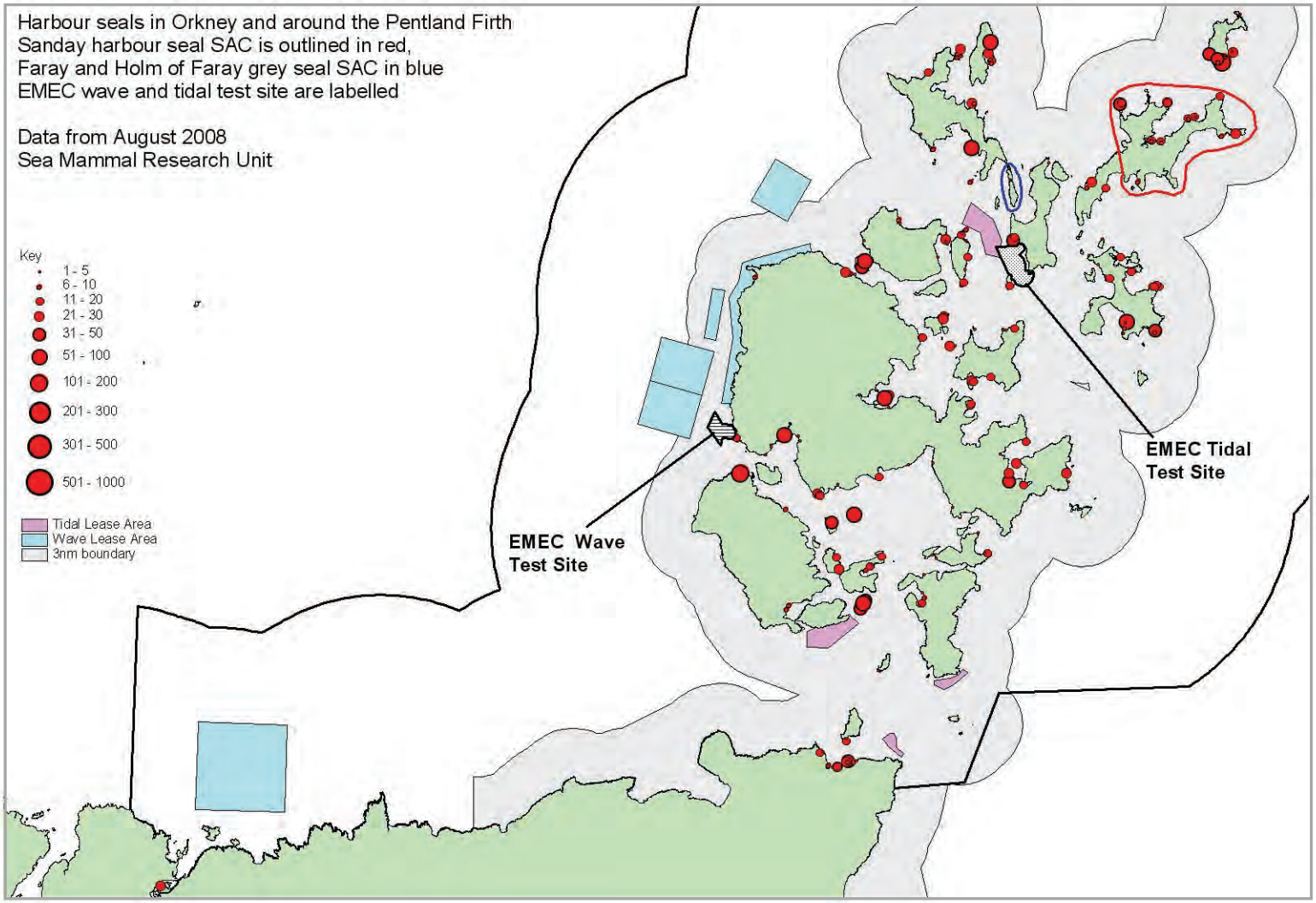

Figure 5. Harbour seal distribution in Orkney and around the Pentland Firth in August 2008 in relation to the approximate locations of wave and tidal development lease areas. The Sanday harbour seal SAC is outlined in red. This figure shows the same information as the previous one but is magnified to show the Orkney region in more detail.

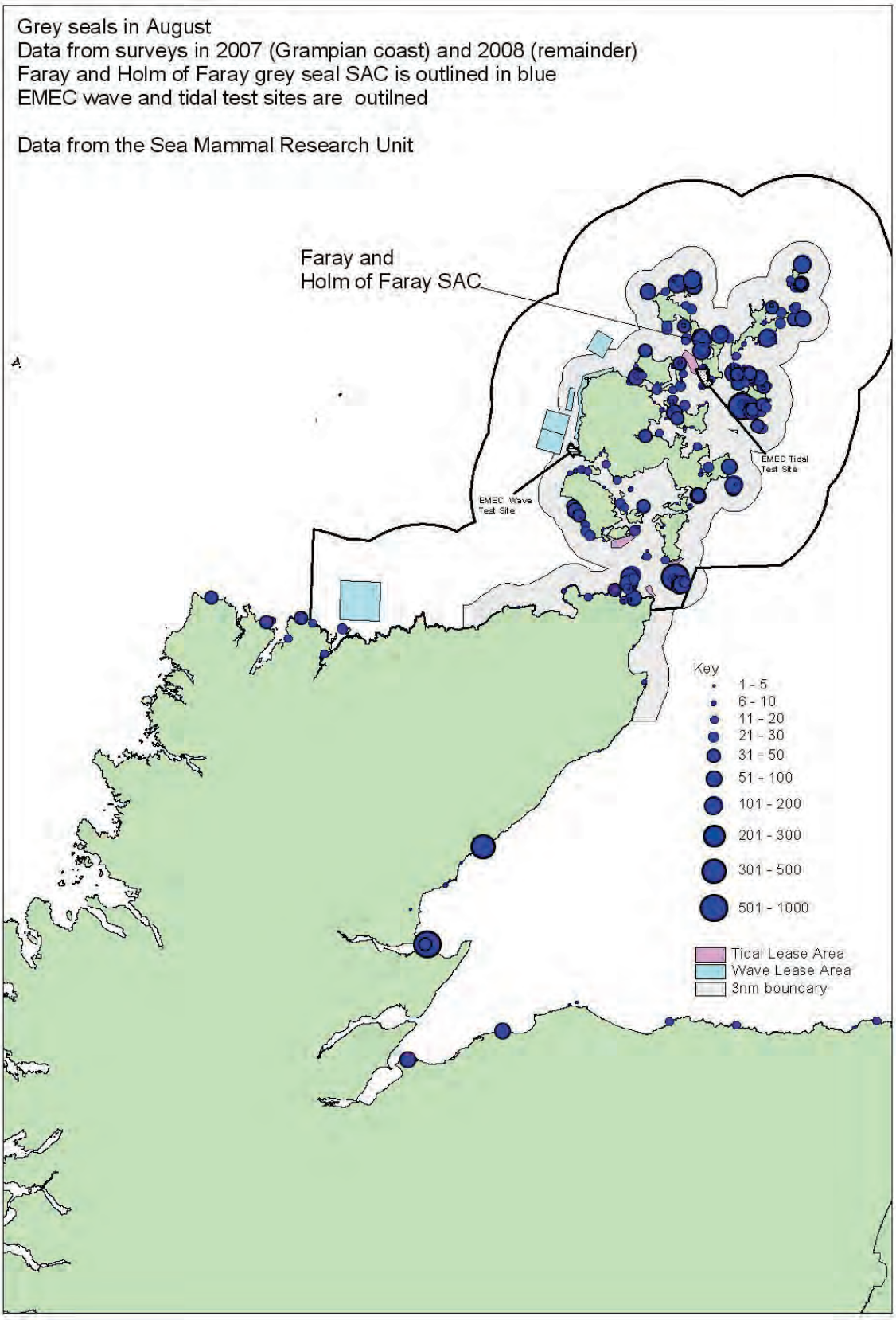

Figure 6. Grey seal distribution between Rattray Head and Cape Wrath, including Orkney, in August 2007 and August 2008 in relation to the approximate locations of wave and tidal development lease areas. The Faray and Holm of Faray grey seal SAC is labelled.

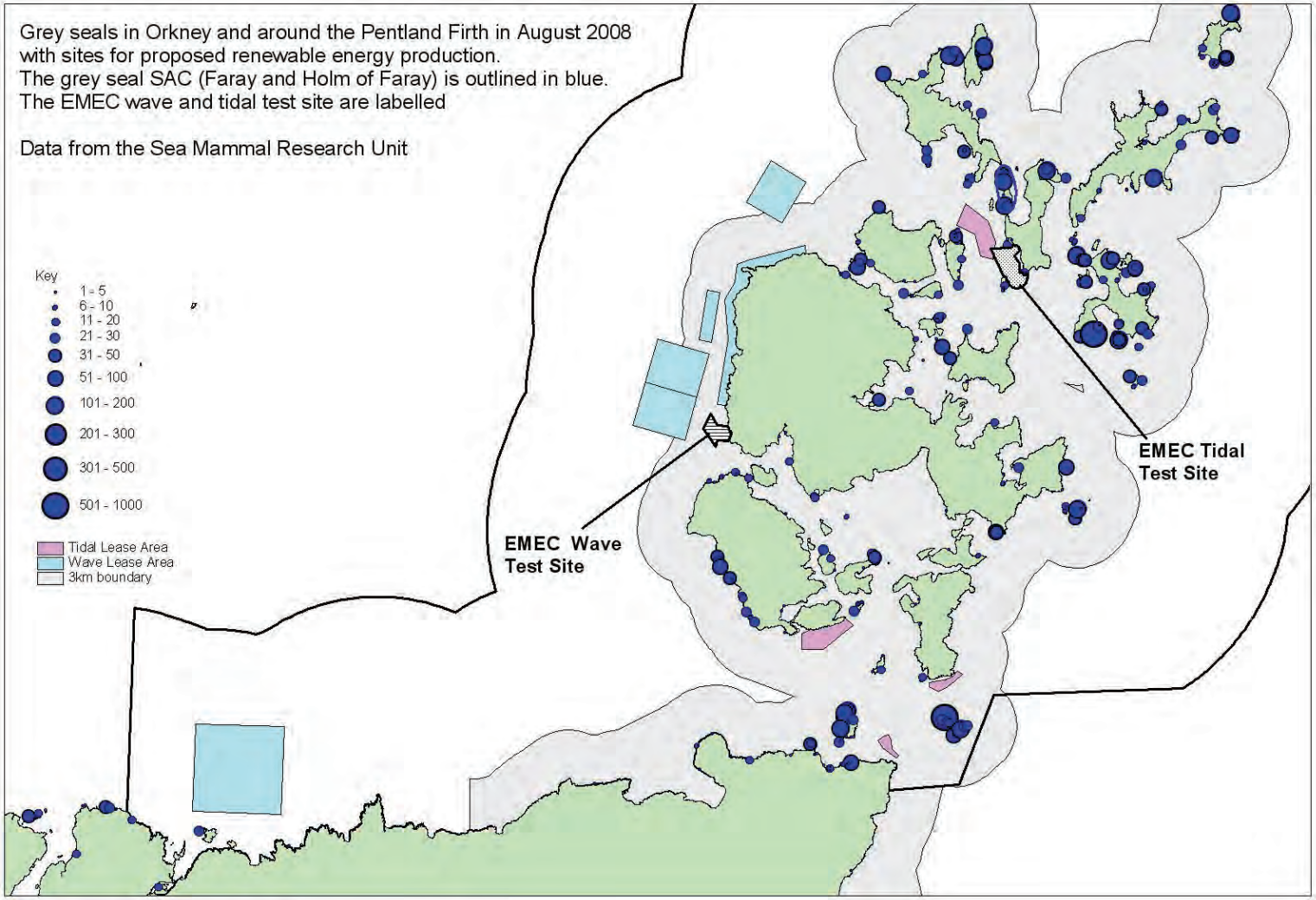

Figure 7. Grey seal distribution in Orkney and around the Pentland Firth in August 2008 in relation to the approximate locations of wave and tidal development lease areas. The Faray and Holm of Faray grey seal SAC is outlined in blue. This figure shows the same information as the previous one but is magnified to show the Orkney region in more detail.

3.2 Telemetry

3.2.1 Variability and gaps in tagging effort

Over the last 25 years, telemetry data from 212 harbour seals and 247 grey seals have been collected within the UK. In this report we consider only those 61 grey seals and 47 harbour seals whose tracks at least once entered the PFOSA (as shown in Figure 1). However, we also include all 17 adult grey seals females tagged at the next nearest SAC to the PFOSA, North Rona, in 2003.

The tag deployments are split into five Deployment Groups, based on the type of tag and nature of the study (see Table 4 for details). Details of the individual seals which were tagged are provided in the Appendices, grouped by the five Deployment Groups detailed in Table 4. It should be noted that in Deployment Group 1 only 3 of the 44 tags were SMRU GSM/GPS phone tags (see Appendix 1).

Tagging effort has relied on a variety of funding sources, and thus has been irregular from year to year.
Figure 8 shows the yearly and monthly coverage (seal days) for each of the five Deployment Groups.

It should also be noted that the tagging effort is age biased. Only four of the 61 grey seals considered here were tagged as pups. However 15 out of the 47 harbour seals considered here were tagged as pups.

Deployment Group	Tag type	Nature of study	Comments	n
1. Grey seals	SMRU Argos and SMRU GSM/GPS tag	General foraging ecology	The bulk of the data were collected in 1997 and extended mainly from June to November.	44
2. North Rona grey seals	WC Argos SPOT tag	At-sea associations of individuals	A one-off project where breeding female grey seals were tagged in October 2003. All tags detached due to the moult in January.	17
3. Harbour seals	SMRU Argos tag	General foraging ecology	The bulk of the data were collected in 2003-4 and excluded the breeding/moult (and census) period of June-September.	17
4. Harbour seals	WC Argos flipper tag	Haulout behaviour over the moult period (August)	A one-off project in 2009 targeting the moult period, but extending to the end of the year.	15
5. Harbour seal pups	WC Argos SPOT tag	Pup survival	A one-off project in 2007, extending from newly-weaned pups in June/July to the end of the year.	15

Table 4. Details of the five Deployment Groups, based on the type of tag and nature of the study.

3.2.2 Maps with track locations

We present a series of maps that illustrate the tracks of seals in the vicinity of the PFOSA. Each set of tracks is presented at two geographical scales and shows the PFOSA, the 3 nautical mile buffer zone and the appropriate SAC boundaries. The Figures are grouped by Deployment Groups one through five.

1. Grey seals – SMRU Argos and SMRU GSM/GPS tag (Figure 9 with a more detailed view of Orkney and the Pentland Firth shown in Figure 10)

The major feature of these tracks is that they show that grey seals are capable of moving over large distances. Seals that entered the PFOSA were tagged at Abertay (10), the Farnes (4), the Inner Hebrides (1), Isle of May (2), Monachs (5), Moray Firth (2), Shetland (3) and Orkney (17). There was a high density of tracks (from Abertay-caught seals) at Stroma in the Pentland Firth. However there was not total regional mixing and seals that were tagged in Orkney had a higher likelihood of being within the PFOSA (and thus also the 3 nm zone). Note that most of the tracks were collected outside the breeding season (see Figure 8) when there is a high degree of site fidelity from year to year.

