Strategic Regional Pre-Construction Marine Mammal Monitoring Programme Interim Report 2015

Graham, I.M., Cheney, B., Hewitt, R.C., Hastie, G.D. and Thompson, P.M.

1 4 9 5
UNIVERSITY OF ABERDEEN

Executive Summary

In May 2014, a Marine Mammal Monitoring Programme (MMMP) was developed for the Moray Firth. The programme aims to address both project-specific and strategic research and monitoring questions relating to the potential impacts of offshore wind farm construction and operation upon key protected marine mammal populations. The initial two-year pre-construction phase of the programme is being funded through a consortium that includes developers (BOWL and MORL), Marine Scotland, The Crown Estate and Highlands and Islands Enterprise.

Following extensive consultation with key stakeholders, the programme is focussing upon two key species, harbour seals and bottlenose dolphins, and key questions that address uncertainties identified during the consenting process. Specifically, the pre-construction MMMP aims to collect additional data on the distribution, abundance and vital rates of both priority species, thereby providing a baseline against which the population consequences of disturbance during construction can be quantified.

The MMMP consists of work packages for each priority species, each including individual based studies of reproduction and survival rates, assessments of trends in abundance, and the collection of data on distribution patterns. This interim report provides background on the programme aims and the methodologies being used within each of these work packages, and provides an overview of fieldwork that has been conducted in 2015.

Harbour seal work has focused upon the breeding population in Loch Fleet NNR. Between 26th May and 30th July 45 surveys were made and over 8,000 photographic images of individual seals were collected. Analysis of these pictures is ongoing to underpin annual estimates of reproduction and survival. Counts made in Loch Fleet and at other sites along the Moray Firth will provide local estimates of abundance. In February 2015, 13 seals were captured at Loch Fleet and fitted with GPS/GSM tags which have provided information on foraging distribution and diving behaviour during spring and early summer.

Bottlenose dolphin photo-identification surveys in the Moray Firth SAC were made on 20 days between May and September and over 13,000 photographs were taken during 121 encounters. Analysis of these pictures is ongoing to underpin annual estimates of abundance and to update estimates of vital rates. Passive acoustic monitoring data were successfully collected to determine baseline levels of occurrence in favoured areas.

In summary, all proposed fieldwork was successfully completed, providing data that can be used to address all key project objectives. Further analysis of these data will be provided in an annual report in April 2016.

Background

The Moray Firth contains internationally important populations of marine mammals. European Union (EU) Special Areas of Conservation (SAC) have been designated for both harbour seals and bottlenose dolphins, and the area is frequented by other protected species such as grey seal, harbour porpoise and minke whale. There has also been a long history of research in the area, and Moray Firth harbour seals and bottlenose dolphins are now two of the most intensively studied marine mammal populations in the world.

The presence of these well studied protected populations provides a unique mix of challenges and opportunities for regulators and industries wishing to undertake new developments in the Moray Firth. The region has long supported a broad range economic activity, including fisheries, oil and gas developments, and tourism. For emerging industries such as offshore renewables recent EU legislation has led to a challenging step change in assessment and monitoring requirements. Previous research has provided important baseline data, for both site-specific assessments and more general development of methods to meet new legislative requirements. Unique opportunities now exist for conducting research and monitoring alongside regional developments.

A key driver for this Marine Mammal Monitoring Programme (MMMP) has been the requirement for monitoring due to the proposed offshore wind farm developments in the Moray Firth namely, BOWL (Beatrice Offshore Windfarm Ltd.) and MORL (Moray Offshore Renewables Ltd.). However, this MMMP has wider relevance for two reasons: Firstly, other stakeholders require the same monitoring data on trends in these protected populations, particularly for the bottlenose dolphins that range widely along the east coast of Scotland. For example, the UK government must provide regular status updates to the EU; and other developers both within (e.g. ports and harbours, oil and gas) and outside (e.g. other east coast wind farms) the region must consider cumulative impacts on the dolphin population that uses the Moray Firth SAC. Secondly, research around these regional developments can be used to test and develop assessment frameworks that are now being used in other areas, particularly those assessing the population consequences of disturbance.

Given the broader significance of this programme, an initial two-year pre-construction phase of work has been funded through a consortium that includes BOWL, MORL, Marine Scotland, The Crown Estate and Highlands and Island Enterprise. This document presents background on the programme aims and the methodologies being used for the study, and provides an overview of fieldwork that has been conducted in 2015.

Aims

The pre-construction MMMP aims to provide baseline data on two priority species (harbour seals and bottlenose dolphins) during the two years prior to construction (2014 and 2015). This pre-construction monitoring period will now need to be extended into 2016.

Following extensive consultation with a range of stakeholders the selection of these priority species was based upon the proximity of EU protected sites (SACs) to the BOWL and MORL sites (see Annex 1), and the opportunities to address key questions that can reduce uncertainty in future assessments (see Annex 2). Specifically, the pre-construction MMMP aims to collect additional data on the distribution, abundance and vital rates of both priority species, thereby providing a baseline against which the population consequences of disturbance during construction can be quantified.

Programme structure

The MMMP consists of two sets of work packages, the first covering the requirements for harbour seal monitoring, and the second for bottlenose dolphin monitoring.

Harbour Seal Monitoring

1) Individual based studies of reproduction and survival;
2) Trends in abundance; and
3) Characterisation of foraging areas.

Bottlenose Dolphin Monitoring

1) Individual based studies of reproduction and survival;
2) Trends in abundance; and
3) Baseline occurrence of dolphins in favoured areas.

Harbour Seal Monitoring Work Packages

WP 1.1: Individual based studies of reproduction and survival

Introduction and Objectives

This work package is being used to assess baseline variability in harbour seal vital rates and condition. This will permit future comparison with data collected during the construction period. These data will then be used to test and refine assumptions in the Moray Firth harbour seal assessment framework (Thompson *et al.* 2013b) that link noise exposure to changes in vital rates.

Parameters to be measured

- Female fecundity (i.e. birth rates);
- Female pupping dates;
- Sex specific survival rates.

Survey Design

Land-based photo-identification is being used to recognise individual harbour seals from their distinct facial pelage markings (Figure 1) (Thompson & Wheeler 2008). Repeated observations of known females can then be used to determine whether or not different females in the population give birth each year, and data on the timing of births provides an index of over-winter body condition (see Cordes & Thompson 2013). Repeated sightings of males and females can be used to estimate sex-specific survival rates (Cordes & Thompson 2014).

Figure 1. Examples of suitable photographs for individual photo-identification, showing the distinct facial patterns on the left and right side of four individuals that regularly use the Loch Fleet haul-out site.

Methodology

Regular photo-identification surveys of harbour seals were carried out from late May until late July at Loch Fleet National Nature Reserve (NNR), which is the nearest major harbour seal breeding site to the BOWL and MORL developments (Figure 2). Over the last two decades, Loch Fleet has become an increasingly important breeding site for the Moray Firth harbour seal population (Cordes *et al.* 2011), and the proximity of the haul-out to a public road makes it particularly suitable for photo-identification studies.

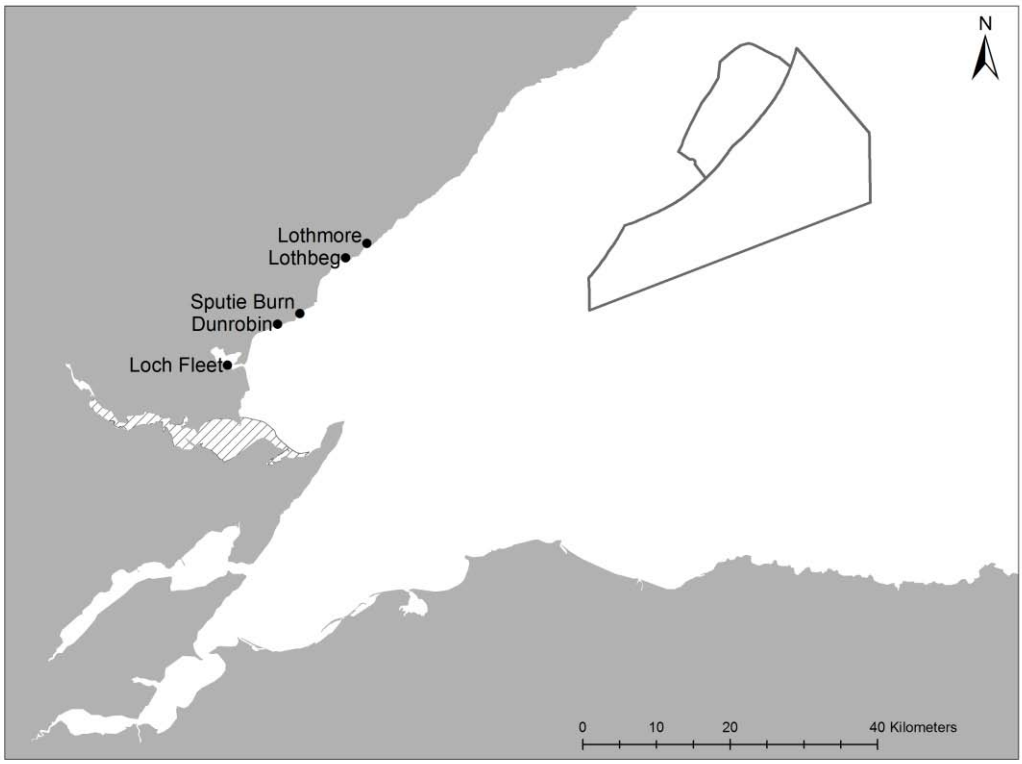


Figure 2. A map of the Moray Firth showing the position of the BOWL and MORL development areas and the five closest harbour seal haul-out sites. The Dornoch Firth and Morrich More SAC is hatched.

Surveys were started around low tide, with observations made from a vehicle parked at a standard vantage point (Grid Ref: NH 791 956). High quality photographic images were taken of all individuals using the main sandbank by trained observers using a digital SLR camera (Canon 60D) attached to a telescope (20–60 x 80 mm Swarovski HD-ATS 80). For adult females, data were also recorded, ideally by photograph, on whether or not a pup was present on each encounter.

Results

In 2015, a total of 45 photo-identification trips were conducted during the pupping period at Loch Fleet from the 26th May to the 30th July. The first pup was seen on the 4th June and the maximum pup count was 51 on the 5th July (Figure 3). The majority of seals present were successfully photographed on all trips, and particular effort was made to ensure that all attending mothers were photographed to allow analysis of pupping dates and individual reproductive success. In total, 8015 images of harbour seals were taken at Loch Fleet during the pupping period.

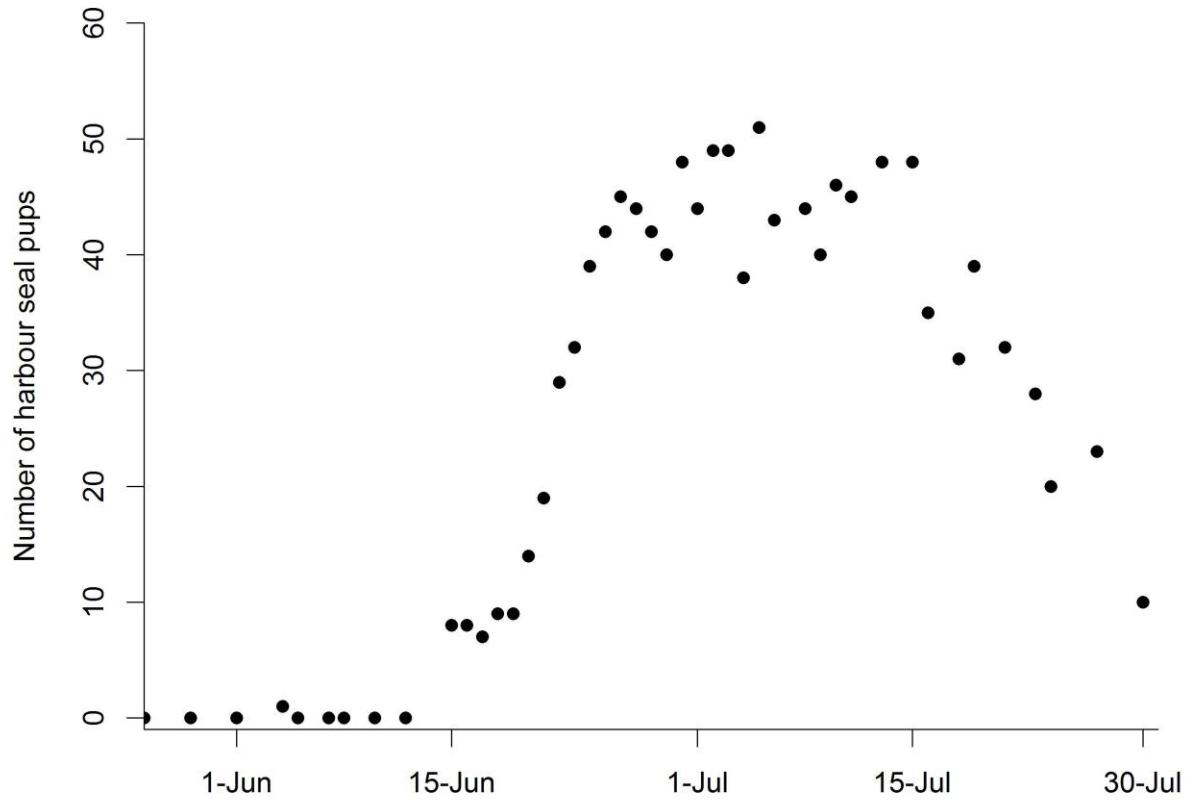


Figure 3. The number of harbour seal pups counted at Loch Fleet during the pupping period from the 26th May to the 30th July 2015.

Data Analysis

Analysis of the 2015 data is ongoing. All images have been graded for photographic quality and archived. The best quality picture for each seal, on each day, is being matched to the existing photo-identification catalogue by an experienced analyst and archived with associated field data.

This process is almost complete, and these initial matches will be confirmed by a second experienced analyst early in 2016. The resulting observations will be used to create a capture matrix that will be used to provide annual estimates of fecundity and underpin subsequent Capture Mark Recapture (CMR) analyses of survival (see Cordes & Thompson 2014 for statistical approaches used in these analyses).

Repeated sightings of females will be used to estimate individual birth dates, and provide an annual estimate of median birth date (Cordes & Thompson 2013).

WP 1.2: Trends in abundance

Introduction and Objectives

This work package is being used to assess baseline variability in summer and winter abundance at harbour seal haul-out sites along the northern Moray Firth coast (Figure 2: Loch Fleet and smaller sites near Brora and Helmsdale). These finer–scale summer abundance data from sites that are closest to the BOWL and MORL developments can then be related to broad-scale survey data that are routinely collected by the University of St Andrews Sea Mammal Research Unit (SMRU); i.e. Regional Site Condition Monitoring data from the Dornoch Firth and Morrich More SAC and national harbour seal survey data. This will permit future comparison with data collected during the construction and post-construction period, allowing a test of the short term decline and subsequent recovery predicted under the Moray Firth seal assessment framework.

Parameters to be measured

- Summer abundance of harbour seals during the pupping season and moult;
- Winter abundance of harbour seals.

Survey Design

Throughout their global range, trends in harbour seal abundance are based upon low-tide counts made during either the pupping season (Thompson *et al.* 1997; Huber *et al.* 2001) or moult (Thompson & Harwood 1990; Lonergan *et al.* 2007), when a higher and more consistent proportion of seals are ashore. A range of counting methods has been used in other studies, including land-based counts (Thompson *et al.* 1997), aerial photographic survey (Thompson & Harwood 1990) and thermal imagery (Lonergan *et al.* 2007). In future it is likely that UAVs (unmanned aerial vehicles) may also become a viable survey platform.

Methodology

Land-based counts were made (Figure 2) during the pupping season (15th June – 15th July) and moult (1st – 31st August) following the protocols used by the University of Aberdeen during previous studies of trends in harbour seal abundance (Thompson *et al.* 1996; Thompson *et al.* 1997; Thompson *et al.* 2007; Cordes *et al.* 2011). Monthly counts were also made at all sites throughout the winter months (from September to May. Counts were made at Dunrobin, Sputie Burn and Lothmore from June 2014 and at Lothbeg from May 2015, and have been ongoing at Loch Fleet since 1988.

Counts were made around low tide and, when possible, in the absence of rain and on days with good visibility. Counts were made from suitable vantage points by a trained observer, using a Swarovski HD-ATS 80 telescope. In Loch Fleet, counts were made as part of the on-

going photo-identification studies. Where conditions allowed at other sites, opportunistic photographs were also taken these are being processed using the same approaches outlined in WP 1.1.

Results

In 2015, a minimum of four counts were made at Loch Fleet, Dunrobin, Sputie Burn, Lothbeg and Lothmore during the pupping season and moult (Tables 1 & 2). In addition, throughout the winter, monthly counts were made at each of these sites from September 2014 to May 2015 and started again in September 2015 and are ongoing (Tables 1 & 3).

Table 1. Number of count trips made to each site during the 2015 pupping season (15th June to 15th July), moult (1st to 31st August), winter 2014 (1st September 2014 to 31st May 2015) and winter 2015 (1st September to 31st October 2015).

	Lothmore	Lothbeg	Sputie Burn	Dunrobin	Loch Fleet
Pupping	4	4	4	4	28
Moult	4	4	4	4	4
Winter 2014	9	1	9	9	19*
Winter 2015	2	2	2	2	2

* includes 4 trips made to Loch Fleet for non-MMMP fieldwork activities

Table 2. Mean counts (± 1 SE) of adult harbour seals at each site during the 2015 pupping season (15th June to 15th July) and moult (1st to 31st August).

	Lothmore	Lothbeg	Sputie Burn	Dunrobin	Loch Fleet
Pupping	2 (0.41)	0.75 (0.48)	29 (2.2)	0 (0)	101.57 (4.11)
Moult	3 (1.22)	1.75 (1.18)	37.5 (7.19)	2 (1.08)	128.75 (11.17)

Table 3. Mean counts (± 1 SE) of adult harbour seals at each site during the winter 2014 (1st September 2014 to 31st May 2015) and 2015 (1st September to 31st October 2015).

	Lothmore	Lothbeg	Sputie Burn	Dunrobin	Loch Fleet
Winter 2014	2.22 (1.06)	3 (-)	24.56 (4.19)	0 (0)	79.84 (9.95)
Winter 2015	2 (2)	3.5 (3.5)	38.5 (19.5)	0 (0)	73.5 (12.5)

Data Analysis

Annual data from the pupping season and moult will be used to update the existing time-series that uses mean annual counts in each time period to provide an index of abundance at different haul-out sites. These can, in turn, be related to available broader scale harbour seal survey data from the east coast of Scotland that are made available through the Natural Environment Research Council Special Committee on Seals (e.g. SCOS 2012).

Estimates of total abundance will be made using two different approaches. First, counts made during the pupping season can be adjusted using available telemetry data following the approach described in Thompson *et al.* (1997). Second, the matrix of photographic recaptures used to estimate survival (WP 1.1) can also be used to provide CMR estimates of absolute abundance in Loch Fleet (Cordes & Thompson 2015) and, potentially, at all sites.

WP 1.3: Characterisation of foraging areas

Introduction and Objectives

This work package will be used to obtain up to date information on baseline variability in the at-sea distribution and foraging patterns of harbour seals breeding at haul-out sites in the northern part of the Moray Firth. This will permit future comparison with data collected from animals that are exposed to piling noise. These data will also be used to characterise the foraging areas used by different identifiable individuals (see WP 1.1). This will, in turn, allow us to evaluate whether individual variation in vital rates is related to the extent of overlap between individual foraging ranges and areas impacted by construction noise.

Parameters to be measured

- Population distribution at sea during summer and winter;
- Individual home ranges and foraging areas;
- Dive patterns.