2. Grey seals – WC Argos SPOT tag (Figure 11 with a more detailed view of Orkney and the Pentland Firth shown in Figure 12)

These 17 post-breeding grey seals females showed rapid dispersal from the capture site of North Rona. The direction of dispersal was variable but most (14) travelled eastwards, of which 13 hauled out at Sule Skerry (midway between North Rona and Orkney). Two of these Sule Skerry seals entered the PFOSA but none entered the 3nm zone. However since the 17 tagged animals represent a small proportion of the c. 900 breeding females, and because the average tag duration was only 50 days (due to moult detachment), it is likely that a significant number of North Rona breeding females (and probably males) do haul out within the PFOSA and utilise at sea areas shown in Figure 9 and Figure 10. Indeed it is quite likely that some of the 44 seals tagged outside the breeding season in Figure 9 and Figure 10 bred at North Rona.

3. Harbour seals – SMRU Argos tag (Figure 13 with a more detailed view of Orkney and the Pentland Firth shown in Figure 14)

Compared to the grey seal tracks shown in Figure 9 and Figure 10, the movements of the 17 harbour seals were more local. There were only three examples of distant movement – two seals tagged in the Moray Firth that travelled within the PFOSA and one tagged in Orkney that travelled twice to Yell Sound in Shetland. Foraging was generally within 20km of the departure haulout sites and there was little movement between haulout regions within the Orkney Isles.

4. Harbour seals – WC Argos flipper tag (Figure 15 with a more detailed view of Orkney and the Pentland Firth shown in Figure 16)

The pattern of restricted movements of adult harbour seals between haulout regions was also shown by the Argos flipper tags deployed during the moult period. Note that this tag type did not produce locations at sea.

5. Harbour seals – WC Argos SPOT tag (Figure 17 with a more detailed view of Orkney and the Pentland Firth shown in Figure 18)

In contrast to adults, harbour seals pups (13 tagged at Stronsay and two at Scapa Flow) showed more extensive movement. Eight of the 15 either visited or relocated to Shetland. Three moved westwards past Cape Wrath. Again in contrast to adults, the pups showed little persistent fidelity to any at-sea location. Many of the offshore trips were meandering and up to 200km off shore.

3.2.3 Movements relating to SACs

Three SACs are considered: North Rona (grey seals), Faray and Holm of Faray (grey seals) and Sanday (harbour seals).

The general pattern of grey seal movement outside the breeding season (shown in Figure 9 and Figure 10) is that grey seals may travel large distances between haulout regions. Thus those grey seals that haul out at, say, Faray and Holm of Faray, may not breed there.

The movements of the grey seals tagged with WC Argos tags at the North Rona SAC have been described above.

We considered the data derived from SMRU Argos or SMRU GSM/GPS tags for the two Orkney SACs in a different way. Trips (defined in the Methods section above) were assigned to the departure/arrival haulout sites. All trips that started or ended at a haulout site within an SAC were selected. These ('first order') trips are show in red in Figure 19 for grey seals at Faray and Holm of Faray (with a more detailed view of Orkney and the Pentland Firth shown in Figure 20) and Figure 21 for harbour seals at Sanday (with a more detailed view of Orkney and the Pentland Firth shown in Figure 22). However seals (grey seals in particular) can move from one haulout site/region to another. Thus to consider the at-sea usage of seals that, at least once, haul out within an SAC we should consider all other haulout sites that such seals would be likely to visit. Quantifying this network of haulout site connectivity is beyond the scope of this report. However in Figure 19 to Figure 22 we also include trips (in blue) that are one 'trip jump' from the relevant SAC. For example, if a seal hauled out at haulout A (outside an SAC) and next hauled out (after a 'trip') within an SAC we would term haulout A as being one 'trip jump' from the SAC. In the description of trip durations and extents below we present medians rather than means due to the highly left skewed nature of the frequency distributions.

Figure 19 and Figure 20 emphasise the large extents of first and second order trips for grey seals to and from the Faray and Holm of Faray SAC. Indeed one trip started at the Monachs SAC, skirted the North Rona SAC and ended at the Faray and Holm of Faray SAC. The major finding is that the range of a grey seal may extend large distances from any one of its haulout sites. This large range is also shown in the post-breeding dispersal of grey seals from North Rona (Figure 11 and Figure 12). Of local interest is the fact that the Pentland Firth was frequently used in second order trips from Faray and Holm of Faray. The median trip duration was 8.5h (6.0 – 20.0h 25% and 75% quantiles) and the median trip extent[8] was 9.9km (4.3 – 22.4km 25% and 75% quantiles).

Figure 21 and Figure 22 show the first and second order trips for harbour seals to and from the Sanday SAC. Most first order trips were to the north and east of Sanday and within the PFOSA. However, there were two examples of connectivity with haulouts in Yell Sound, Shetland. The median trip duration was 23.0h (15.2 – 44.0h 25% and 75% quantiles) and the median trip extent was 3.2km (1.8 – 8.9km 25% and 75% quantiles).

3.2.4 Dive and swim speed patterns

Four dive and movement parameters have been calculated and are shown in Table 5, Figure 27 and Figure 28. Note that in Figure 28, *max dive depth*, *dive duration* and *surface duration* values are discontinuous. This is due to a data transmission rounding system that was used on the earlier SRDLs and no bias is introduced.

[8] The *extent* is the maximum distance from the departure haulout within a *trip.*

The maximum dive depth is first expressed in actual depth (m). We also plot dive depth against the local depth of the sea. This is an attempt to characterise the maximum dive depth in relation to the water column (e.g. epi-benthic foraging) independently of actual water depth. However, the plots in both Figure 27 and Figure 28 show many impossible dives (above the red line) where the maximum dive depth was greater than the depth of the sea. This is due to the error in locating dives from the track data accurately – especially near-shore where generally there is a more rapid rate of change of depth. However both species dived to depths of up to 100 m and the mean maximum depths were similar for both species (grey seals 29.83m and harbour seals 30.91m).

Dive durations were variable within species, but the mean durations were similar (grey seals 3.82 min and harbour seals 4.14 min). One grey seal carried out an exceptionally long dive of 35.91 min.

The plots of dive duration against surface duration indicate that there is no simple relationship between the two parameters. The grey seals showed a significant number of surface periods longer than 10 minutes. It is likely that such large durations were behavioural choice, rather than just for the physiological requirement of gas exchange in readiness for the next dive. These longer grey seal surface periods are evident in the histograms of percentage *of time at the surface* and are reflected in the respective mean values (grey seals 27.09 min, harbour seals 18.32 min).

The speed values are subject to the biases discussed in the Methods section. Nevertheless speeds were greater for grey seals than for harbour seals (grey 75%ile 0.77 m/s; harbour 75%ile 0.14 m/s).

	Grey seals				Harbour seals			
	25%ile	Median	Mean	75%ile	25%ile	Median	Mean	75%ile
Max dive depth (m)	9.57	21.10	29.83	46.3	17.00	29.00	30.91	41.00
Dive duration (min)	2.20	3.48	3.82	5.13	3.20	4.0	4.14	4.8
Time at surface (%)	16.43	20.60	27.09	29.21	13.16	16.28	18.32	88.57
Speed (m/s)	0.16	0.38	0.54	0.77	0.01	0.04	0.11	0.14

Table 5. Dive and movement values for grey and harbour seals.

3.3 Aerial counts and telemetry

Figure 23 and Figure 24 show the haulout counts (shown previously in Figure 4 to Figure 7) overlaid on the tracks of grey and harbour seals (fitted with non-WC tags; shown previously in Figure 9, Figure 10, Figure 13 and Figure 14). Note that the counts refer just to the *August* aerial survey counts.

Since grey seals travel frequently between haulout sites and regions, most of the major haulout sites are well represented by trips from these sites (Figure 23). However the situation is very different for harbour seals (Figure 24). Since they travel less, and most of the tagging effort was in the Northern Isles, trips from the Southern Isles and the Pentland Firth haulout sites are hardly represented at all. However, just considering the data that are available, we do note that the licensed area to the west of Rousay overlaps with the route taken by animals foraging further offshore to the west of Orkney (having passed through Eynhallow Sound).

3.4 Seal locations and tidal current

In Figure 25 and Figure 26 we show all the location fixes of grey and harbour seals, respectively, overlaid onto the magnitude of tidal currents[9]. Tidal energy data were obtained from the Department Of Energy and Climate Change and are Crown Copyright (all rights reserved 2008). The units presented are peak current speed of a Mean Spring tide (m/s). The dominant tidal current is within the Pentland Firth. Lesser current hotspots occur in Stromness Sound, Eynhallow Sound, to the west of Eday, between Sanday and North Ronaldsay, and to the north of North Ronaldsay.

The major overlap between grey seals and high tidal current sites appears to be around Stroma and the Pentland Skerries where there are large numbers of grey seals hauled out and consequent local high usage at-sea.

The situation may be similar in the Pentland Firth for harbour seals but there are insufficient telemetry data from local haulout sites in order to be able to evaluate this.

[9] Note that these locations are a biased representation of seal usage since trips are not weighted by the counts of seals at the departure haulout site (such bias is removed in *modelled* usage). However they do represent the actual usage of a *sample* of seals.

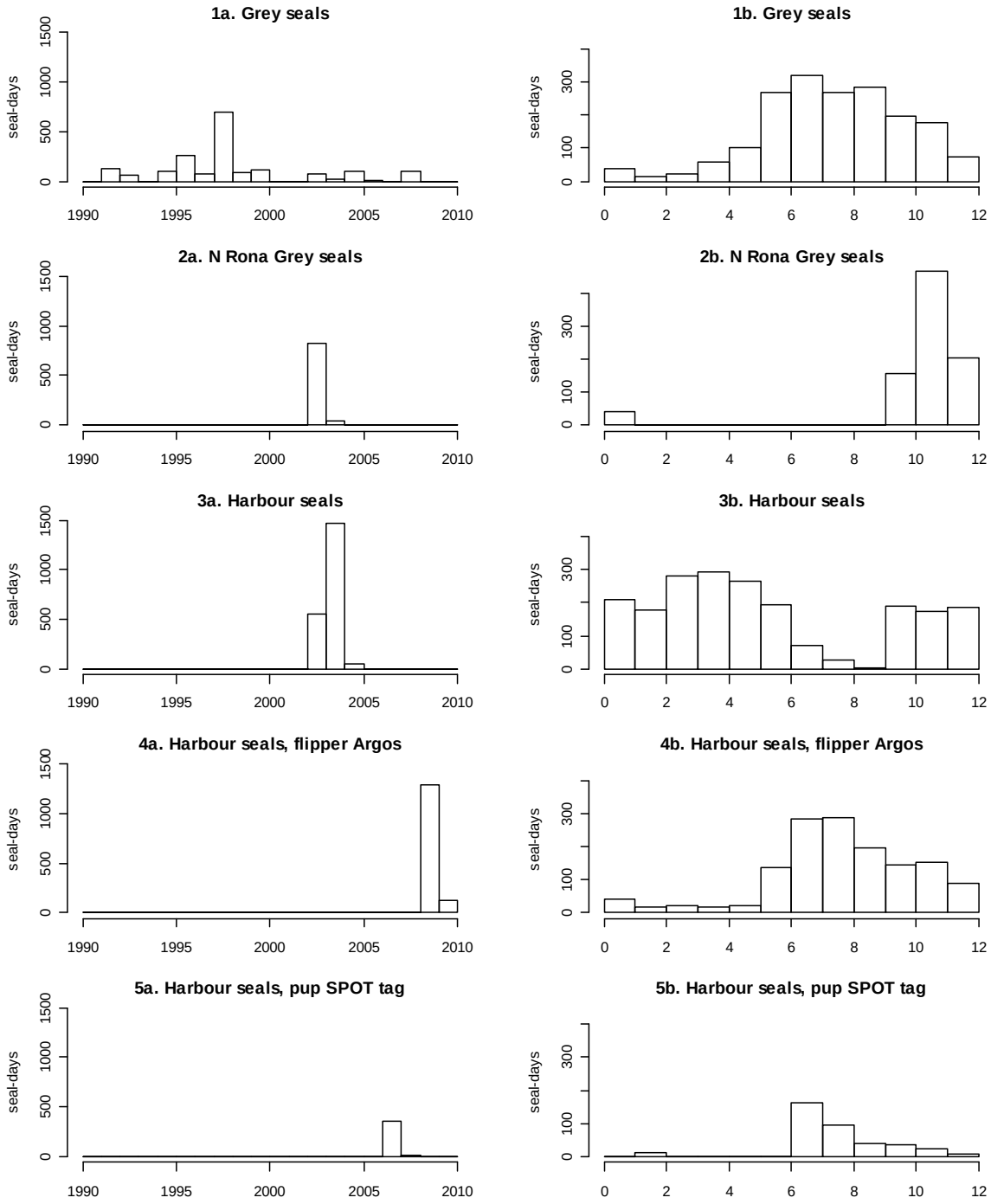

Figure 8. Histograms showing yearly (left) and monthly (right; first bar is January and so on) coverage for each of the five Deployment Groups.

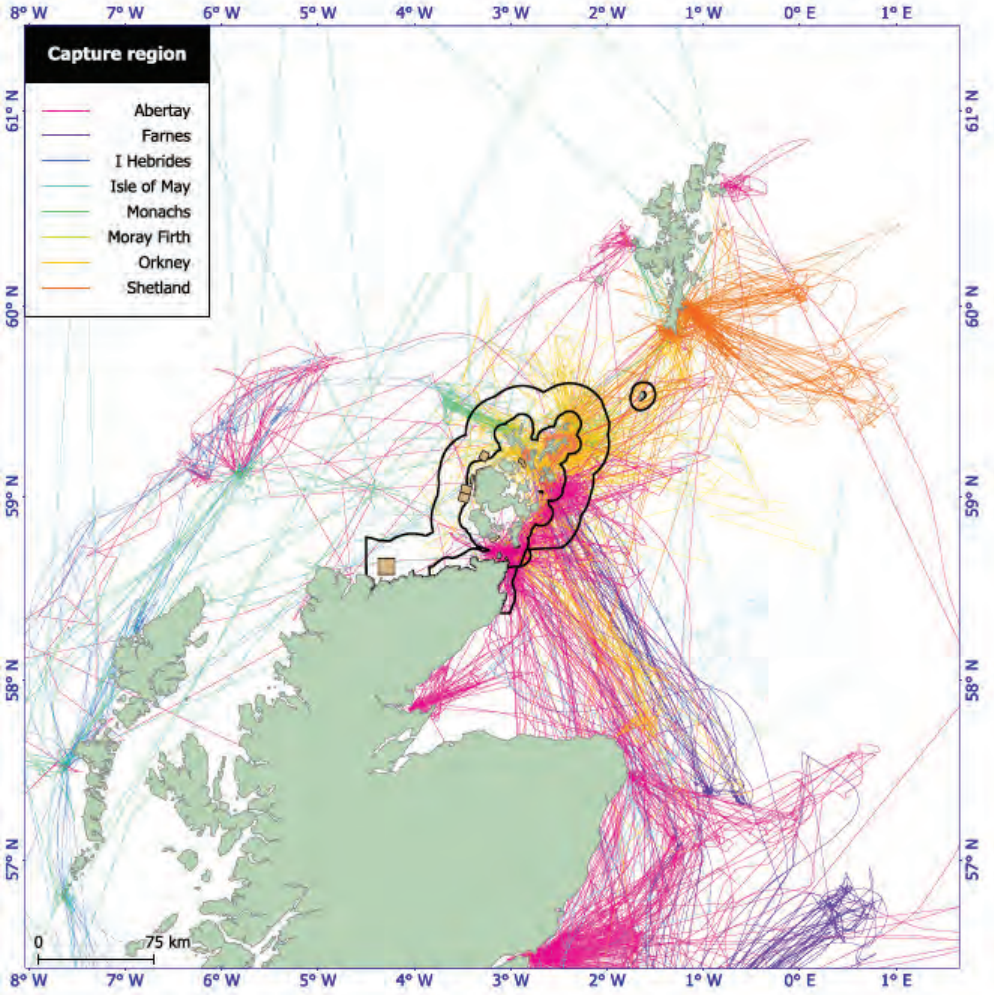

Figure 9. 44 grey seals tagged with SMRU Argos and SMRU GSM/GPS tags which at least once entered the PFOSA. Note that this excludes the grey seals tagged at North Rona (Figure 11 and Figure 12). The tracks are colour coded by capture region (see legend).

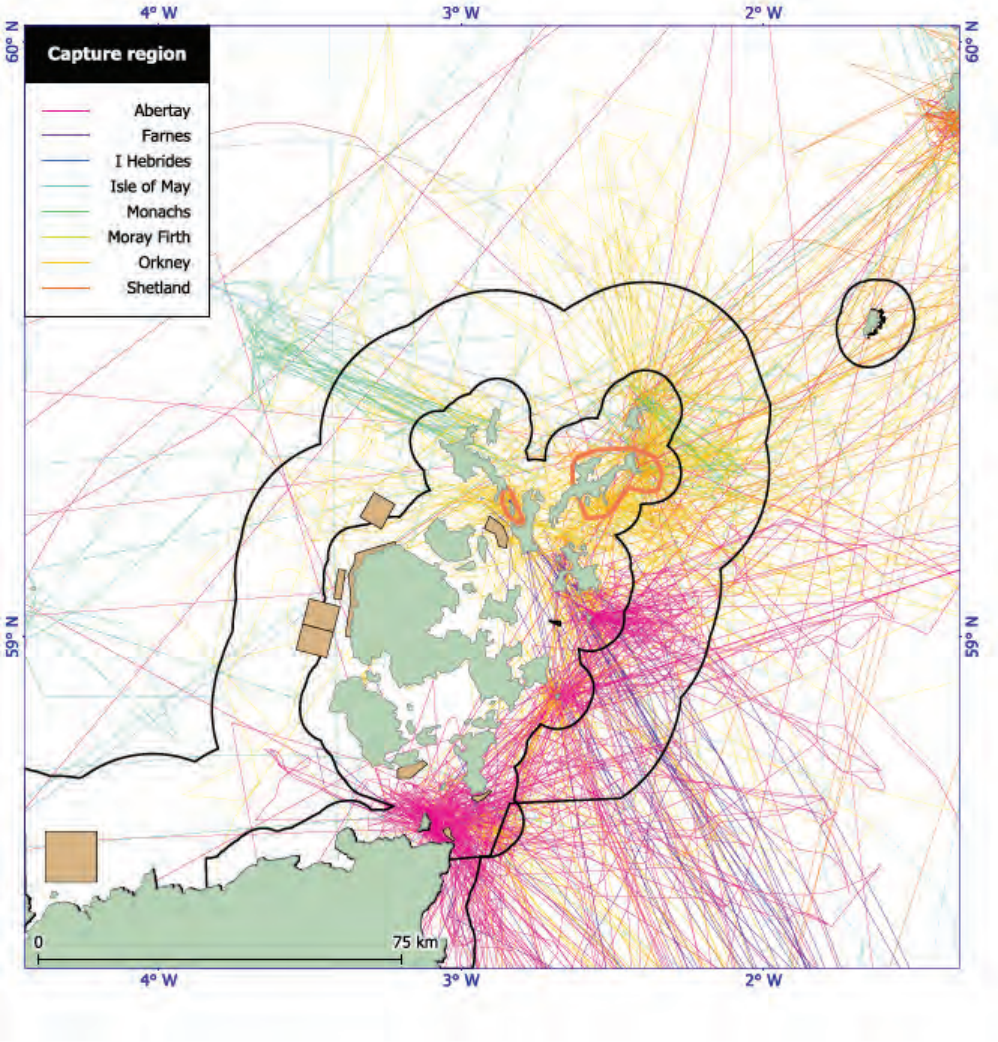

Figure 10. 44 grey seals tagged with SMRU Argos and SMRU GSM/GPS tags which at least once entered the PFOSA. Note that this excludes the grey seals tagged at North Rona (Figure 11 and Figure 12). The tracks are colour coded by capture region (see legend). This figure shows the same information as the previous one but is magnified to show the Orkney region in more detail.

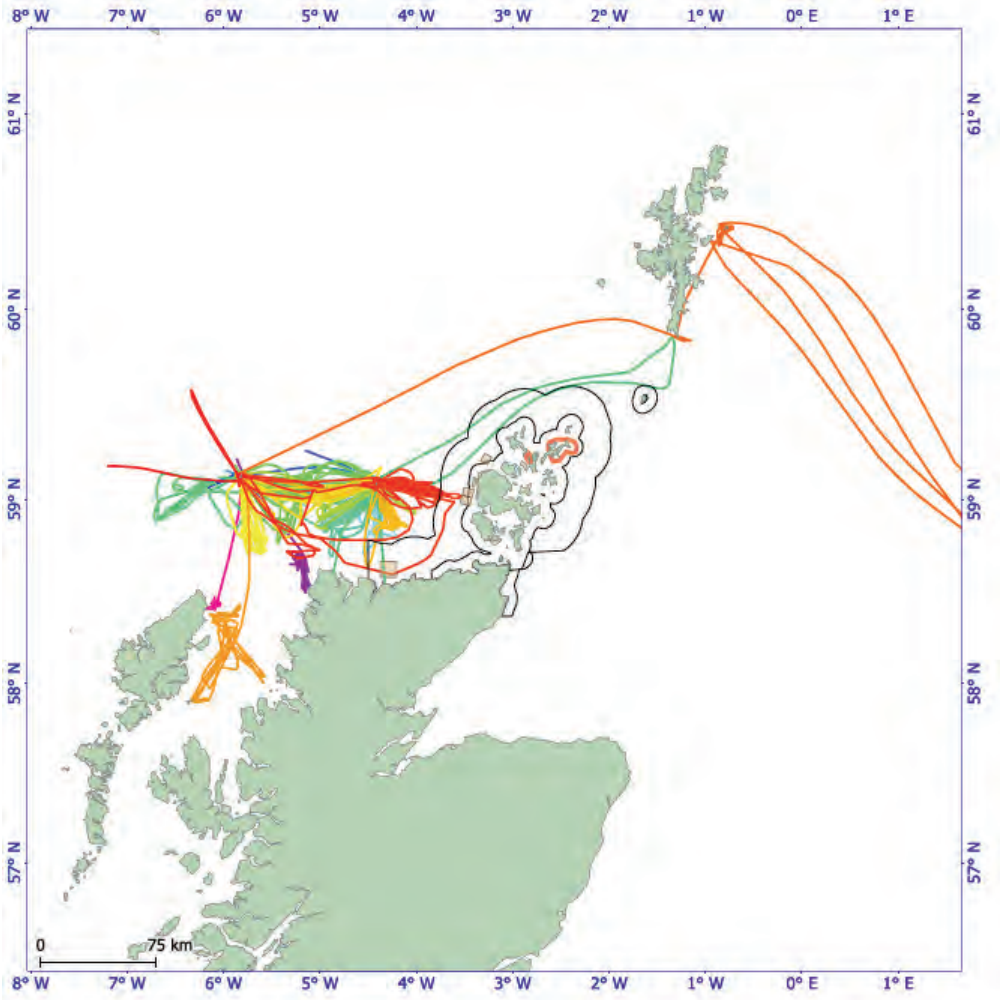

Figure 11. Grey seals tagged with Wildlife Computers Argos SPOT tags at North Rona. Colour coded by individual seal.

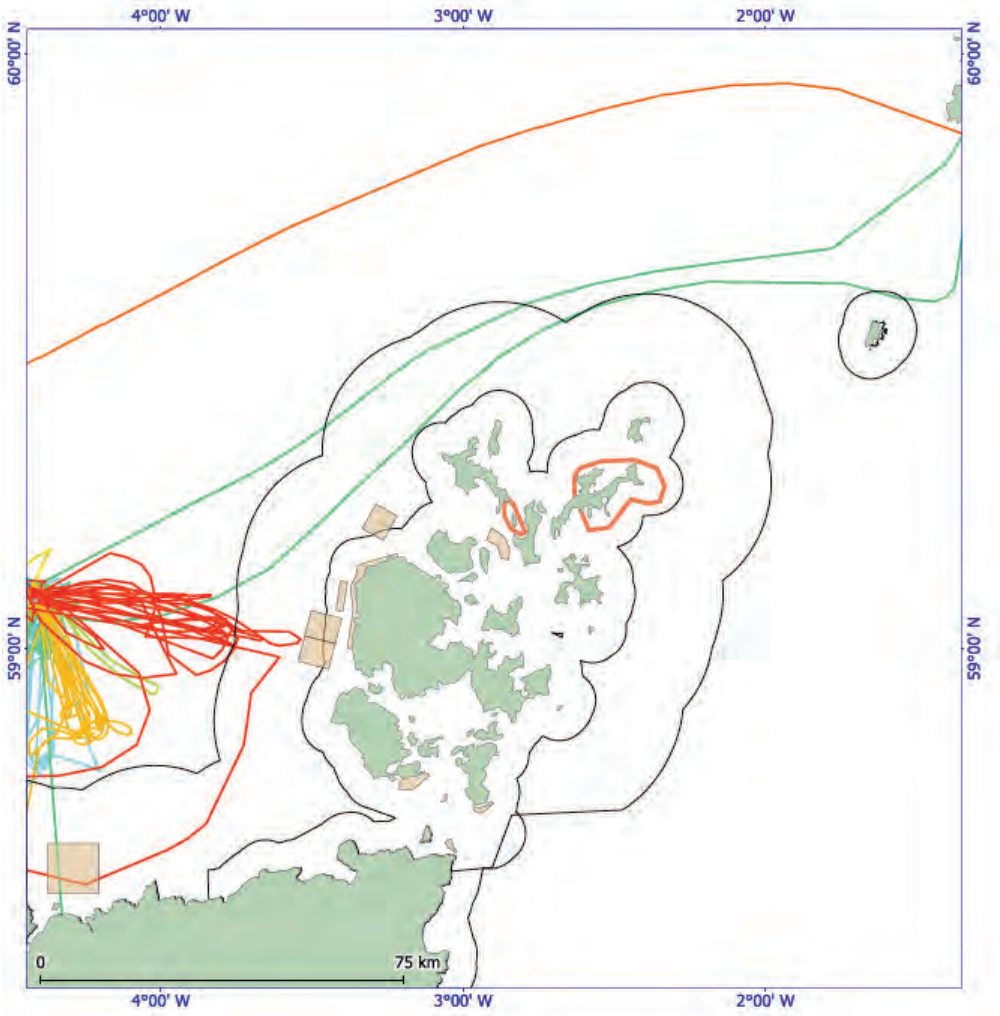

Figure 12. Grey seals tagged with Wildlife Computers Argos SPOT tags at North Rona. Colour coded by individual seal. This figure shows the same information as the previous one but is magnified to show the Orkney region in more detail.

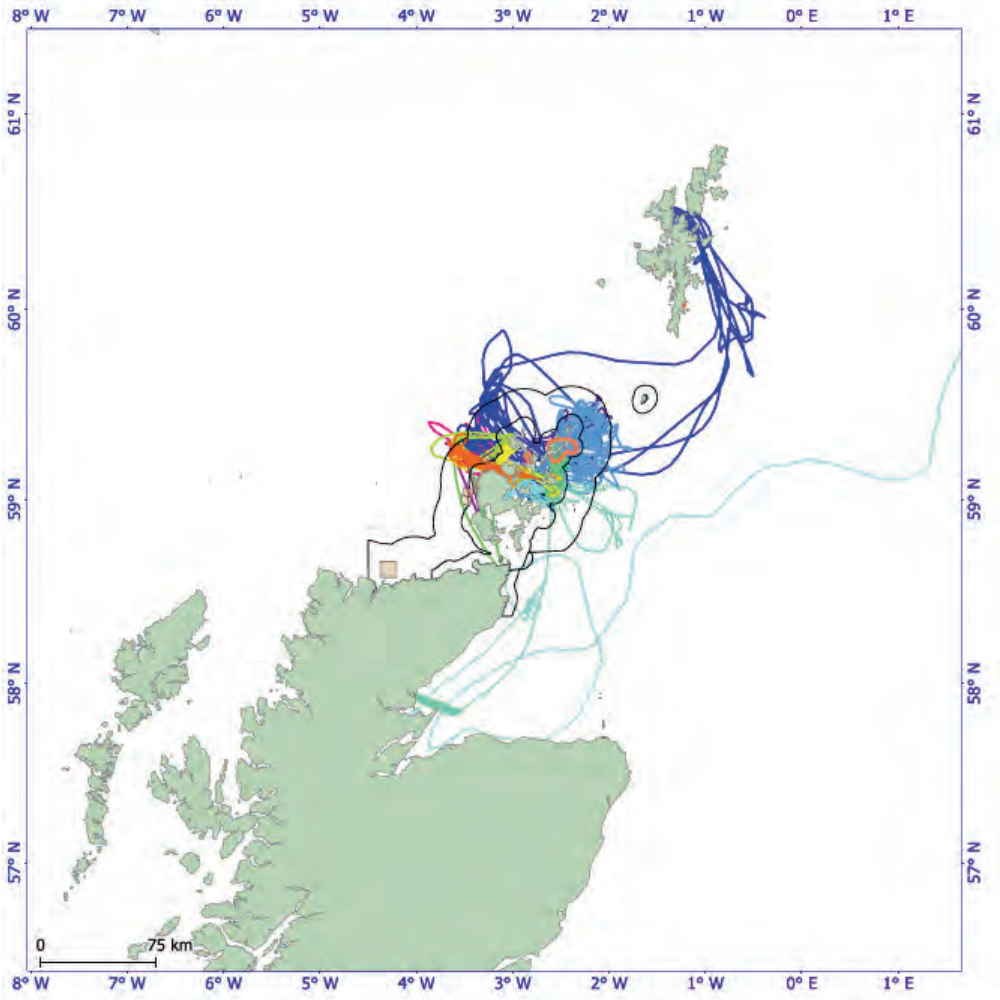

Figure 13. 17 harbour seals tagged with SMRU Argos tags, which at least once entered the PFOSA. The tracks are colour coded by individual seal. All but two of the seals were tagged in the northern Isles (Sanday, Eynhallow, Rousay and Stronsay of Orkney). The remaining two (show by triangles) were tagged in the Moray Firth.