Survey Design

A wide range of telemetry devices have previously been used to track harbour seals. The study used GPS/GSM tags produced by SMRU Instrumentation, that have been widely used to obtain fine-scale data on distribution and activity of harbour seals in UK waters (Cordes *et al.* 2011; Sharples *et al.* 2012).

Tags were expected to last 3-9 months, and the survey was designed to include two capture periods to maximise the chance of obtaining a balanced dataset across both winter and summer seasons.

Methodology

To collect pre-construction data during the winter of 2014/15 and spring/summer of 2015, harbour seals were captured in Loch Fleet (Figure 2) in September 2014 and February 2015. Study individuals were captured using barrier nets as they flushed from their haul-out sites, before being weighed and anaesthetized. Handling and anaesthesia was conducted by suitably trained and licensed personnel, using specialist boats and equipment (see Sharples *et al.* 2012 for full details).

GPS/GSM tags were attached to the hair at the back of the neck using Loctite® 422 Instant Adhesive and the seals released following collection of standard samples and measurements. Seal capture and handling was conducted under the terms of licences issued by the UK Home Office under the Animals (Scientific Procedures) Act 1986 (# 70/7806) and Marine Scotland under the Marine (Scotland) Act 2010.

Results

A total of 25 harbour seals were captured at Loch Fleet and tagged with GPS/GSM tags: twelve harbour seals, six female and six male, in September 2014; and thirteen harbour seals, seven female and six male, in February 2015. The capture histories and latest GPS tracks for the seals captured at Loch Fleet in February 2015 are summarised in Annex 3. Figure 4 shows the tracks from 23rd February – 19th July 2015 for the 13 harbour seals captured in February 2015.

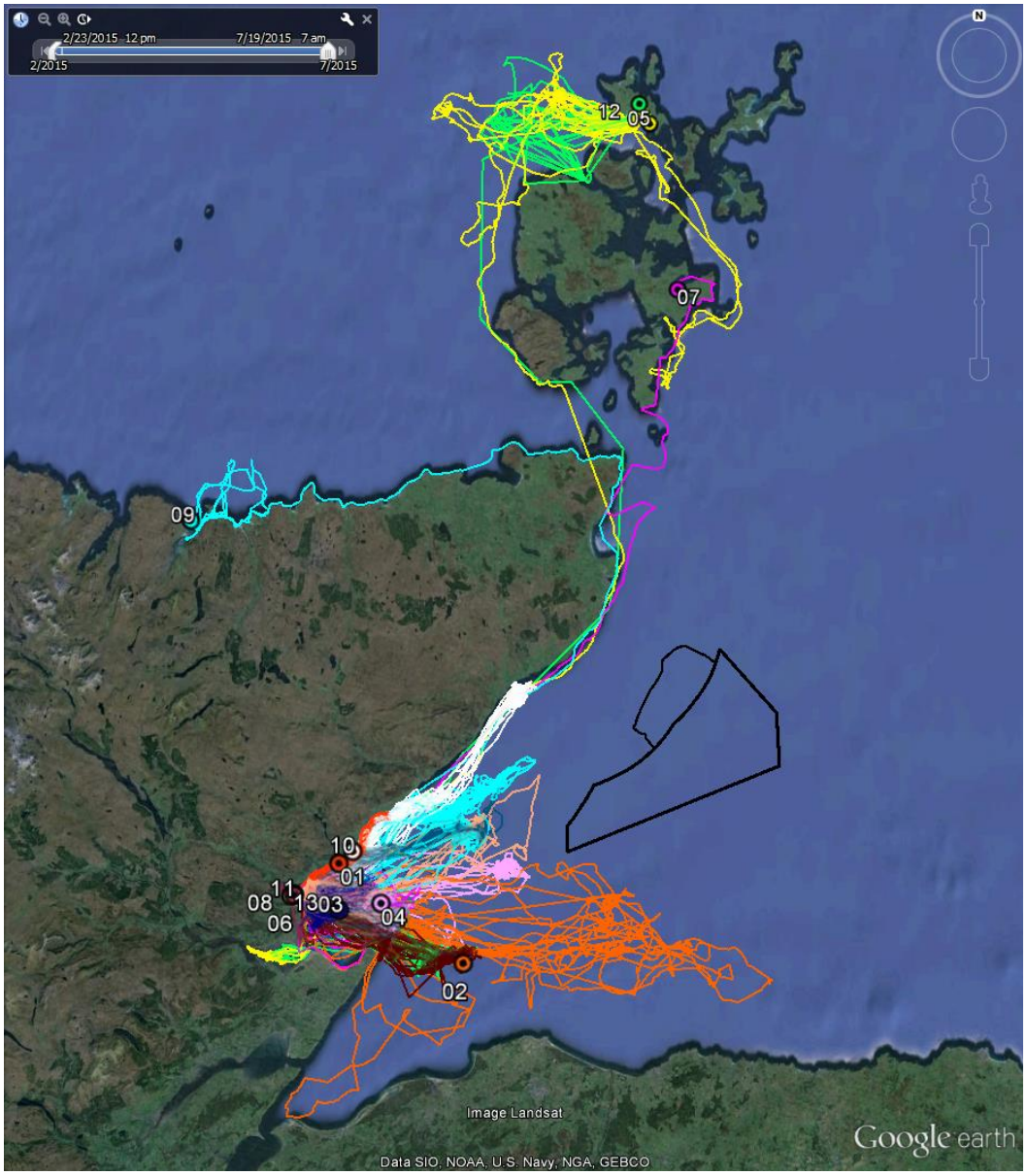


Figure 4. GPS tracks from 23rd February – 19th July 2015 of 13 harbour seals captured at Loch Fleet in February 2015: each colour represents a different individual.

Data Analysis

Data on the locations and activity patterns of individual tagged seals are transmitted via GSM to the University of St Andrews when seals move within range of mobile phone masts. The data are then subject to routine error checking and estimation of summary statistics, and archived on a server from which data can regularly be extracted via a secure web portal.

For the baseline characterization, location data will be used to update the habitat association analyses presented in Bailey, Hammond and Thompson (2014), as used to provide the underlying at-sea distribution for the Moray Firth Seal Assessment Framework. Individual home ranges will be characterised using kernel analysis (see Cordes *et al.* 2011). These data will be used to derive estimates of individual and sex specific differences in the duration and range of foraging trips, and the extent to which different individuals use the wind farm development areas.

These data will also be used to support the design of additional tracking studies during construction, which are required to validate the dose response curves used in the Moray Firth Seal Assessment Framework and identify how long it takes individuals to return to disturbed sites. All location and activity data will be archived as a baseline for more detailed comparison with subsequent data collected during construction.

Bottlenose Dolphin Monitoring Work Packages

WP 2.1: Individual based studies of reproduction and survival

Introduction and Objectives

This work package is being used to assess baseline variability in bottlenose dolphin vital rates. This will permit future comparison with data collected during the construction period.

Parameters to be measured

- Female fecundity;
- Sex specific survival rates.

Survey Design

Established boat-based photo-identification techniques are used to recognise individual bottlenose dolphins from their distinct dorsal fin markings (Figure 5) (Wilson, Hammond & Thompson 1999; Wilson *et al.* 2004; Cheney *et al.* 2013). Following agreed methods for monitoring the population that uses the Moray Firth SAC (Cheney *et al.* 2012), repeated observations can then be used to determine whether or not different females in the population give birth each year. Repeated sightings of known males and females can be used to estimate sex-specific survival rates.

Figure 5. Examples of suitable photographs for individual photo-identification, showing the distinct nicks and tooth rake marks on the left and right side of four individuals that regularly use the Moray Firth SAC.

Methodology

Photo-identification surveys within the Moray Firth SAC were conducted between May and September. Surveys were conducted from the Lighthouse Field Station in Cromarty using a specialist MCA coded workboat. Standard and established protocols for monitoring the Moray Firth SAC have been agreed with SNH (Thompson *et al.* 2004; Cheney *et al.* 2014b). Surveys aimed to target areas that maximise the probability of encountering bottlenose dolphins. Whenever groups were encountered, the boat was manoeuvred at slow speed around the dolphins to allow dorsal fin photographs to be taken with an SLR camera. Surveys aimed to obtain high quality pictures of the left and right sides of the dorsal fins of as many individuals as possible, whilst minimising disturbance and ensuring that as many different members of the group were photographed as possible. All survey work was conducted under SNH licence that permits disturbance to dolphins for scientific research. Surveys were carried out by at least three personnel, including an experienced photographer and a suitably certified boat skipper.

Results

In 2015, a total of 20 photo-identification surveys were conducted in the Moray Firth, from the 9th May to the 30th September (Table 4 and Figure 6). Of these, 1 survey went outside the SAC along the south coast of the Moray Firth (Table 4b and Figure 6).