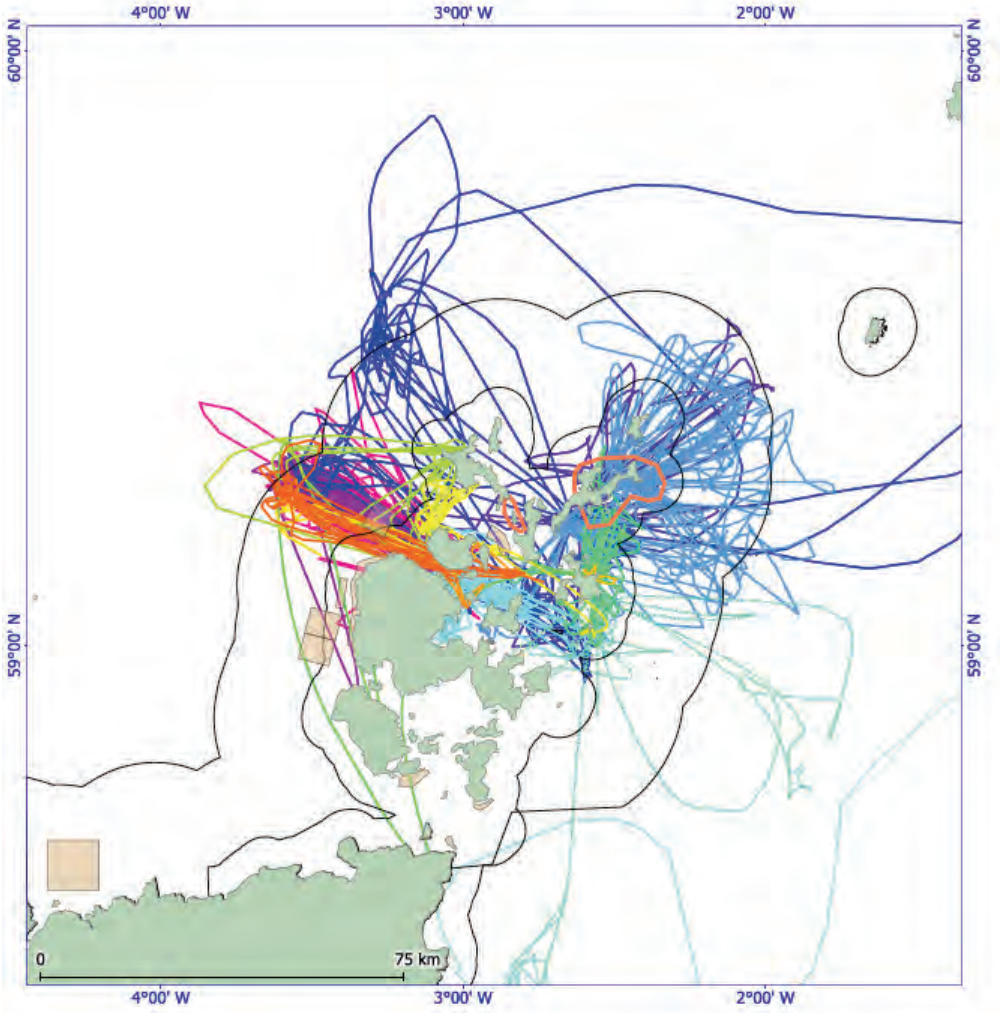

Figure 14. 17 harbour seals tagged with SMRU Argos tags, which at least once entered the PFOSA. The tracks are colour coded by individual seal. All but two of the seals were tagged in the northern Isles (Sanday, Eynhallow, Rousay and Stronsay of Orkney). The remaining two (show by triangles) were tagged in the Moray Firth. This figure shows the same information as the previous one but is magnified to show the Orkney region in more detail.

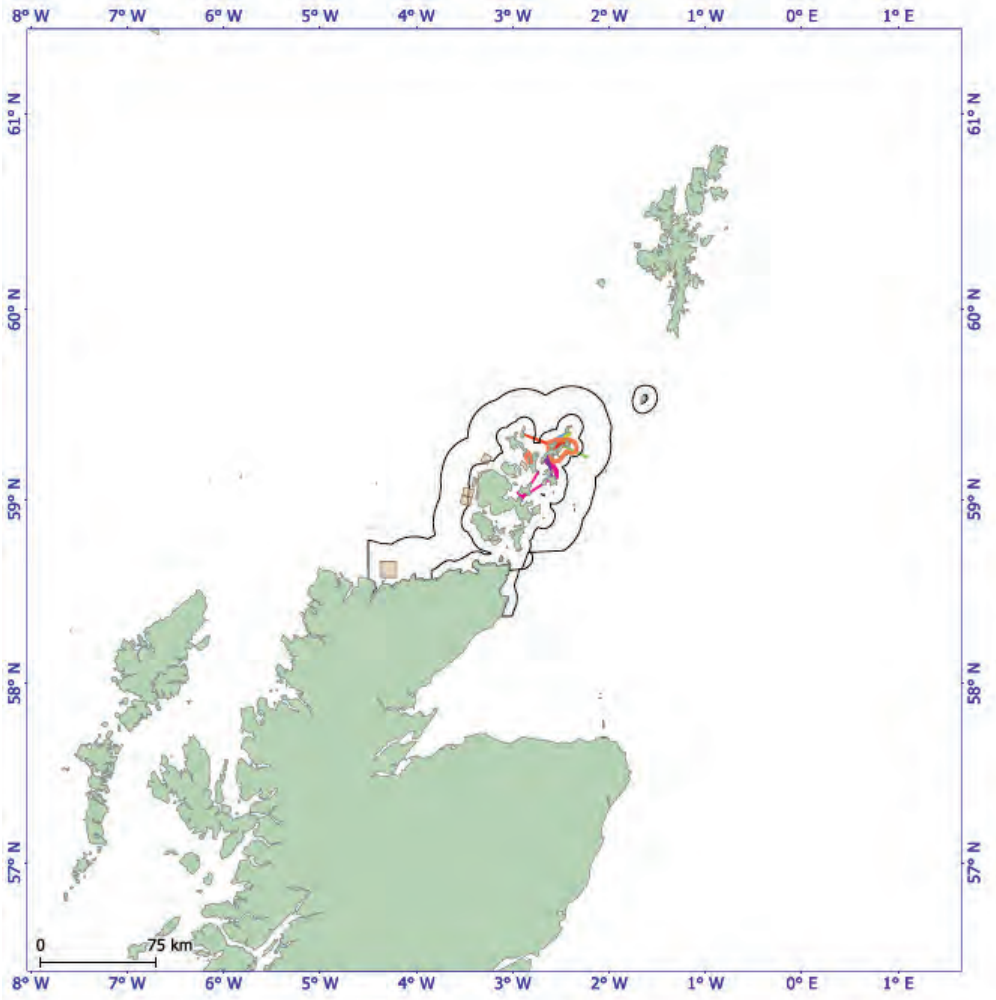

Figure 15. Tracks of the 15 adult harbour seals fitted with WC Argos flipper tags at Sanday, Orkney. The tracks are colour coded by individual seal.

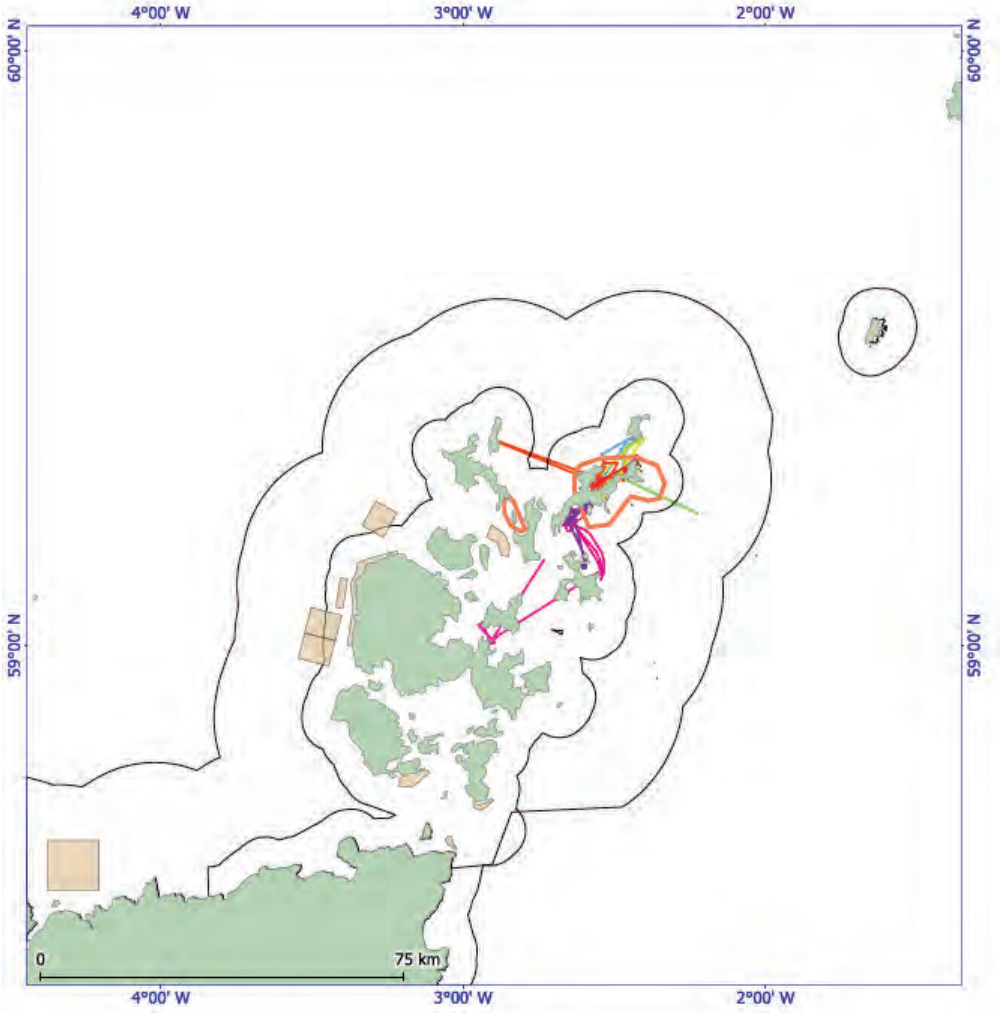

Figure 16. Tracks of the 15 adult harbour seals fitted with WC Argos flipper tags at Sanday, Orkney. The tracks are colour coded by individual seal. This figure shows the same information as the previous one but is magnified to show the Orkney region in more detail.

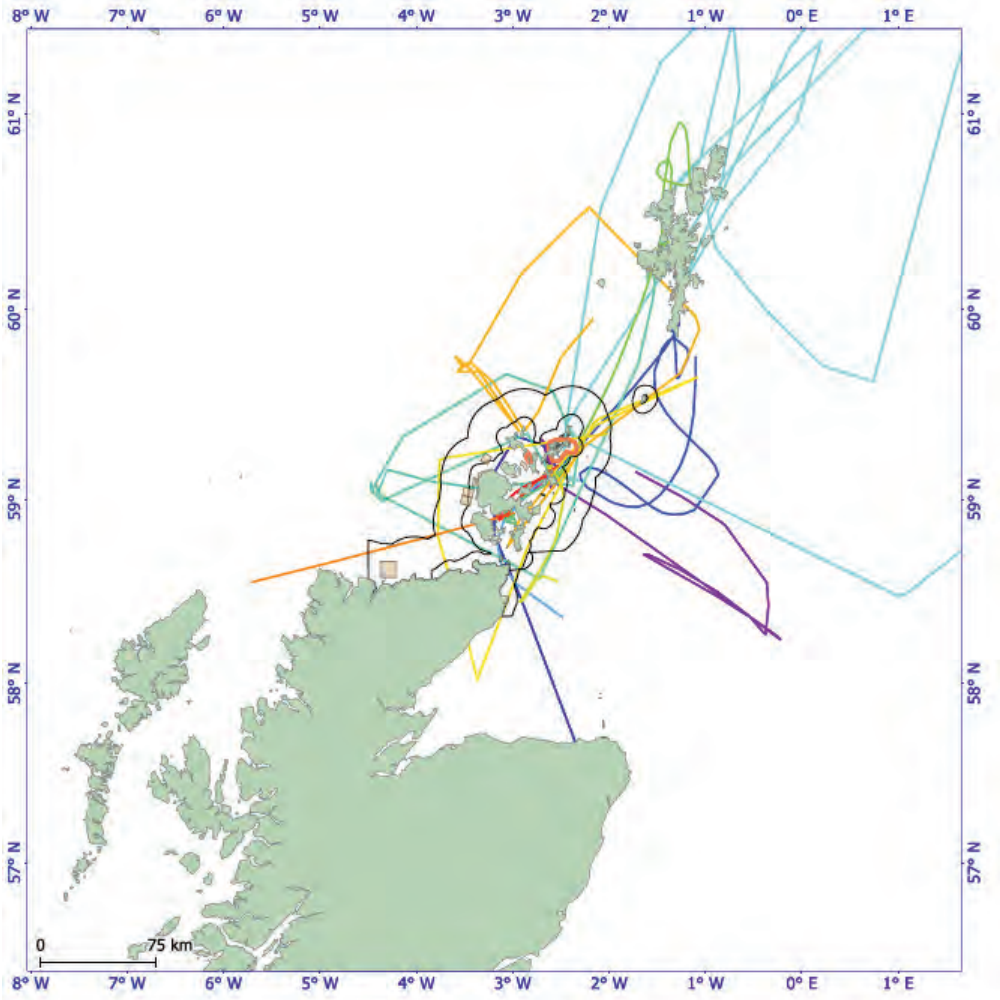

Figure 17. Tracks of 15 female harbour seal pups fitted with WC Argos SPOT tags in Orkney. The tracks are colour coded by individual seal.

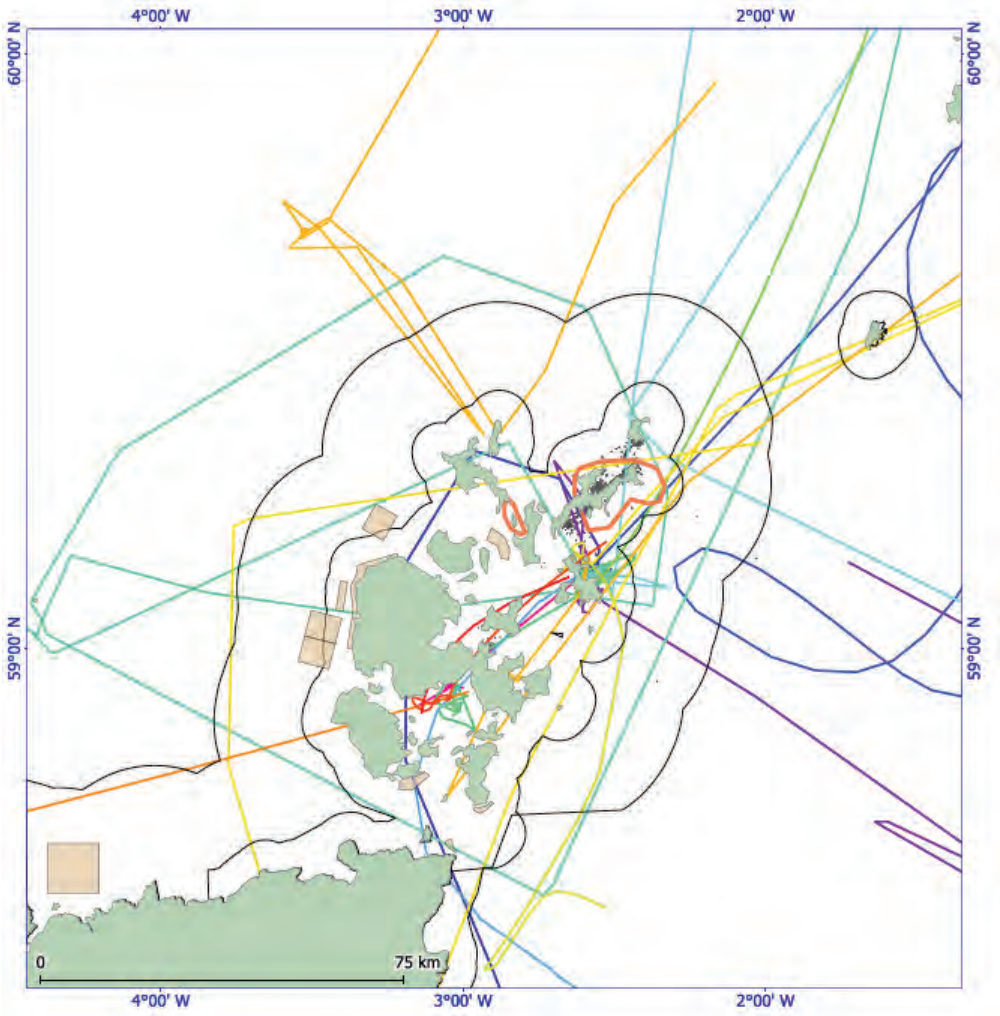

Figure 18. Tracks of 15 female harbour seal pups fitted with WC Argos SPOT tags in Orkney. The tracks are colour coded by individual seal. This figure shows the same information as the previous one but is magnified to show the Orkney region in more detail.

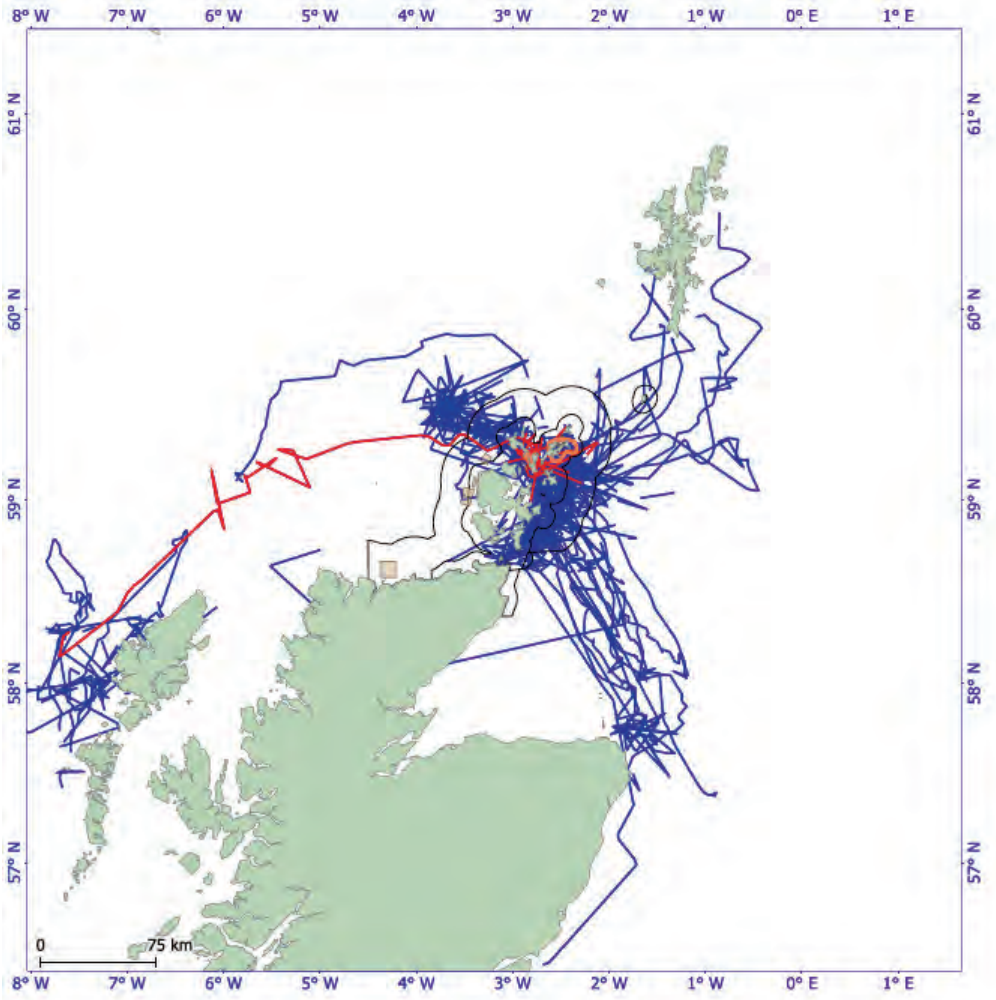

Figure 19. Grey seal trips departing from, or arriving at, the Faray and Holm of Faray SAC are shown in red. Trips departing from, or arriving at, haulout sites that are connected by only one trip from this SAC are shown in blue.

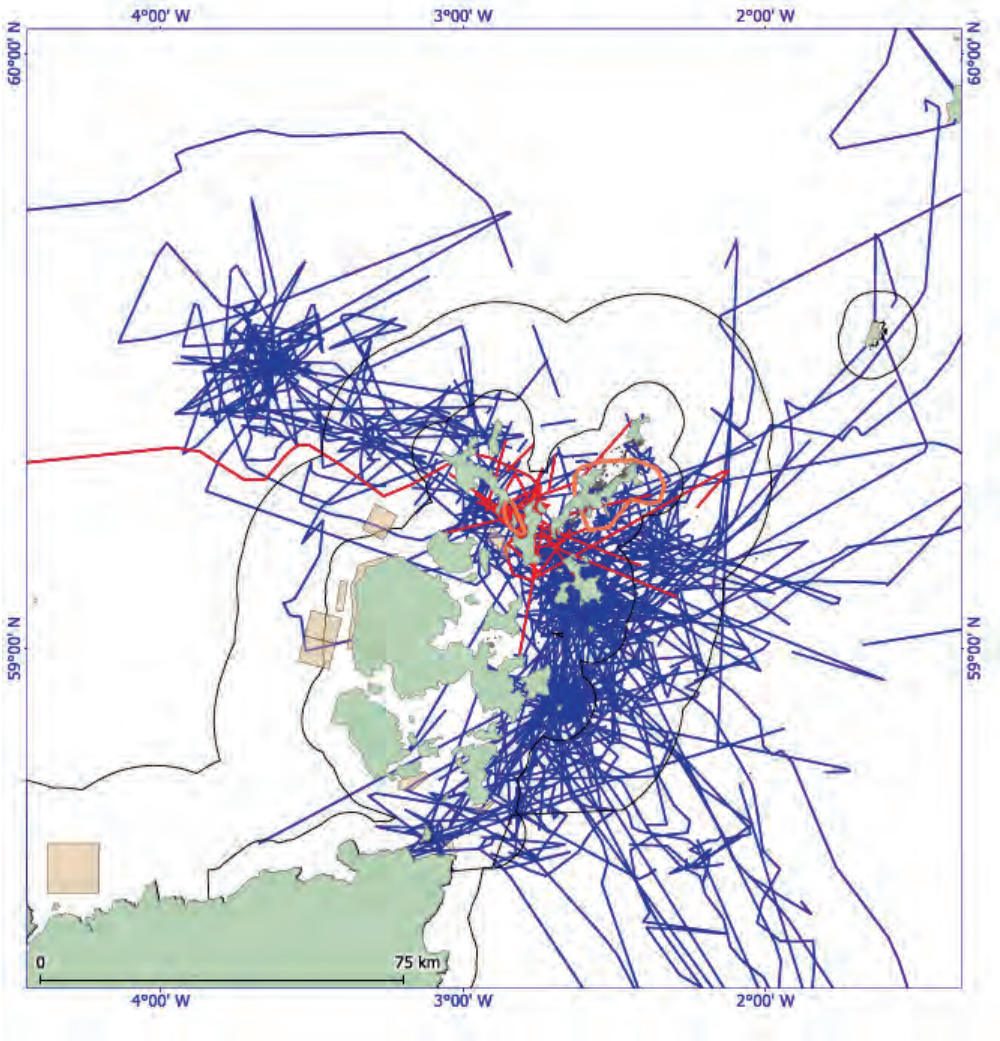

Figure 20. Grey seal trips departing from, or arriving at, the Faray and Holm of Faray SAC are shown in red. Trips departing from, or arriving at, haulout sites that are connected by only one trip from this SAC are shown in blue. This figure shows the same information as the previous one but is magnified to show the Orkney region in more detail.

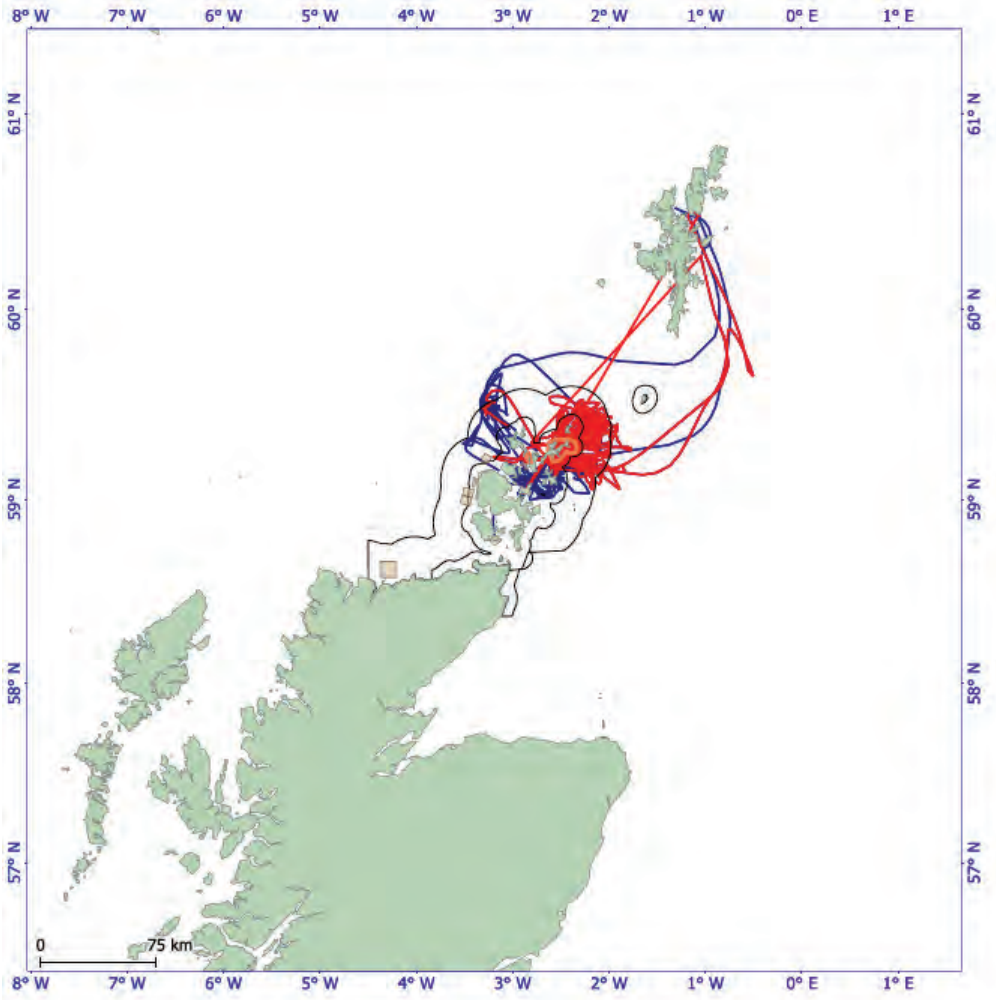

Figure 21. Harbour seal trips departing from, or arriving at, the Sanday SAC are shown in red. Trips departing from, or arriving at, haulout sites that are connected by only one trip from this SAC are shown in blue.

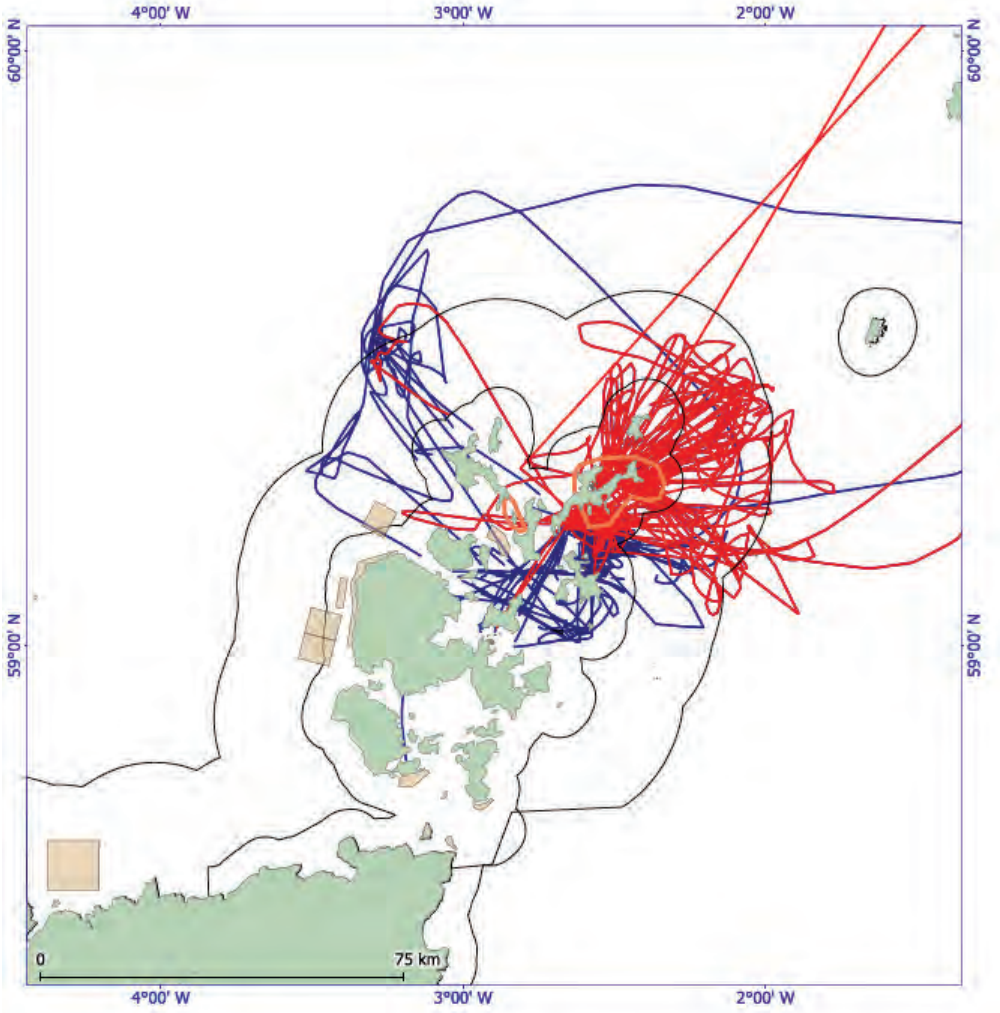

Figure 22. Harbour seal trips departing from, or arriving at, the Sanday SAC are shown in red. Trips departing from, or arriving at, haulout sites that are connected by only one trip from this SAC are shown in blue. This figure shows the same information as the previous one but is magnified to show the Orkney region in more detail.