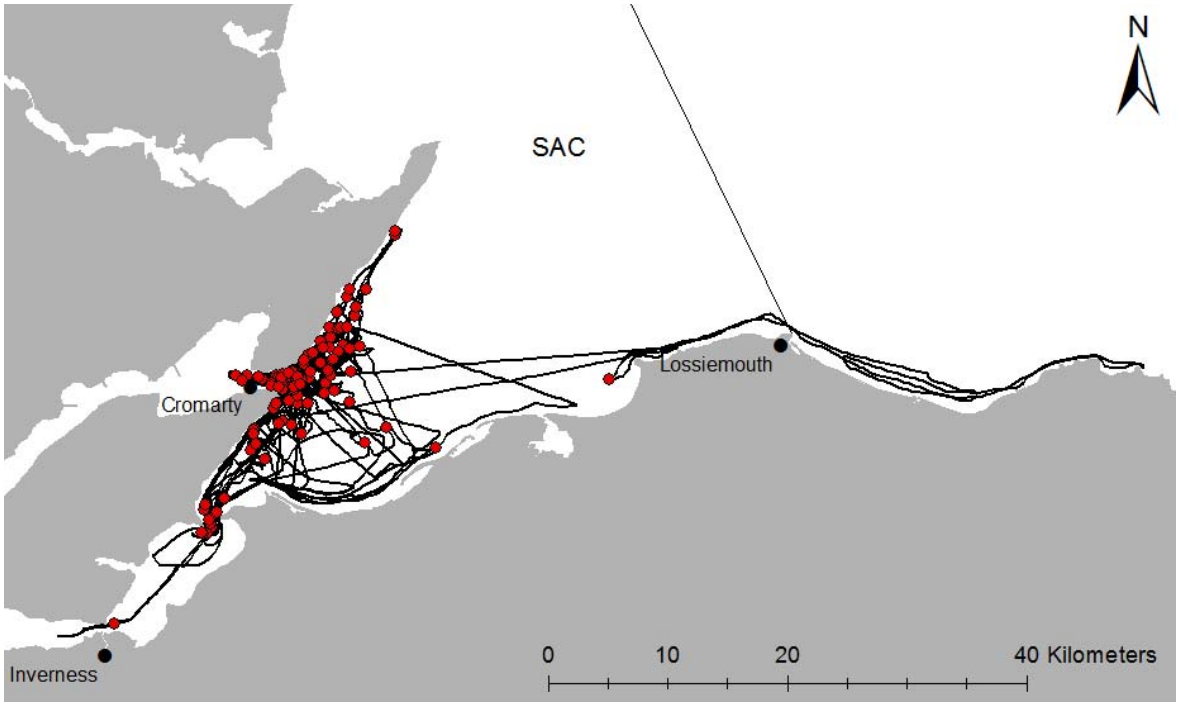


Figure 6. A map showing all the areas covered by photo-identification surveys (black lines) in 2015 and the location of all encounters with groups of bottlenose dolphins (red dots).

Over 124 hours were spent on photo-identification trips within the Moray Firth, with bottlenose dolphins seen on every trip. In total there were 121 encounters with bottlenose dolphins lasting on average 24 minutes each. This makes a total of 49 hours spent with dolphins in the Moray Firth, approximately 39% of our survey time (Table 4a). All of these encounters were within the Moray Firth SAC (Figure 6).

Table 4. 2015 photo-identification survey details, by month, for the Moray Firth (a. all surveys, b. south side Moray Firth).

a.

	Number of Surveys	Survey Duration (hours)	Number of Encounters	Time on Encounters (hours)	% of survey time with dolphins
May	3	16.27	16	5.83	36%
June	4	24.15	24	10.85	45%
July	4	30.33	24	11.07	36%
August	5	28.62	31	10.37	36%
September	4	25.05	26	10.52	42%
Total	**20**	**124.42**	**121**	**48.63**	**39%**

b.

	Number of Surveys	Survey Duration (hours)	Number of Encounters	Time on Encounter (hours)
May	0	0	0	0
June	0	0	0	0
July	0	0	0	0
August	1	10.20	3	1.90
September	0	0	0	0
Total	**1**	**10.20**	**3**	**1.90**

Boat based estimates of group sizes ranged from 1 to 40 dolphins, with a median of 6 (interquartile range = 3 to 12) (Figure 7).

A total of 13,403 photographs were taken during bottlenose dolphin photo-identification surveys in 2015.

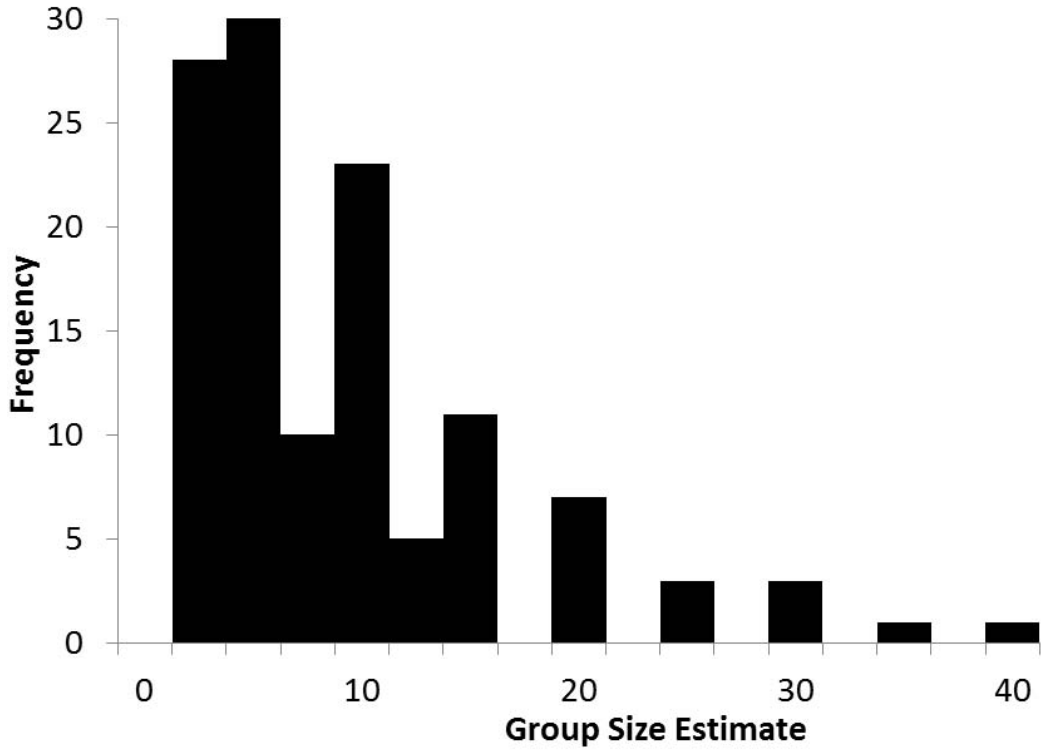


Figure 7. Frequency distribution of different dolphin group sizes (estimated on the boat) during photo-identification surveys in 2015.

Female Fecundity

Identifying newborn calves can be difficult as they have few if any marks on their dorsal fin. However, initial results indicate that 6 different well-known female dolphins and 2 as yet unidentified females were seen in association with a newborn calf in echelon position (where the newborn is seen consistently surfacing alongside or just behind the mother's dorsal fin).

Data Analysis

Analysis of the 2015 data is ongoing. All images have been graded for photographic quality and archived. Approximately 50% of the high quality pictures have now been matched to the existing photo-identification catalogue by an experienced analyst and archived with associated field data. This process will be completed in spring 2016, after which all the initial matches will be confirmed by a second experienced analyst. The resulting observations will be used to create a capture matrix that will be used to provide annual estimates of fecundity and underpin subsequent CMR analyses of survival.

WP 2.2: Trends in abundance

Introduction and Objectives

This work package is being used to assess baseline variability in the abundance of bottlenose within the Moray Firth SAC and relate these numbers to the overall size of the east coast bottlenose population. This will permit future comparison with data collected during the construction period, allowing an assessment of whether far-field disturbance has led to change in the number of dolphins using the SAC.

Parameters to be measured

- Abundance of dolphins using the Moray Firth SAC in each summer;
- Trends in overall population size.

Survey Design

Regular photo-identification surveys have been carried out from May to September (summer) in the Moray Firth SAC from 1990 to 2014. As per WP 2.1 surveys use established boat-based photo-identification techniques to recognise individual bottlenose dolphins using their distinct dorsal fin markings (Wilson, Hammond & Thompson 1999; Wilson *et al.* 2004; Cheney *et al.* 2013). Following agreed methods for monitoring the population that uses the Moray Firth SAC (Thompson *et al.* 2004; Cheney *et al.* 2014b), repeated observations will be used to provide annual estimates of the abundance of bottlenose dolphins within the SAC.

In most years, some data has also been collected during less regular summer surveys in other parts of the population's range (Cheney *et al.* 2013). These data have also been collected using standardised photo-identification procedures (Wilson *et al.* 2004; Quick & Janik 2008; Quick, Rendell & Janik 2008; Islas-Villanueva 2010; Cheney *et al.* 2013). However, the design and number of surveys has varied among survey areas and years.

Methodology

Sampling Techniques

Abundance estimates are based upon the individual based data collected to estimate vital rates outlined in WP 2.1.

To estimate the abundance of dolphins using the Moray Firth SAC each year, sampling was based upon the University of Aberdeen summer boat based photo-identification surveys in 2015.

Our own sampling effort is focussed within the Moray Firth SAC, but analyses of population trends will integrate any additional data available from other parts of the population's range through continued collaboration with other research groups (see Cheney *et al.* 2013).

Results

The results to date from our 2015 photo-identification surveys are outlined in WP 2.1.

Data Analysis

Abundance of dolphins using the Moray Firth SAC in each summer

Initial data processing is ongoing as described for WP 2.1. Data from Moray Firth SAC surveys will be used to create a capture matrix of well-marked individuals seen each year, that will use PROGRAM CAPTURE to provide an annual estimate of the abundance of dolphins within the SAC. This technique is based on the approach described by Wilson, Hammond and Thompson (1999), with modifications described in Cheney *et al.* (2014a).

Trends in overall population size.

A second capture matrix incorporating annual sightings from all available areas will also be updated, and the state-space model described in Corkrey *et al.* (2008) used to provide an updated estimate of trends in the total size of the east coast bottlenose dolphin population (see Cheney *et al.* 2014a for details).

Trends in the proportion of the total population using the SAC will also be investigated (see Cheney *et al.* 2014a for an example).

WP 2.3: Baseline occurrence of dolphins in favoured areas

Introduction and Objectives

This work package is being used to assess baseline variability in the occurrence of bottlenose dolphins at key sites within the Moray Firth SAC and along the southern Moray Firth coast. This will permit future comparison with data collected during the construction period, allowing an assessment of whether far-field disturbance has led to a change in the occurrence of dolphins within these areas.

Parameters to be measured

- Presence of dolphin echolocation clicks in given time periods (minutes, hours and days).