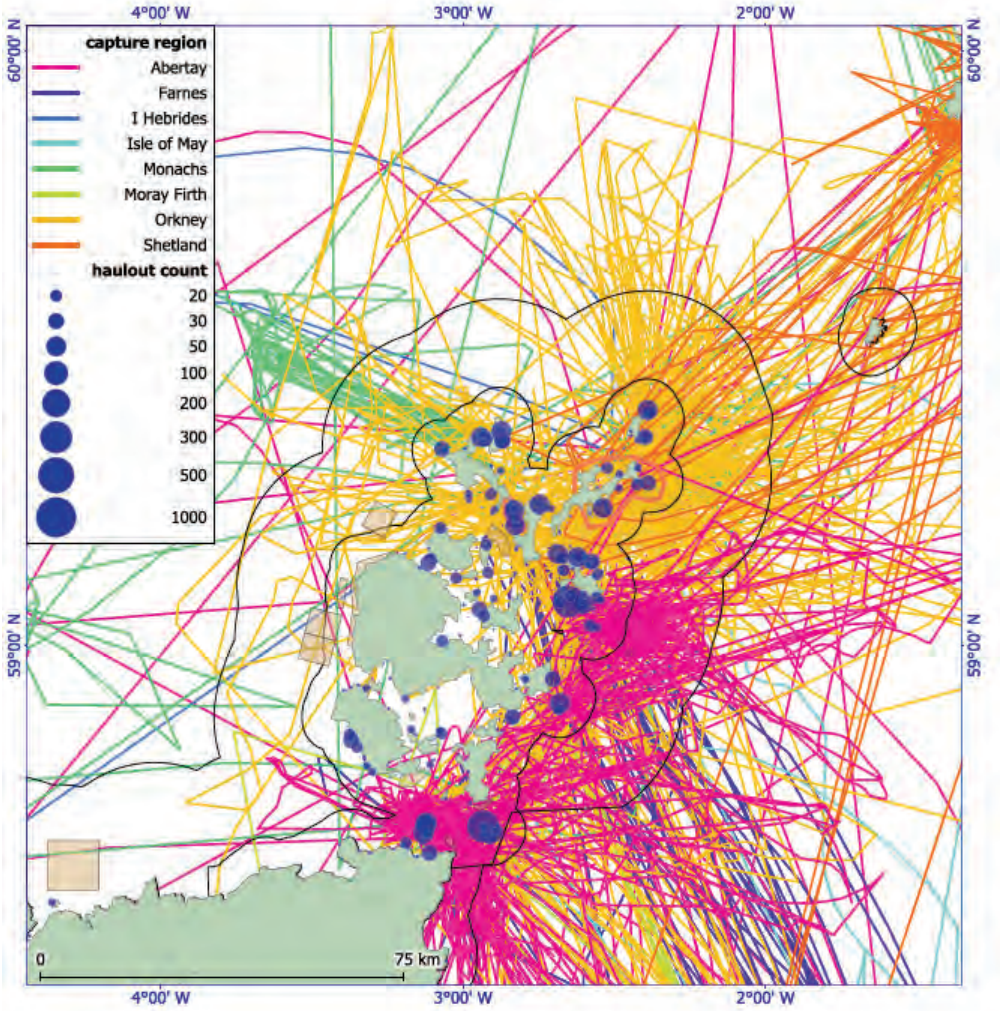

Figure 23. Tracks as Figure 10 (44 grey seals tagged with SMRU Argos and SMRU GSM/GPS tags which at least once entered the PFOSA) with August grey seal counts (Figure 7) overlaid.

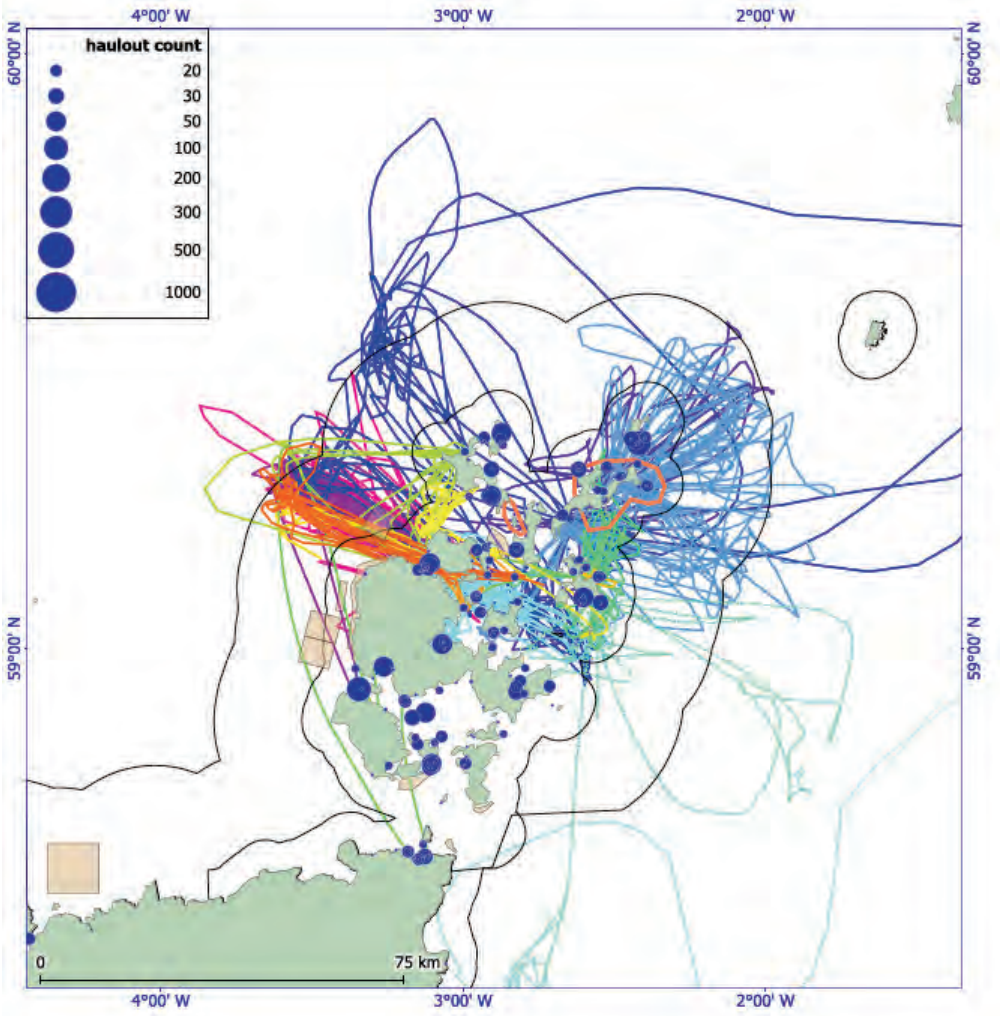

Figure 24. Tracks as Figure 14 (17 harbour seals tagged with SMRU Argos tags, which at least once entered the PFOSA) with August harbour seal counts (Figure 5) overlaid.

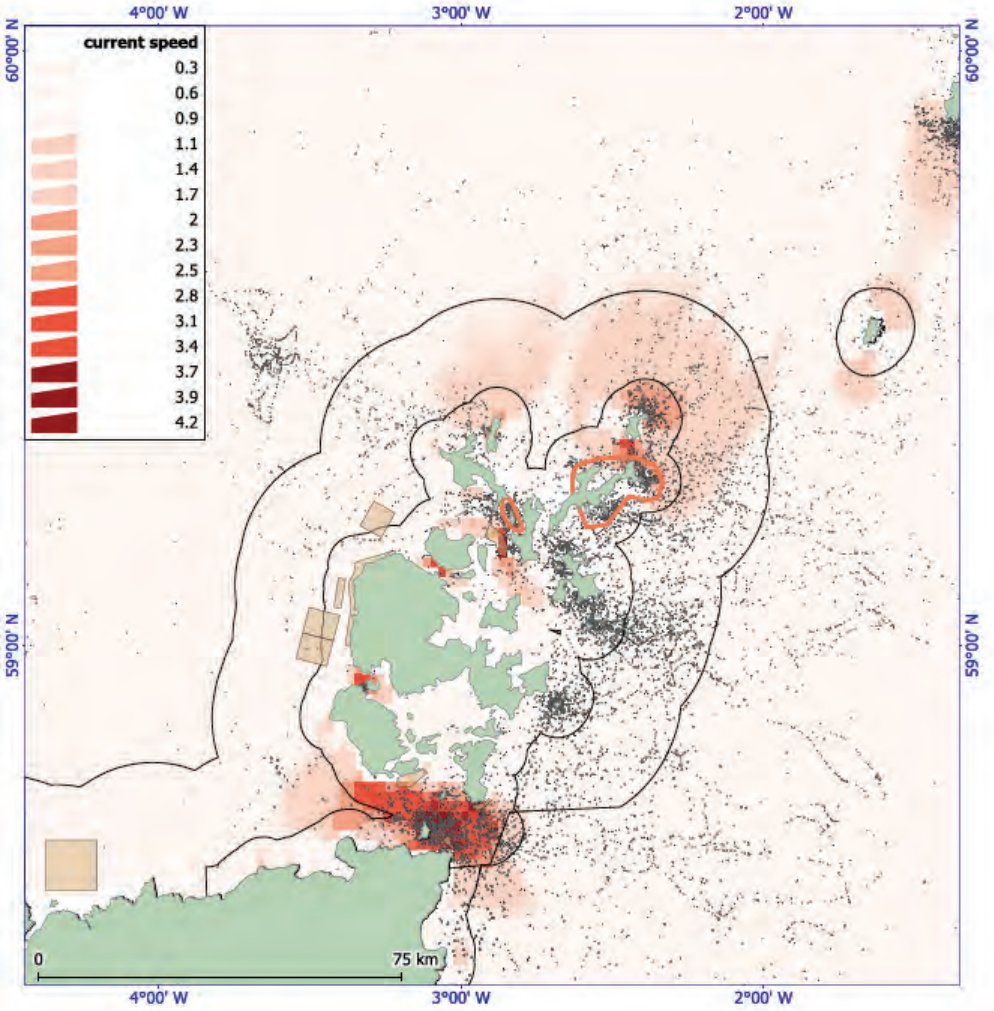

Figure 25. As Figure 10 (44 grey seals tagged with SMRU Argos and SMRU GSM/GPS tags which at least once entered the PFOSA) but showing locations rather than track lines. The red grid indicates the tidal energy (peak current speed of a Mean Spring tide in m/s). Both Faray and Holm of Faray and Sanday SACs are shown.

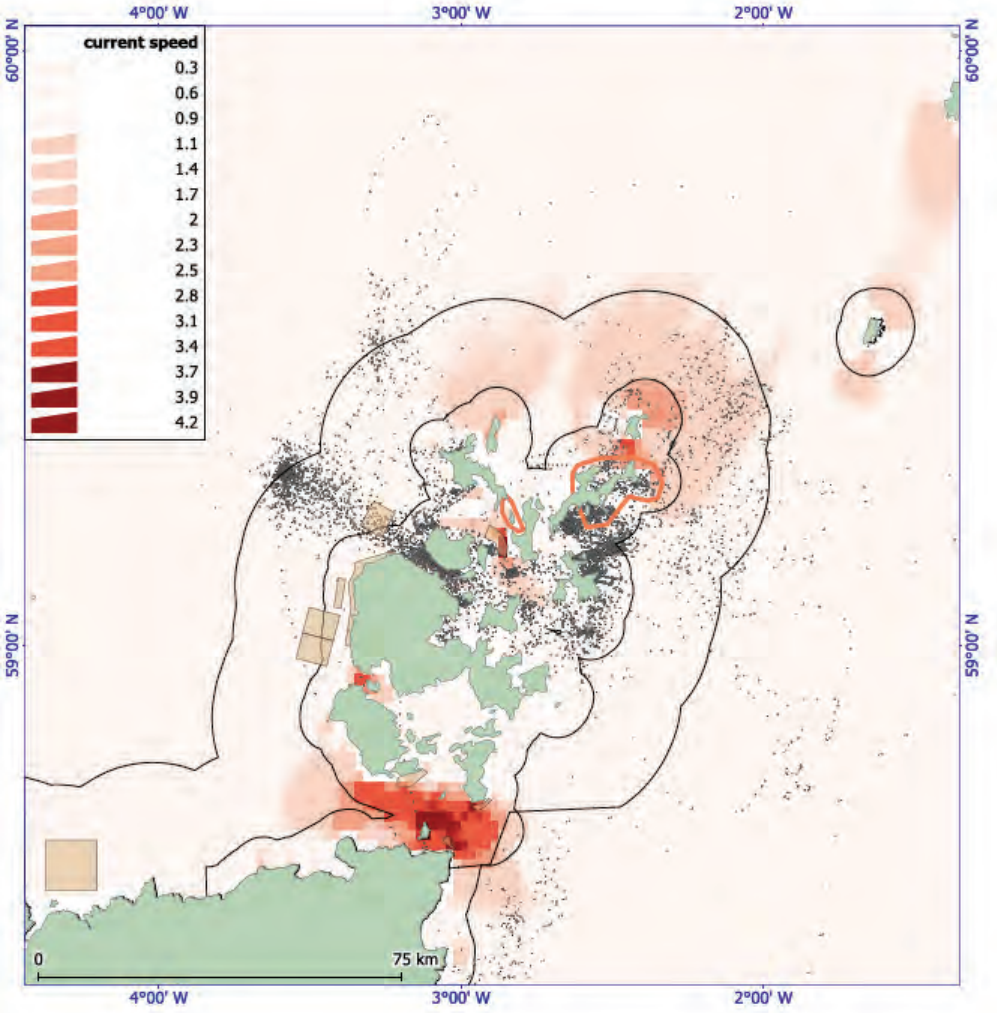

Figure 26. As Figure 14 (17 harbour seals tagged with SMRU Argos tags, which at least once entered the PFOSA) but showing locations rather than track lines. The red grid indicates the tidal energy (peak current speed of a Mean Spring tide in m/s). Both Faray and Holm of Faray and Sanday SACs are shown.

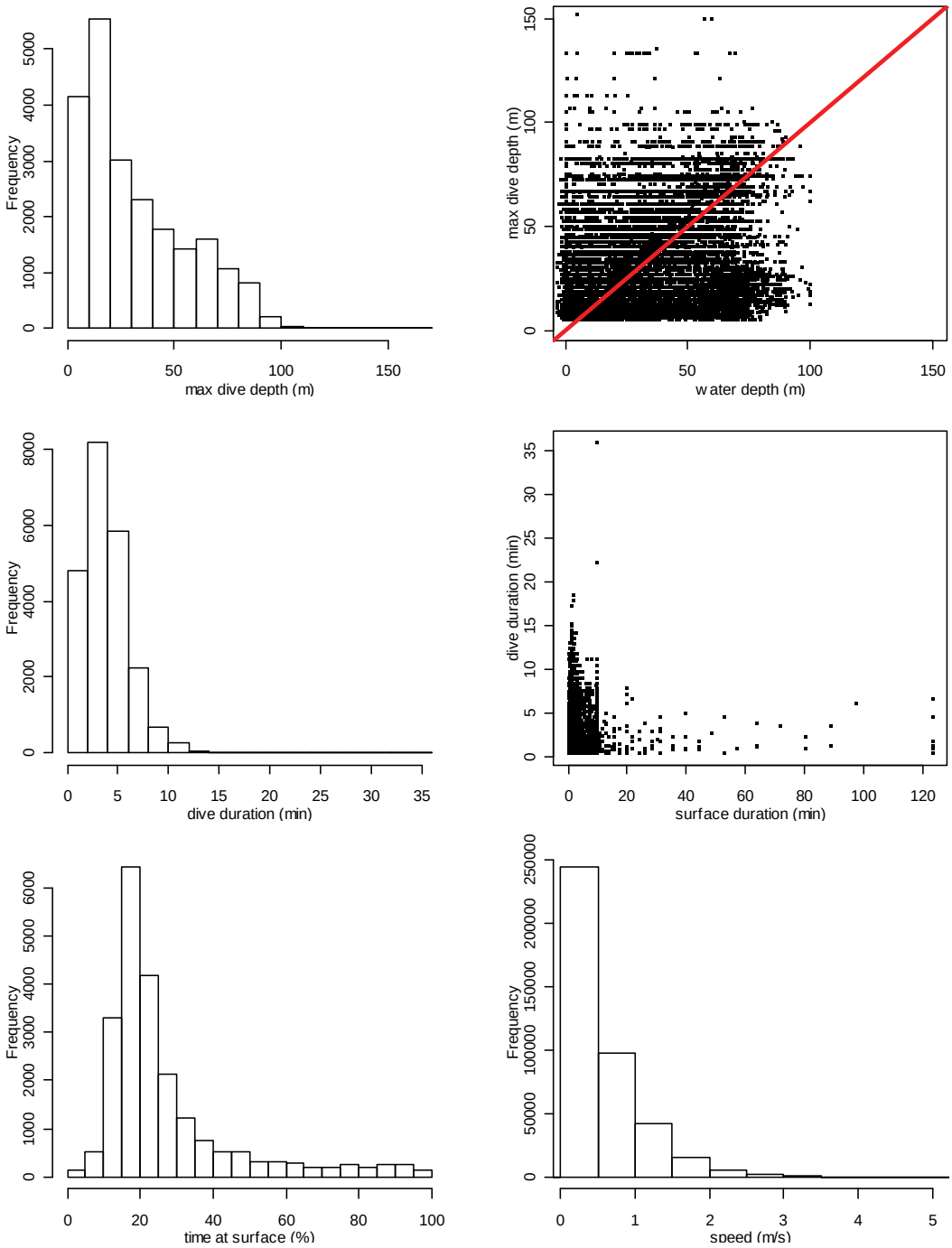

Figure 27. Grey seal dive and movement data.

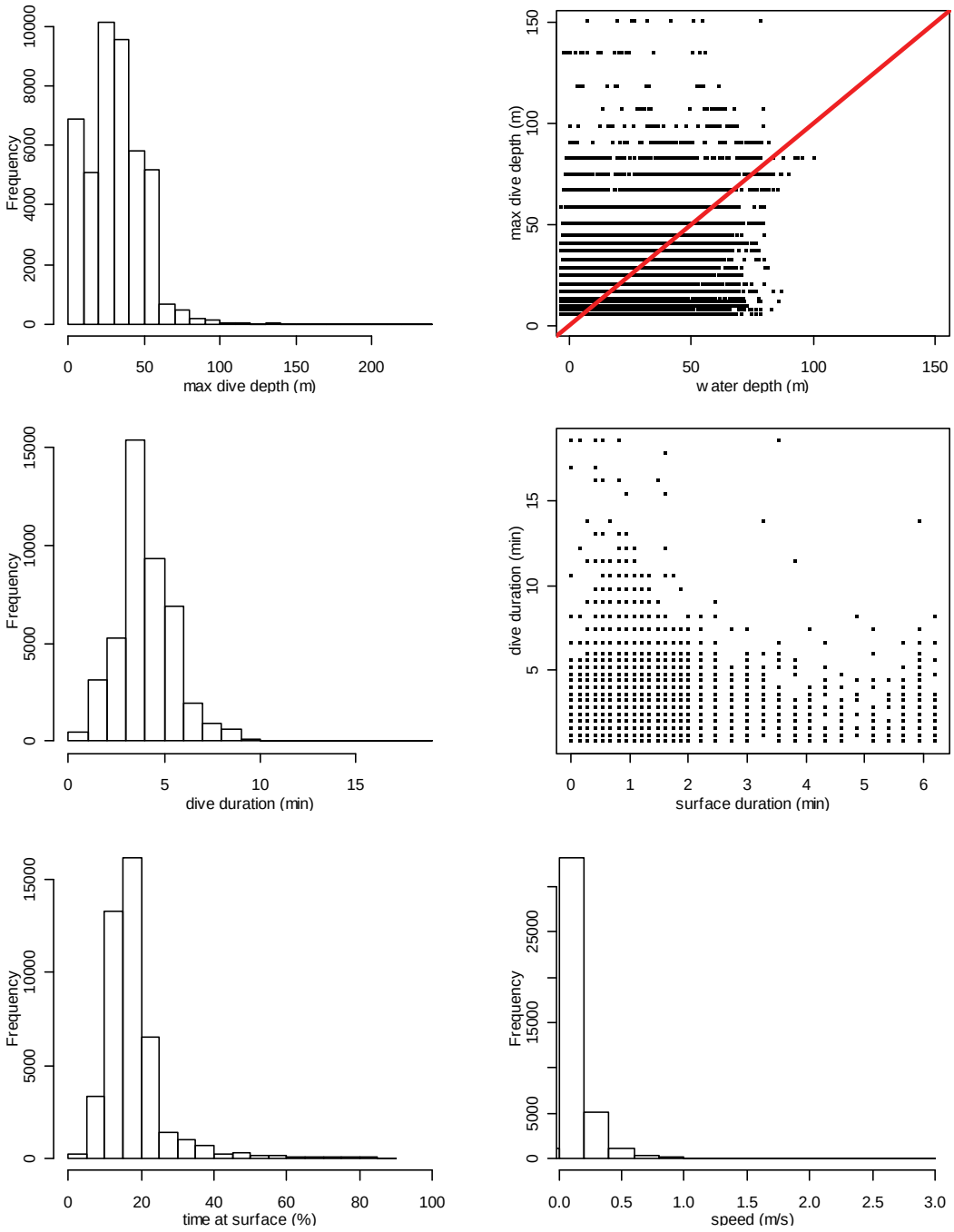

Figure 28. Harbour seal dive and movement data.

4 DISCUSSION

The PFOSA supports significant populations of both grey and harbour seals.

Grey seals: Between October and December 2008 approximately 7,000 grey seal pups were born at breeding colonies within 25km of the Pentland Firth, accounting for 17% of grey seal pups born in Scotland. Grey seal breeding colonies in the PFOSA collectively produce approximately 20,000 pups annually, accounting for 48% of pups born in Scotland and 44% of pups born in the UK. Surveys in August (outside the breeding season) 2008 found between 2,000 and 4,000 grey seals on haulout sites at the Pentland Skerries, Stroma, Swona, Copinsay, south-west Hoy and the Scottish mainland coast around Thurso.

Harbour seals: Between 1989 and 2001, Orkney was the main stronghold for harbour seals in both Scotland and the UK. Since 2001, numbers of harbour seals in Orkney have declined by over 60% (Lonergan *et al*. 2007). Despite this decline, there remain important harbour seal haulout sites in and around the Pentland Firth which are used by harbour seals during their annual moult in August. These include Switha, Flotta, South Fara, Cava, Barrel of Butter, Stroma and the Scottish mainland coast around Gills Bay by Thurso. There are additional significant haulout sites on north Hoy, the Bay of Ireland (east of Stromness) and in Widewall Bay on the west side of South Ronaldsay. Surveys of harbour seals are limited to their annual moult, in August. Their numbers and distribution in the PFOSA at other times of the year are not known.

The telemetry data used for this project come from 61 grey seals and 47 harbour seals. While this is a relatively large sample of animals, the data are split by capture location, tag type, season, year, sex and age. Caution must thus be exercised in extrapolating from this potentially biased *sample* of movement patterns to the overall *populations* of grey and harbour seals throughout all seasons, sites and years. In this report we emphasise a qualitative analysis. We outline areas of spatial and temporal overlap between seals and wet renewable lease areas, but the actual response of seals in the immediate vicinity of wave and tidal devices is not known and we therefore make no inference about the risk, or probability, of injury.

Our main findings are as follows:

4.1 Grey seals

The significant breeding colonies in and close to the Pentland Firth produce 17% of grey seal pups born in Scotland. These breeding colonies are at Stroma (2008 pup production estimate is 1,397), Swona (1,285), Switha (573), Flotta and Calf of Flotta (604), South Fara (236), Pentland Skerry (39), Copinsay (2,384), South Ronaldsay (349), Hoy (124) and the coast immediately south of Duncansby Head (292).

Haulout sites in and around the Pentland Firth were used by between 2,000 and 4,000 grey seals in August 2008. The main haulout groups were located on the Pentland Skerries, Stroma, along south-west Hoy and around Gills Bay by Thurso.

Only 17 (28%) of the 61 grey seals whose tracks, at some stage while they were tagged, entered the PFOSA were actually captured and tagged within the PFOSA (mainly at Eynhallow and the Green Holms in 1996). This will not cause bias in our interpretation if the assumption that grey seals mix completely over their Scottish range is true. But it is likely (or at least reasonably possible) that there may be individuals which are more ‘resident’ in the PFOSA and it is possible that they may have different movement patterns to ‘transients’ captured elsewhere. This is of special concern in the Pentland Firth itself, where no grey

seals were captured and tagged. Further analysis may allow us to detect whether there is any difference in the movement patterns of resident and transient animals. The most effective answer, however, will be through tagging seals caught in the Pentland Firth.

Tracks of weaned grey seals pups are under-represented in the PFOSA and none have been tracked from Orkney breeding colonies (although a number of tags have recently been deployed on pups on Stroma). Unpublished SMRU data show that grey seal pups disperse very widely from their natal sites.

Adult grey seals routinely move large distances. In fact, seals from eight different capture regions (Farnes, Isle of May, Abertay, Moray Firth, Orkney, Shetland, Monachs and Inner Hebrides) have been tracked entering the PFOSA (and indeed the 3nm zone). However, the resulting network of grey seal haulout sites has a strong seasonal pattern. This is of specific relevance to grey seal SACs since their designation is primarily directed at the breeding population. Most grey seals breeding within an SAC use different haulout sites at other times of the year. For example, approximately 1800 grey seal pups are born at the Isle of May SAC (Duck 2009). At least this number of females must be present on the island during the breeding season, plus breeding males and any non-breeders i.e. seals at this time of year will number in the low thousands. However, grey seals using the island at other times of year number in the low tens. Dispersal from grey seal breeding colonies to other haulout sites is shown by movements of seals tagged during the breeding season at North Rona (Figure 11 and Figure 12). However tagging during the breeding season is always limited in duration due to tag detachment during the subsequent moult (December-April).

Likewise, grey seals using SACs outwith the breeding season may breed elsewhere. Note that the existing distribution surveys only cover the breeding season (September to November) and summer (August); there is no information on the distribution of moulting grey seals (December to April).

The main overlap between grey seals and high tidal currents appears to be in the Pentland Firth, in particular the area around Stroma, Pentland Skerries and Swona.

Within the 3nm zone, grey seals appear to use the whole water column – from the surface to the seabed. Mean dive duration was 3.82 minutes.

4.2 Harbour seals

Numbers of harbour seals in Orkney and on the north coast of Scotland have declined dramatically in recent years (Lonergan *et al*. 2007). During surveys carried out in August 2008, approximately 750 harbour seals were counted in the southern part of Orkney, 26% of the 2008 Orkney total. This count is equivalent to just 30% of the 2001 count for the same area.

Harbour seal movements are more local than those of grey seals, with little movement between widely separated haulout sites.

While the regional tagging coverage in the Northern Isles of Orkney is reasonable, none of these animals travelled to haulout sites in the southern part of the PFOSA and so there are no at-sea foraging patterns available for the Pentland Firth or southern Orkney Islands. However, if the spatial pattern of foraging trip extents found in the north also apply in the south then there is likely to be spatial overlap with the lease areas (seals are likely to use the Pentland Firth either for foraging or en route to foraging locations nearby).

It is unclear from current tagging effort (restricted to the Northern Isles) whether the high tidal current area in the Pentland Firth is used by harbour seals.

The proposed wave lease area to the west of Rousay (Costa Head) overlaps a corridor used by harbour seals moving to and from a foraging area to the west of Orkney.

Within the 3nm zone, harbour seals appear to use the whole water column. Mean dive duration was 4.14 minutes.

There is no doubt that, to a greater or lesser extent, both grey and harbour seals use the lease areas that are earmarked for marine renewable development. This is particularly true for the tidal development lease areas. Seals also transit through some of these development lease areas en route, for example, to foraging areas further offshore. Because seals use the whole water column when they dive, they will undoubtedly come in close proximity to tidal energy generating devices unless there is avoidance behaviour.

5 DATA GAPS

The main data gaps identified during the course of this work which need to be addressed are as follows:

1. There is a lack of at-sea distribution data from harbour seals in the southern part of the PFOSA, particularly in and around the Pentland Firth. GSM/GPS tags should be applied to harbour seals caught in this area.
2. There is a lack of harbour seal haulout number and distribution data at times outside of August (the moulting season). Appropriate surveys should be carried out.
3. Only a small number of grey seals have been tracked through to their breeding colonies. Similarly, in the region of this study, data on the distribution of grey seals after the breeding season is restricted to North Rona. This latter data set is restricted in duration since the tags detach during the moult. Thus there is a need to tie in distribution outside the breeding season (the period for which grey seal designation applies) with breeding colony used. Flipper Argos tags should be deployed to grey seals during the breeding season. These would provide information on the geographical range of haulout sites used throughout the rest of the year (the tags will not provide locations at sea).
4. There is a lack of data about the movement of grey seal pups born in and close to the PFOSA. It is likely that their range will initially be greater than that of adults (SMRU unpublished data). GSM/GPS tags should be applied to grey seals pups within the PFOSA.
5. There may be a difference in behaviour between 'resident' and 'transient' grey seals. Thus GSM/GPS tags should be applied to grey seals caught within the PFOSA, especially at the two SACs (North Rona and Faray and Holm of Faray).
6. There remains the problem of not knowing what the small scale movements of seals are around wet renewable devices. There may be attraction or avoidance, or there may be no reaction at all. Current tagging technology is insufficient to record movement data at the required spatial and temporal resolution. We therefore suggest a feasibility study into the development of a high resolution tag (using internal dead-reckoning to obtain the temporal resolution required).

6 REGULATORY ISSUES

Under the Habitats Regulations, an Appropriate Assessment[10] needs to be carried out for any project which is likely to have a 'significant effect' on a Natura site. For tidal arrays in the lease areas being considered, assuming there may be a risk of collision between seals and rotating turbines, the harbour seal SAC which should be considered is Sanday. However, the harbour seal SACs at Dornoch Firth and Morrich More, Mousa and Yell Sound Coast should also be considered because the young harbour seals tagged in Orkney also used these areas (see Figure 17). Because grey seals range more widely than harbour seals (see Figure 9), all of the Scottish grey seal SACs may need to be considered when carrying out Appropriate Assessments.