Survey Design

Passive acoustic studies using CPODs will use established techniques for monitoring changes in the occurrence of dolphins in different parts of the SAC. This study design is based on previous studies that have demonstrated that echolocation detections can be used to provide a robust index of occurrence for bottlenose dolphins when compared to visual observations (Philpott *et al.* 2007; Bailey *et al.* 2010). These techniques have subsequently been used to compare broad scale spatial variation in the occurrence of bottlenose dolphins around the east coast of Scotland (Thompson *et al.* 2011) and year to year variation in the occurrence of dolphins at key sites within the Moray Firth SAC (Cheney *et al.* 2012; Cheney *et al.* 2014b). These techniques have the advantage that dolphin occurrence at sampling sites can be remotely monitored for 24 hr/day over periods of several months.

Methodology

Year-round samples are being collected at four long-term monitoring sites (Figure 8). Between May and September of each year, deployments are also being made at four additional sites on the south coast of the Moray Firth (Figure 8). Data are collected using V0 and V1 CPODs using seabed moorings that have been optimised for deployments at these sites, and licensed for scientific use by Marine Scotland (# 04860/14/0) and consented by the Crown Estate.

Deployments and recoveries have been made using specialist workboats operated by Moray First Marine, who have extensive experience of these activities through previous work for the University of Aberdeen on Department of Energy and Climate Change funded studies (Thompson *et al.* 2013a) and during baseline data collection for MORL and BOWL.

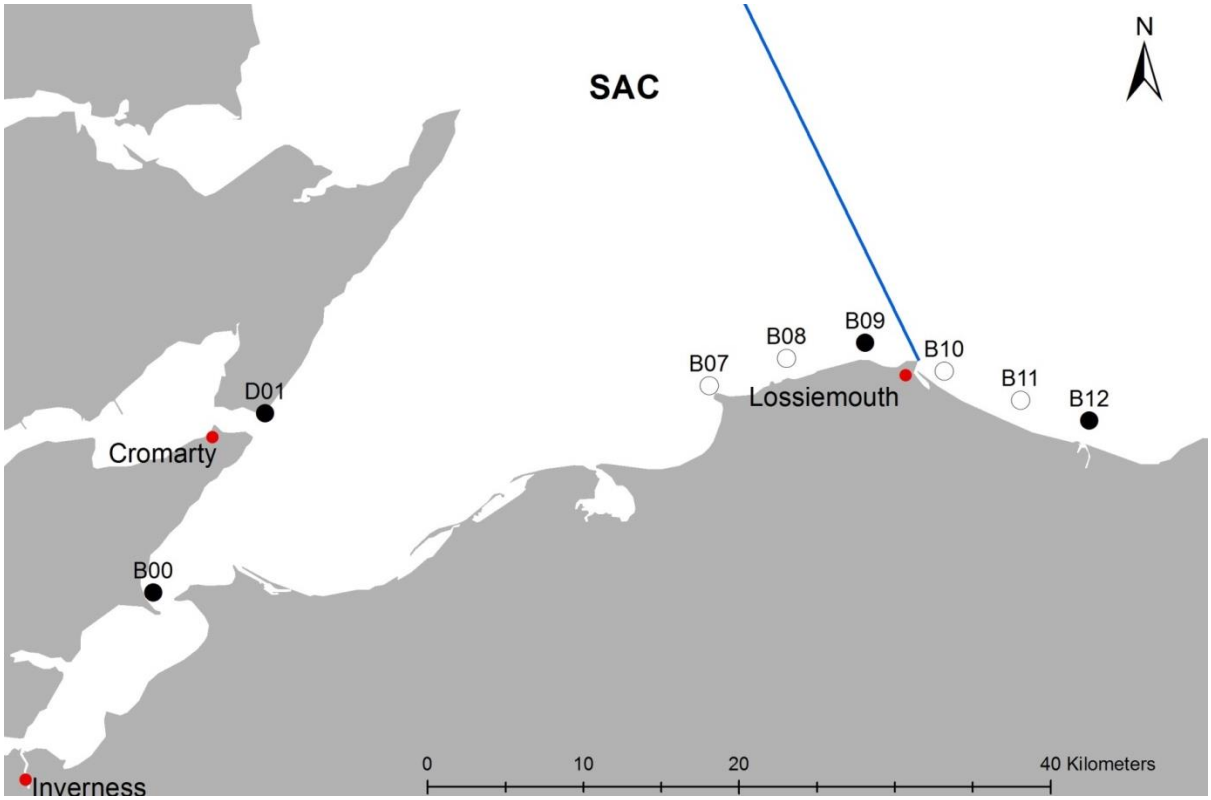


Figure 8. A map showing the CPOD locations (long-term sites = black circles; summer only sites = clear circles). The location of the Moray Firth SAC is shown.

Table 5. Deployment and recovery details for the CPODs at the four long-term and four additional sites on the south coast.

Location	Deployment Date	Recovery Date	Data
Long-term sites:			
Sutors (D01)	09/04/15	02/07/15	✓
	02/07/15	09/10/15	✓
	09/10/15		
Chanonry (B00)	19/03/15	02/07/15	✓
	02/07/15	09/10/15	✓
	09/10/15		
Lossiemouth (B09)	19/03/15	29/06/15	✓
	29/06/15	10/10/15	✓
	10/10/15		
Spey Bay (B12)	24/03/15	29/06/15	✓
	29/06/15	05/10/15	✓
	05/10/15		
Additional south coast sites:			
B07	23/05/15	08/10/15	✓
B08	23/05/15	08/10/15	✓
B10	23/05/15	05/10/15	✓
B11	23/05/15	05/10/15	✓

Results

Details of the CPOD deployments and recoveries are shown in Table 5.

Data Analysis

Analysis of the 2015 data is ongoing. Data were downloaded using the manufacturer's software, which is also used to identify clicks trains and categorise these as either porpoise or dolphin clicks. Only click trains categorized with high or medium confidence will be used in subsequent analyses (Brookes, Bailey & Thompson 2013). Data are currently being processed using established routines and will be summarised to provide an indication of whether click trains were detected in each minute or hour of the day. Spatial and temporal variation in occurrence will then be expressed in terms of detection positive hours per day, or distributions of waiting times. Further details of the analysis approaches to be used are provided in Bailey *et al.* (2010); Thompson *et al.* (2010); Brookes, Bailey and Thompson (2013); Thompson *et al.* (2013a).

REFERENCES

Bailey, H., Clay, G., Coates, E.A., Lusseau, D., Senior, B. & Thompson, P.M. (2010) Using T-PODs to assess variations in the occurrence of coastal bottlenose dolphins and harbour porpoises. *Aquatic Conservation: Marine and Freshwater Ecosystems,* **20,** 150-158.

Bailey, H., Hammond, P.S. & Thompson, P.M. (2014) Modelling harbour seal habitat by combining data from multiple tracking. *Journal of Experimental Marine Biology and Ecology,* **450,** 30-39.

Brookes, K.L., Bailey, H. & Thompson, P.M. (2013) Predictions from harbor porpoise habitat association models are confirmed by long-term passive acoustic monitoring. *Journal of the Acoustical Society of America,* **134,** 2523-2533.

Cheney, B., Corkrey, R., Durban, J.W., Grellier, K., Hammond, P.S., Islas-Villanueva, V., Janik, V.M., Lusseau, S.M., Parsons, K.M., Quick, N.J., Wilson, B. & Thompson, P.M. (2014a) Long-term trends in the use of a protected area by small cetaceans in relation to changes in population status. *Global Ecology and Conservation,* **2,** 118-128.

Cheney, B., Corkrey, R., Quick, N.J., Janik, V.M., Islas-Villanueva, V., Hammond, P.S. & Thompson, P.M. (2012) Site Condition Monitoring of bottlenose dolphins within the Moray Firth Special Area of Conservation: 2008 - 2010. pp. 41. Scottish Natural Heritage, Inverness.

Cheney, B., Graham, I.M., Barton, T.R., Hammond, P.S. & Thompson, P.M. (2014b) Site Condition Monitoring of bottlenose dolphins within the Moray Firth Special Area of Conservation: 2011-2013. Scottish Natural Heritage, Inverness.

Cheney, B., Thompson, P.M., Ingram, S.N., Hammond, P.S., Stevick, P.T., Durban, J.W., Culloch, R.M., Elwen, S.H., Mandleberg, L., Janik, V.M., Quick, N.J., Islas-Villanueva, V., Robinson, K.P., Costa, M., Eisfeld, S.M., Walters, A., Phillips, C., Weir, C.R., Evans, P.G.H., Anderwald, P., Reid, R.J., Reid, J.B. & Wilson, B. (2013) Integrating multiple data sources to assess the distribution and abundance of bottlenose dolphins Tursiops truncatus in Scottish waters. *Mammal Review,* **43,** 71-88.

Cordes, L.S., Duck, C.D., Mackey, B.L., Hall, A.J. & Thompson, P.M. (2011) Long-term patterns in harbour seal site-use and the consequences for managing protected areas. *Animal Conservation,* **14,** 430-438.

Cordes, L.S. & Thompson, P.M. (2013) Variation in breeding phenology provides insights into drivers of long-term population change in harbour seals. *Proceedings of the Royal Society B-Biological Sciences,* **280**.

Cordes, L.S. & Thompson, P.M. (2014) Mark-recapture modeling accounting for state uncertainty provides concurrent estimates of survival and fecundity in a protected harbor seal population. *Marine Mammal Science,* **30,** 691-705.

Cordes, L.S. & Thompson, P.M. (2015) Mark-resight estimates of seasonal variation in harbor seal abundance and site fidelity. *Population Ecology,* **57,** 467-472.

Corkrey, R., Brooks, S., Lusseau, D., Parsons, K., Durban, J.W., Hammond, P.S. & Thompson, P.M. (2008) A Bayesian Capture-Recapture Population Model With Simultaneous Estimation of Heterogeneity. *Journal of the American Statistical Association,* **103,** 948-960.

Huber, H.R., Jeffries, S.J., Brown, R.F., DeLong, R.L. & VanBlaricom, G. (2001) Correcting aerial survey counts of harbor seals (Phoca vitulina richardsi) in Washington and Oregon. *Marine Mammal Science,* **17,** 276-293.