Methods which may be used to address baseline monitoring questions include aerial, boat and ground counts of animals hauled out (for species presence, distribution and abundance), photo-identification (for information on abundance, individual movements etc.) and telemetry (to assess habitat use, individual movements etc.). Details of the questions these different methods can be applied to, and what needs to be considered in order to be able to use them effectively, are beyond the scope of this report.

All activity relating to catching and working with seals in the UK is licensed by the Home Office in accordance with the Animals (Scientific Procedures) Act 1986. This is of particular relevance to the telemetry work. If information on habitat use and/or individual movements is required and telemetry is the method of choice, the first step will be to assess whether adequate data are already in existence. If this is not the case then thought will need to be given to a co-ordinated approach by those who require the information. Collection of data which are already in existence, and multiple telemetry deployments which will supply the same information, will not be given the go-ahead. It may also be a stipulation of the data collection that data will be made available to SMRU (and others).

[10] http://www.mceu.gov.uk/MCEU_LOCAL/Ref-Docs/EN-HabsRegs-AA.pdf

7 REFERENCES

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8 APPENDICES

Appendices 1-5 provide details of the individual seals whose tracks are shown in the body of the report. The funding sources are coded as follows:

DBERR	Department for Business Enterprise and Regulatory Reform – SEA project
DSTL	Defence Science and Technology Laboratory
EU	EU – ELIFONTS project
NERC 1	SMRU – NERC core funding
NERC 2	NERC Grant to P Pomeroy, SMRU
SG/SNH	Scottish Government/Scottish Natural Heritage
UA	University of Aberdeen

For the grey seals tagged with WC Argos SPOT tags at the North Rona SAC in 2003 (Appendix 2), the data presented are “Start date” (the date the tag was deployed), “End date” (the date the tag stopped working) and “duration” (the total number of days the tag was working for). For all other seals, the data presented are “first day” (the date that the tagged seal first entered the PFOSA), “last day” (the date that the tagged seal was last in the PFOSA) and “days in area” (the number of days that the seal was in the PFOSA).

Appendix 6 shows details of the SMRU aerial surveys.

ref	funding	sex	age	tagging location	first day	last day	days in area
ab2-28500-97	EU	f	adult	Abertay	27/06/1997	31/07/1997	25
ab2-28501-97	EU	m	adult	Abertay	01/07/1997	19/07/1997	18
ab2-28503-97	EU	m	adult	Megstone, Farnes	08/08/1997	13/08/1997	6
ab3-20915-98	EU	f	adult	Abertay	29/10/1998	17/11/1998	18
ab3-28495-98	EU	m	adult	Abertay	13/06/1998	09/11/1998	22
ab3-28507-98	EU	f	adult	Abertay	06/06/1998	03/12/1998	46
ab3-28508-98	EU	m	adult	Abertay	19/07/1998	06/11/1998	24
fa2-2443-92	NERC 1	m	adult	Farnes, Longstone	01/05/1992	10/07/1992	30
gp13-902-08	DBERR	m	adult	Abertay	07/10/2008	13/11/2008	14
gp13-915-08	DBERR	f	adult	Abertay	03/07/2008	17/07/2008	15
gp13-916-08	DBERR	f	adult	Abertay	07/10/2008	03/11/2008	8
gp13b-481-08	DBERR	f	adult	Knox's Reef, Farnes	06/05/2008	20/09/2008	60
gp13b-732-08	DBERR	m	adult	Knox's Reef, Farnes	29/10/2008	31/10/2008	3
hg13-Emma-05	DSTL	m	adult	Oronsay, I Hebrides	03/01/2006	06/01/2006	12
hg8-Vera-04	NERC 1	f	adult	Abertay	09/11/2004	02/12/2004	24
im5-Dumbo-02	NERC 1	m	pup	Isle of May	26/01/2003	27/01/2003	2
im5-Lassie-02	NERC 1	f	pup	Isle of May	01/01/2003	04/01/2003	4
mn1-22484-95	NERC 1	m	adult	Monachs	20/06/1995	23/06/1995	4
mn1-22486-95	NERC 1	f	adult	Monachs	05/07/1995	20/09/1995	70
mn1-22488-95	NERC 1	m	adult	Monachs	16/06/1995	14/08/1995	28
mn1-22489-95	NERC 1	m	adult	Monachs	14/06/1995	14/06/1995	1
mn3-22494-96	NERC 1	f	adult	Monachs	15/11/1996	15/11/1996	1
mo-17212-92	UA	f	adult	Dornoch, Whiteness	24/12/1992	22/01/1993	21
mo-17216-92	UA	f	adult	Dornoch, Whiteness	25/08/1992	13/01/1993	104
or2-17213-96	NERC 1	f	juv	Eynhallow, Orkney	31/08/1996	27/09/1996	28
or2-17214-96	NERC 1	f	adult	Eynhallow, Orkney	02/09/1996	13/09/1996	12
or2-17216-96	NERC 1	m	juv	Eynhallow, Orkney	31/08/1996	17/09/1996	18
or2-17217-96	NERC 1	m	juv	Eynhallow, Orkney	31/08/1996	09/09/1996	10
or2-22485-96	NERC 1	m	adult	Orkney	26/04/1996	15/06/1996	19
or2-22487-96	NERC 1	f	adult	M Greenholm, Orkney	20/04/1996	13/07/1996	26
or2-22498-96	NERC 1	m	adult	Orkney	26/04/1996	06/11/1996	89
or2-26629-96	NERC 1	m	adult	L Greenholm, Orkney	18/04/1996	20/04/1996	3
or2-26632-96	NERC 1	f	adult	M Greenholm, Orkney	20/04/1996	07/06/1996	30
or2-26633-96	NERC 1	m	adult	Sweyn Holm, Orkney	19/04/1996	05/08/1997	24
or3-1547-98	NERC 1	m	adult	Sanday, Orkney	06/06/1998	09/08/1998	45
or3-1548-98	NERC 1	f	adult	Sanday, Orkney	05/06/1998	18/12/1998	168
or3-1549-98	NERC 1	m	adult	Sanday, Orkney	06/06/1998	09/02/1999	96
or3-1551-98	NERC 1	m	adult	Sanday, Orkney	06/06/1998	27/11/1998	114
or3-1554-98	NERC 1	f	adult	Sanday, Orkney	06/06/1998	07/06/1999	189
or3-22493-98	NERC 1	m	adult	Sanday, Orkney	05/06/1998	17/07/1998	27
or3-2844-98	NERC 1	m	adult	Sanday, Orkney	06/06/1998	14/12/1999	12
sh-1552-98	NERC 1	m	adult	Mousa, Shetland	16/06/1998	02/11/1998	12
sh-26628-98	NERC 1	m	adult	Mousa, Shetland	11/06/1998	17/06/1998	7
sh-2840-98	NERC 1	m	adult	Mousa, Shetland	10/06/1998	12/06/1998	3

Appendix 1. Details of 44 grey seals tagged with SMRU Argos (n=41) and SMRU GSM/GPS (shaded, n=3) tags that at least once entered the PFOSA.

ref	*funding*	*sex*	*age*	*tagging location*	*Start date*	*End date*	*duration*
pp1-43827-03	NERC 2	f	adult	N Rona	15/10/2003	05/12/2003	48
pp1-43828-03	NERC 2	f	adult	N Rona	15/10/2003	25/11/2003	42
pp1-43830-03	NERC 2	f	adult	N Rona	15/10/2003	01/12/2003	48
pp1-43832-03	NERC 2	f	adult	N Rona	20/10/2003	15/11/2003	27
pp1-43833-03	NERC 2	f	adult	N Rona	24/10/2003	08/12/2003	46
pp1-43834-03	NERC 2	f	adult	N Rona	20/10/2003	14/12/2003	56
pp1-43835-03	NERC 2	f	adult	N Rona	24/10/2003	13/12/2003	51
pp1-43836-03	NERC 2	f	adult	N Rona	24/10/2003	22/12/2003	59
pp1-43837-03	NERC 2	f	adult	N Rona	24/10/2003	20/12/2003	54
pp1-43838-03	NERC 2	f	adult	N Rona	05/11/2003	20/01/2004	73
pp1-43839-03	NERC 2	f	adult	N Rona	24/10/2003	06/12/2003	44
pp1-43840-03	NERC 2	f	adult	N Rona	24/10/2003	11/12/2003	48
pp1-43841-03	NERC 2	f	adult	N Rona	24/10/2003	11/12/2003	49
pp1-43842-03	NERC 2	f	adult	N Rona	24/10/2003	06/12/2003	41
pp1-43843-03	NERC 2	f	adult	N Rona	05/11/2003	11/01/2004	68
pp1-43844-03	NERC 2	f	adult	N Rona	05/11/2003	14/01/2004	71
pp1-43845-03	NERC 2	f	adult	N Rona	05/11/2003	27/11/2003	23

Appendix 2. Details of female grey seals tagged with WC Argos SPOT tags at North Rona in 2003.

ref	*funding*	*sex*	*age*	*tagging location*	*first day*	*last day*	*days in area*
pv11-James-05	UA	m	adult	Dornoch	14/03/2005	14/03/2005	1
pv11-Kath-05	UA	f	adult	Loch Fleet	20/04/2005	22/06/2005	50
pv1-ali-03	DBERR	f	adult	Sanday, Orkney	02/10/2003	06/04/2004	175
pv1-Arnie-03	DBERR	m	adult	Eynhallow, Orkney	02/10/2003	29/03/2004	162
pv1-bo-03	DBERR	f	adult	Sanday, Orkney	02/10/2003	03/04/2004	111
pv1-Bob-03	DBERR	m	adult	Eynhallow, Orkney	02/10/2003	22/02/2004	131
pv1-cat-03	DBERR	f	adult	Sanday, Orkney	02/10/2003	06/05/2004	218
pv1-dot-03	DBERR	f	adult	Sanday, Orkney	02/10/2003	11/07/2004	261
pv1-erin-03	DBERR	f	adult	Rousay, , Orkney	02/10/2003	15/03/2004	165
pv6-Ken-04	DBERR	m	adult	Stronsay, Orkney	15/03/2004	05/08/2004	144
pv6-Len-04	DBERR	m	adult	Stronsay, Orkney	15/03/2004	05/07/2004	110
pv6-Max-04	DBERR	m	adult	Rousay, Orkney	16/03/2004	02/06/2004	74
pv6-Oli-04	DBERR	m	adult	Eynhallow, Orkney	18/03/2004	05/07/2004	110
pv6-pat-04	DBERR	f	adult	Stronsay, Orkney	15/03/2004	07/09/2004	154
pv6-Pete-04	DBERR	m	adult	Eynhallow, Orkney	18/03/2004	13/04/2004	27
pv6-queenie-04	DBERR	f	adult	Rousay, Orkney	16/03/2004	23/06/2004	100
pv6-sally-04	DBERR	f	adult	Eynhallow, Orkney	18/03/2004	31/05/2004	71

Appendix 3. Details of the 17 harbour seals tagged with SMRU Argos tags that at least once entered the PFOSA.

ref	*funding*	*sex*	*age*	*tagging location*	*first day*	*last day*	*days in area*
pvdt-01-09	SG/SNH	f	adult	South Backaskaill, Sanday	09/06/2009	09/12/2009	107
pvdt-02-09	SG/SNH	f	adult	South Backaskaill, Sanday	09/06/2009	19/12/2009	155
pvdt-03-09	SG/SNH	m	adult	Otterswick, Sanday	11/06/2009	04/12/2009	102
pvdt-04-09	SG/SNH	f	adult	Otterswick, Sanday	11/06/2009	03/01/2010	119
pvdt-05-09	SG/SNH	f	adult	Otterswick, Sanday	12/06/2009	19/01/2010	122
pvdt-06-09	SG/SNH	m	adult	Otterswick, Sanday	14/07/2009	26/01/2010	75
pvdt-07-09	SG/SNH	f	adult	Otterswick, Sanday	11/06/2009	14/02/2010	33
pvdt-08-09	SG/SNH	f	adult	Otterswick, Sanday	11/06/2009	13/12/2009	83
pvdt-09-09	SG/SNH	m	adult	Otterswick, Sanday	09/06/2009	29/01/2010	112
pvdt-10-09	SG/SNH	m	adult	Otterswick, Sanday	09/06/2009	04/12/2009	77
pvdt-11-09	SG/SNH	f	adult	Otterswick, Sanday	09/06/2009	19/01/2010	71
pvdt-12-09	SG/SNH	f	adult	Otterswick, Sanday	09/06/2009	04/06/2010	121
pvdt-13-09	SG/SNH	m	adult	Otterswick, Sanday	11/07/2009	19/09/2009	51
pvdt-14-09	SG/SNH	m	adult	Otterswick, Sanday	09/06/2009	23/01/2010	106
pvdt-15-09	SG/SNH	m	adult	Otterswick, Sanday	09/06/2009	24/11/2009	83

Appendix 4. Details of the 15 adult harbour seals fitted with WC Argos flipper tags at Sanday, Orkney.

ref	*funding*	*sex*	*age*	*tagging location*	*first day*	*last day*	*days in area*
pvsurv-03-07	SG/SNH	f	pup	Stronsay	04/07/2007	05/11/2007	35
pvsurv-07-07	SG/SNH	f	pup	Stronsay	04/07/2007	14/09/2007	24
pvsurv-08-07	SG/SNH	f	pup	Stronsay	05/07/2007	02/08/2007	14
pvsurv-10-07	SG/SNH	f	pup	Stronsay	06/07/2007	11/02/2008	18
pvsurv-11-07	SG/SNH	f	pup	Stronsay	05/07/2007	31/07/2007	10
pvsurv-12-07	SG/SNH	f	pup	Stronsay	06/07/2007	09/12/2007	13
pvsurv-14-07	SG/SNH	f	pup	Stronsay	06/07/2007	26/09/2007	26
pvsurv-15-07	SG/SNH	f	pup	Stronsay	06/07/2007	29/02/2008	67
pvsurv-17-07	SG/SNH	f	pup	Stronsay	06/07/2007	29/08/2007	24
pvsurv-18-07	SG/SNH	f	pup	Stronsay	04/07/2007	21/08/2007	21
pvsurv-19-07	SG/SNH	f	pup	Stronsay	04/07/2007	19/08/2007	14
pvsurv-22-07	SG/SNH	f	pup	Stronsay	06/07/2007	07/11/2007	16
pvsurv-23-07	SG/SNH	f	pup	Holm of Houton, Scapa Flow	08/07/2007	14/07/2007	4
pvsurv-27-07	SG/SNH	f	pup	Stronsay,	06/07/2007	29/11/2007	70
pvsurv-41-07	SG/SNH	f	pup	Cava, Scapa Flow	08/07/2007	23/08/2007	19

Appendix 5. Details of the 15 female harbour seal pups fitted with WC Argos SPOT tags at in Orkney.

	Harbour seal (breeding season)	Harbour seal (moult)	Grey seal (breeding season)
Timing of surveys	June-July	August	September-December
Extent of surveys	Moray Firth (Findhorn to Helmsdale)	Scotland (but not the whole coastline in any one year)	Scotland
Reason for surveys	To determine adult and pup numbers in the area	To estimate harbour seal population size in the area	To determine the number of pups born at the main colonies
Funding source	NERC, SNH	NERC, SNH	NERC
Notes	Grey seals are also counted	Grey seals are also counted	

Appendix 6. Details of the different types of SMRU seal surveys.

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