Islas-Villanueva, V. (2010) Genetic characterisation and social structure of the East Scotland population of bottlenose dolphins (Tursiops truncatus). PhD, University of St. Andrews.

Lonergan, M., Duck, C.D., Thompson, D., Mackey, B.L., Cunningham, L. & Boyd, I.L. (2007) Using sparse survey data to investigate the declining abundance of British harbour seals. *Journal of Zoology,* **271,** 261-269.

Philpott, E., Englund, A., Ingram, S. & Rogan, E. (2007) Using T-PODs to investigate the echolocation of coastal bottlenose dolphins. *Journal of the Marine Biological Association of the United Kingdom,* **87,** 11-17.

Quick, N.J. & Janik, V.M. (2008) Whistle rates of wild bottlenose dolphins (Tursiops truncatus): Influences of group size and behavior. *Journal of Comparative Psychology,* **122,** 305-311.

Quick, N.J., Rendell, L.E. & Janik, V.M. (2008) A mobile acoustic localization system for the study of free-ranging dolphins during focal follows. *Marine Mammal Science,* **24,** 979-989.

SCOS (2012) Scientific Advice on Matters Related to the Management of Seal Populations: 2012.

Sharples, R.J., Moss, S.E., Patterson, T.A. & Hammond, P.S. (2012) Spatial Variation in Foraging Behaviour of a Marine Top Predator (Phoca vitulina) Determined by a Large-Scale Satellite Tagging Program. *Plos One,* **7**.

Thompson, P.M., Brookes, K.L., Graham, I.M., Barton, T.R., Needham, K., Bradbury, G. & Merchant, N.D. (2013a) Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises. *Proceedings of the Royal Society B: Biological Sciences,* **280**.

Thompson, P.M., Cheney, B., Ingram, S., Stevick, P., Wilson, B. & Hammond, P.S. (2011) Distribution, abundance and population structure of bottlenose dolphins in Scottish waters. pp. 94. Scottish Natural Heritage, Perth.

Thompson, P.M. & Harwood, J. (1990) Methods for estimating the population size of common seals, *Phoca vitulina*. *Journal of Applied Ecology,* **27,** 924-938.

Thompson, P.M., Hastie, G.D., Nedwell, J., Barham, R., Brookes, K.L., Cordes, L.S., Bailey, H. & McLean, N. (2013b) Framework for assessing impacts of pile-driving noise from offshore wind farm construction on a harbour seal population. *Environmental Impact Assessment Review,* **43,** 73-85.

Thompson, P.M., Lusseau, D., Barton, T., Simmons, D., Rusin, J. & Bailey, H. (2010) Assessing the responses of coastal cetaceans to the construction of offshore wind turbines. *Marine Pollution Bulletin,* **60,** 1200-1208.

Thompson, P.M., Lusseau, D., Corkrey, R. & Hammond, P.S. (2004) Moray Firth bottlenose dolphin monitoring strategy options. pp. 52. Scottish Natural Heritage, Edinburgh.

Thompson, P.M., Mackey, B., Barton, T.R., Duck, C. & Butler, J.R.A. (2007) Assessing the potential impact of salmon fisheries management on the conservation status of harbour seals (Phoca vitulina) in north-east Scotland. *Animal Conservation,* **10,** 48-56.

Thompson, P.M., McConnell, B.J., Tollit, D.J., Mackay, A., Hunter, C. & Racey, P.A. (1996) Comparative distribution, movements and diet of harbour and grey seals from the Moray Firth, NE Scotland. *Journal of Applied Ecology,* **33,** 1572-1584.

Thompson, P.M., Tollit, D.J., Wood, D., Corpe, H.M., Hammond, P.S. & Mackay, A. (1997) Estimating harbour seal abundance and status in an estuarine habitat in north-east Scotland. *Journal of Applied Ecology,* **34,** 43-52.

Thompson, P.M. & Wheeler, H. (2008) Photo-ID-based estimates of reproductive patterns in female harbor seals. *Marine Mammal Science,* **24,** 138-146.

Wilson, B., Hammond, P.S. & Thompson, P.M. (1999) Estimating size and assessing trends in a coastal bottlenose dolphin population. *Ecological Applications,* **9,** 288-300.

Wilson, B., Reid, R.J., Grellier, K., Thompson, P.M. & Hammond, P.S. (2004) Considering the temporal when managing the spatial: a population range expansion impacts protected areas-based management for bottlenose dolphins. *Animal Conservation,* **7,** 331-338.

ANNEX 1. *Rationale for prioritization of monitoring for different marine mammal species as presented in earlier consultation documents.*

Harbour seal	**High priority** species for monitoring at Moray Firth sites • Due to proximity to the Dornoch Firth and Morrich More SAC • Because of predictions of significant short-term impacts on this SAC population in the ES under conservative worst case scenarios • To reduce uncertainties and improve predictions of most likely impacts using the Moray Firth Seal Assessment Framework.
Bottlenose dolphin	**High priority** species for monitoring at Moray Firth sites • Due to proximity of Moray Firth SAC • Monitoring is required in the SAC and along southern Moray Firth coast to test worst case predictions of partial displacement and assess whether this influences movements between the SAC and other parts of their East coast range.
Harbour porpoise	**Medium priority** species for monitoring at Moray Firth sites • No local SAC population • Predictions of significant short-term impacts through displacement are likely to be common at other sites • Excellent baseline from previous studies in the area provides opportunities to reduce uncertainty over spatial and temporal scale of displacement and potential for habituation.
Grey seal	**Low priority** species for monitoring at Moray Firth sites • No local SAC population • Although some displacement from foraging areas is predicted, local breeding sites are small • It is anticipated that monitoring of impacts on grey seals will be focused around Firth of Forth developments due to the existence of larger population sizes, local SACs and existing research infrastructure.
Minke whale	**Low priority** species for monitoring at Moray Firth sites • Some displacement predicted, but low and variable numbers of animals mean that there is low power to detect impacts • These animals are part of a large mobile population, meaning that any monitoring should be conducted at a broader scale or at other sites (e.g. Dogger Bank) which hold larger numbers of animals.

ANNEX 2. *Key questions that could be addressed through wind farm monitoring programme as presented in earlier consultation documents.*

Harbour seal	*Short-term* 1) To what extent are foraging harbour seals displaced by piling activity compared to worst-case scenarios in the Moray Firth Seal Assessment Framework that used proxy data from harbour porpoises? 2) If displaced during piling, do seals return to foraging areas between piling events; how does this reduce worst-case assumptions that seals are excluded from foraging areas year-round throughout construction? *Medium-term* 3) Does individual condition or reproduction at local sites decline during construction years as predicted under worst case scenarios? *Long-term* 4) Does construction noise cause PTS? 5) Do long-term survival or reproduction rates vary in relation either to variation in noise exposure or variation in hearing thresholds? 6) What are the long-term trends in abundance within the Moray Firth seal management unit in relation to other UK and European populations? 7) Do increases in vessel activity pose any additional threats to harbour seals?
Bottlenose dolphin	*Short-term* 8) Does the occurrence of bottlenose dolphins along the southern Moray Firth coast vary in relation to levels of offshore piling activity? *Medium- and long-term* 9) Are there changes in the vital rates of bottlenose dolphins using the SAC? 10) Are there changes in the numbers of bottlenose dolphins using the SAC, or the use of different parts of their overall range, in response to different wind farm construction programmes along the East coast of Scotland?
Harbour porpoise	*Short-term* 11) Can data from Horns Rev II be used as a proxy for the levels of displacement from piling at other sites? 12) How soon do porpoises return to affected areas once piling ends? *Medium-term* 13) Do porpoises become habituated or learn to tolerate piling noise during a prolonged construction period? *Long-term* 14) Are there long-term increases or decreases in porpoise density within the operational wind farm sites?

ANNEX 3. *Summary information, sightings histories and recent movements of the 13 harbour seals captured and tagged in Loch Fleet during February 2015.*

Seal ID # 042

Vital Stats

- Adult
- Female
- First seen 2006
- Breeding female
- 9 pups
- 14/04/2009 - captured at Loch Fleet and fitted with GPS tag

Sightings and Pupping History

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seen	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pup	✓	✓	✓	✓	✓	✓	✓	✓	✓	-

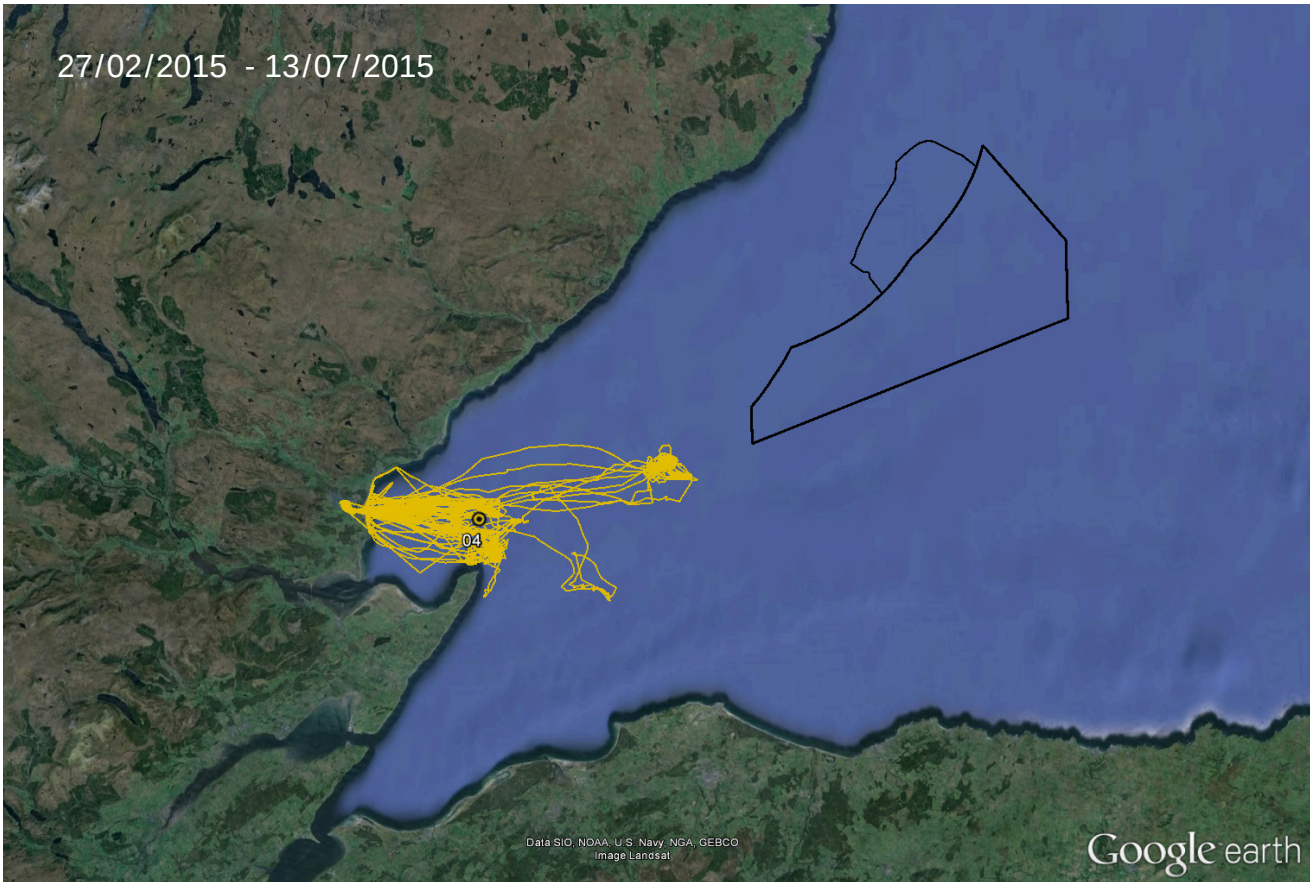
Best Right (2014)

Best Left (2014)

Capture Information

Date captured	27/02/2015
Location	Loch Fleet - SB2
Weight	83.2 kg
Length	144.0 cm
Girth	107.0 cm
Sex	Female
Flipper tag #	00558
GPS/GSM tag attached	Yes
GPS/GSM tag #	13120

Latest GPS Tracks



Seal ID # 076

Vital Stats

- Adult
- Female
- First seen 2006
- Breeding female
- 4 pups
- 19/09/2008 - captured at Loch Fleet and fitted with RFID tag

Sightings and Pupping History

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seen	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pup	✗	✗	✓	✗	✓	✓	✗	✓	✗	-

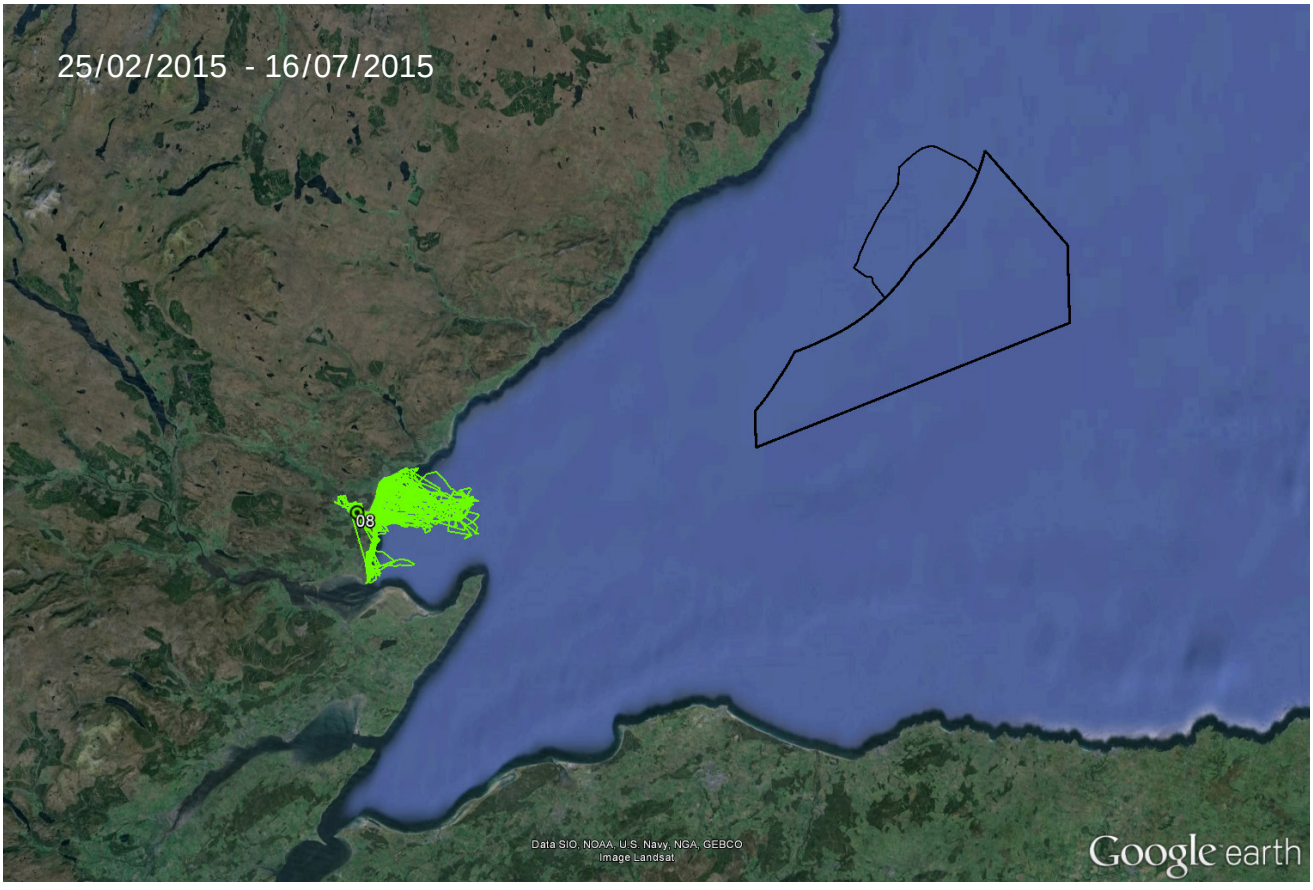
Best Right (2014)

Best Left (2014)

Capture Information

Date captured	25/02/2015
Location	Loch Fleet - SB2
Weight	71.7 kg
Length	135.0 cm
Girth	100.0 cm
Sex	Female
Flipper tag #	00554
GPS/GSM tag attached	Yes
GPS/GSM tag #	13314

Latest GPS Tracks



Seal ID # 105

Vital Stats

- Adult
- Female
- First seen 2006
- Breeding female
- 7 pups
- Not captured before.


2014

Sightings and Pupping History

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seen	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pup	✗	✗	✓	✓	✓	✓	✓	✓	✓	-

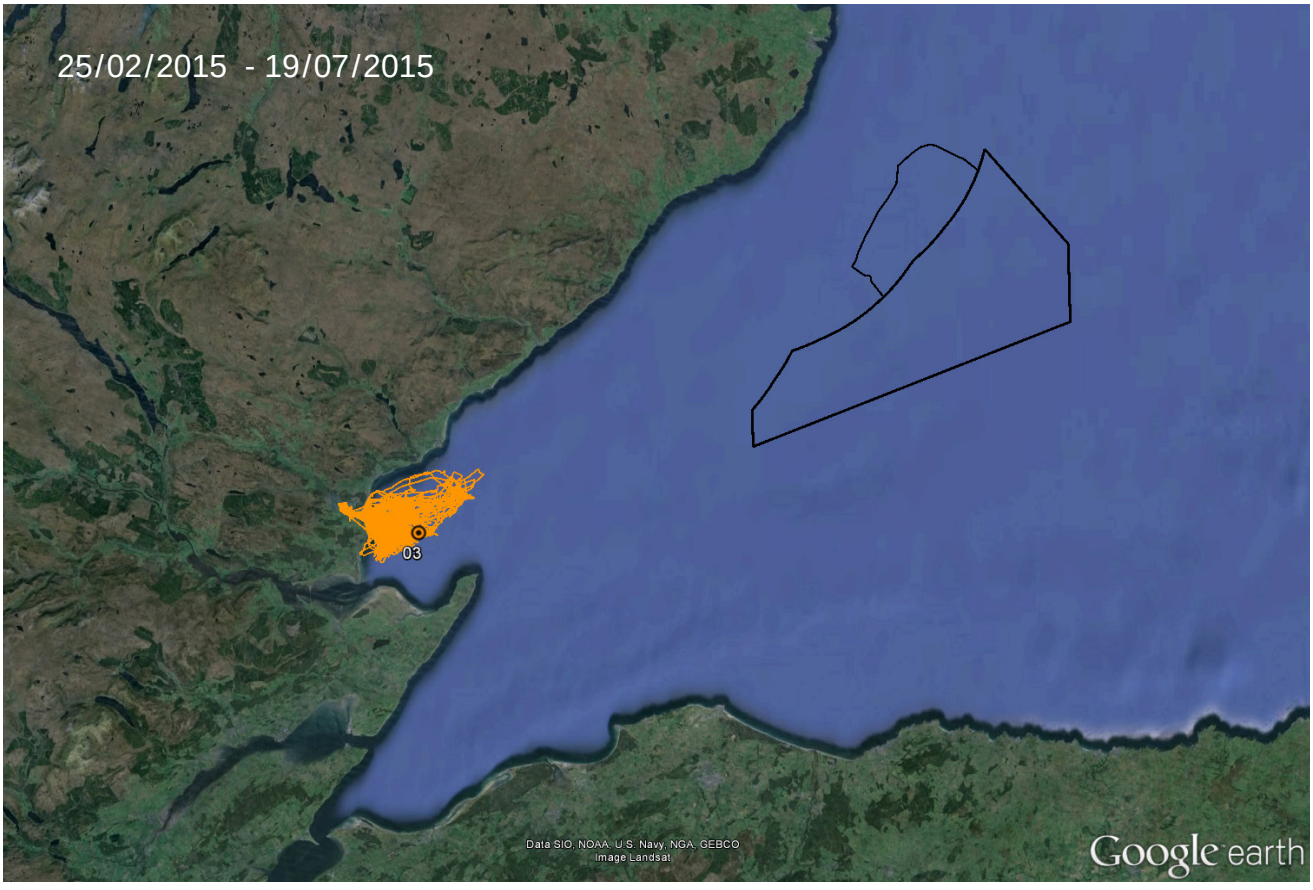
Best Right (2014)

Best Left (2014)

Capture Information

Date captured	25/02/2015
Location	Loch Fleet - SB2
Weight	86.3 kg
Length	139.0 cm
Girth	111.0 cm
Sex	Female
Flipper tag #	00545
GPS/GSM tag attached	Yes
GPS/GSM tag #	13203

Latest GPS Tracks



Seal ID # 158

Vital Stats

- Adult
- Female
- First seen 2006
- Breeding female
- 5 pups
- 18/09/2008 - captured at Loch Fleet and fitted with RFID tag

Sightings and Pupping History

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seen	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pup	✗	✗	✓	✓	✓	✗	✓	✗	✓	-

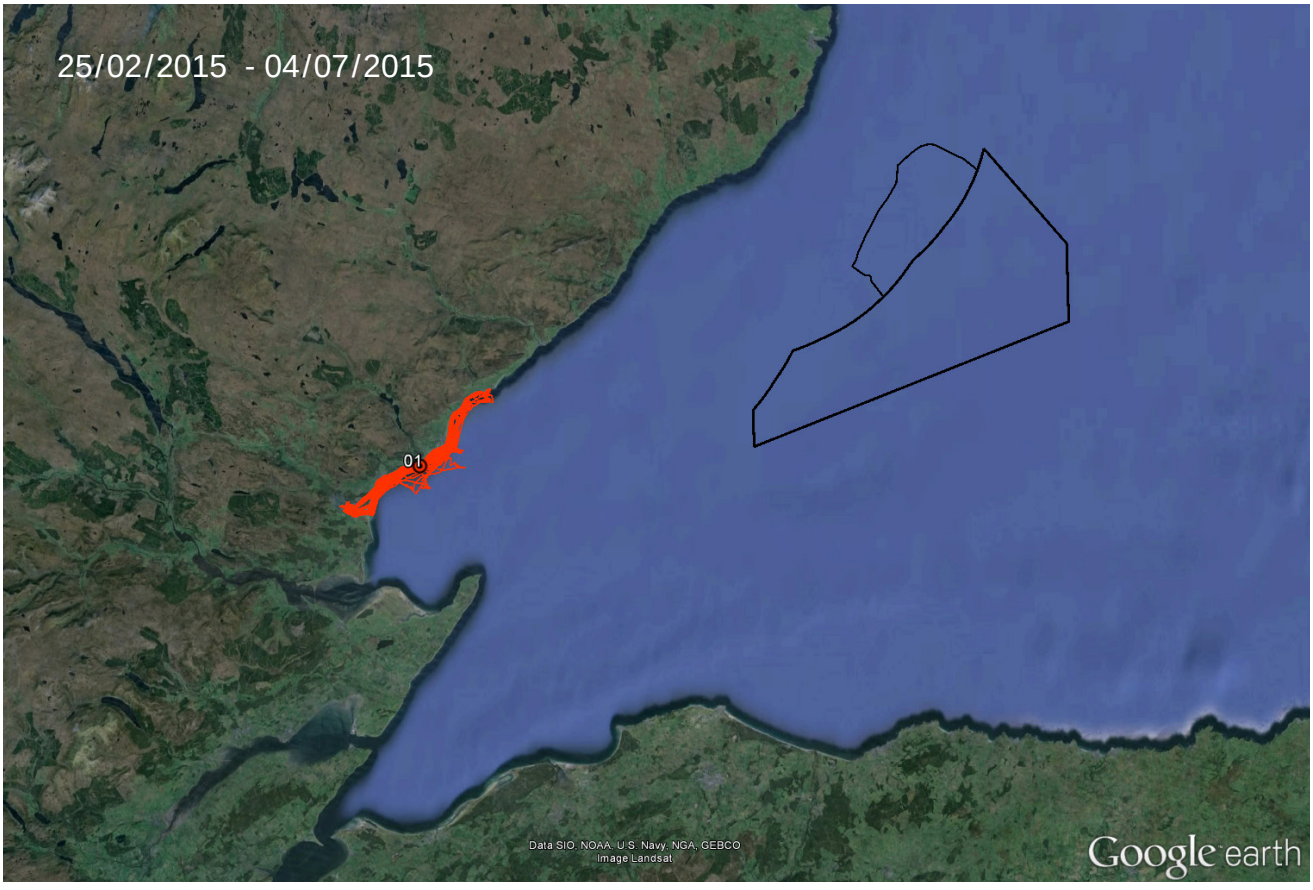
Best Right (2014)

Best Left (2014)

Capture Information

Date captured	25/02/2015
Location	Loch Fleet - SB2
Weight	94.5 kg
Length	145.0 cm
Girth	106.0 cm
Sex	Female
Flipper tag #	00548
GPS/GSM tag attached	Yes
GPS/GSM tag #	13286

Latest GPS Tracks



Seal ID # 341

Vital Stats

- Adult
- Female
- First seen 2014
- Never seen with a pup
- Not captured before

Sightings and Pupping History

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seen	✘	✘	✘	✘	✘	✘	✘	✘	✓	✓
Pup	✘	✘	✘	✘	✘	✘	✘	✘	✘	-

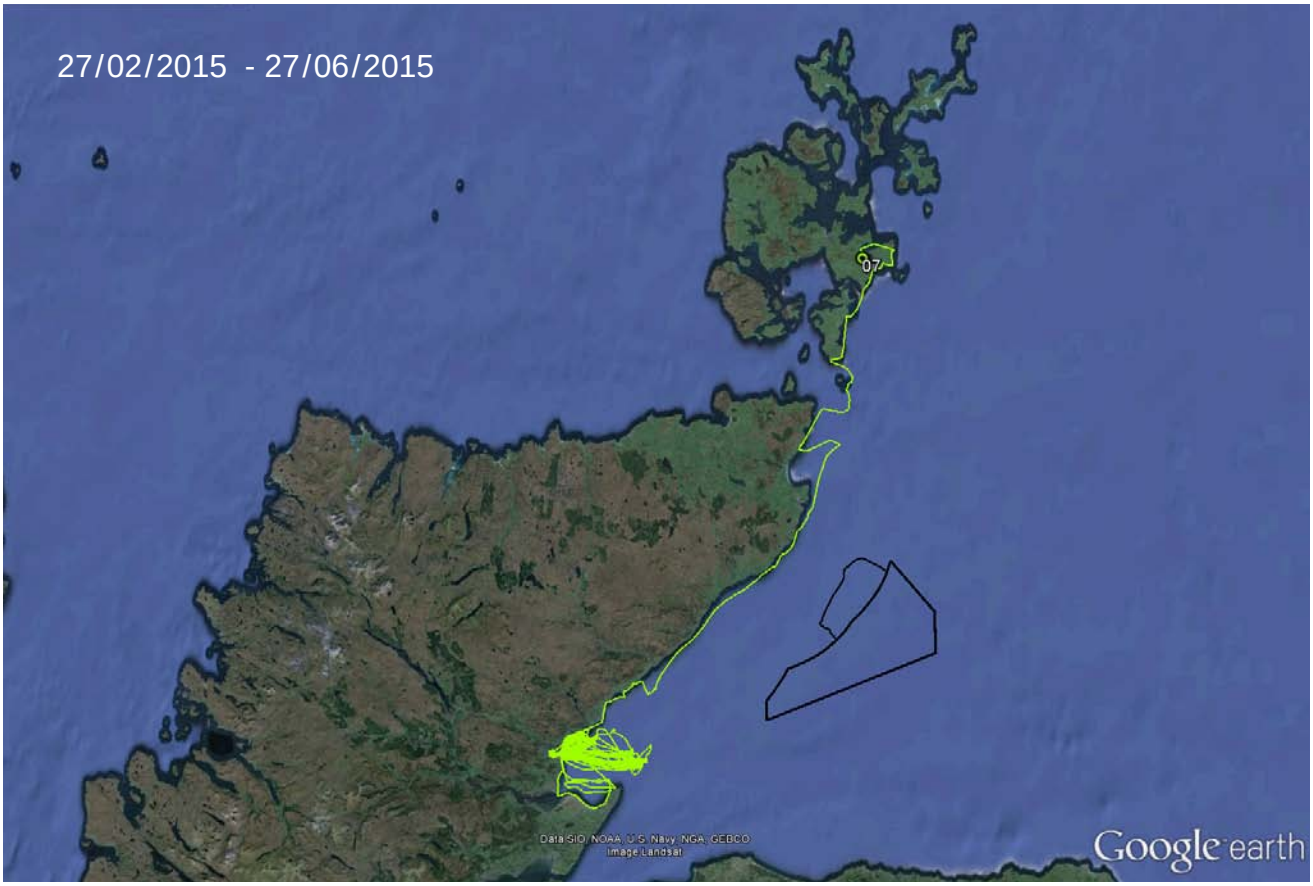
Best Right (2014)

Best Left (2014)

Capture Information

Date captured	27/02/2015
Location	Loch Fleet - SB2
Weight	73.1 kg
Length	141.0 cm
Girth	108.0 cm
Sex	Female
Flipper tag #	00550
GPS/GSM tag attached	Yes
GPS/GSM tag #	13318

Latest GPS Tracks



Seal ID # 383

Vital Stats

- Adult
- Female
- No ID before capture
- Not captured before

Sightings and Pupping History

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seen	✘	✘	✘	✘	✘	✘	✘	✘	✘	✓
Pup	✘	✘	✘	✘	✘	✘	✘	✘	✘	-

Best Right

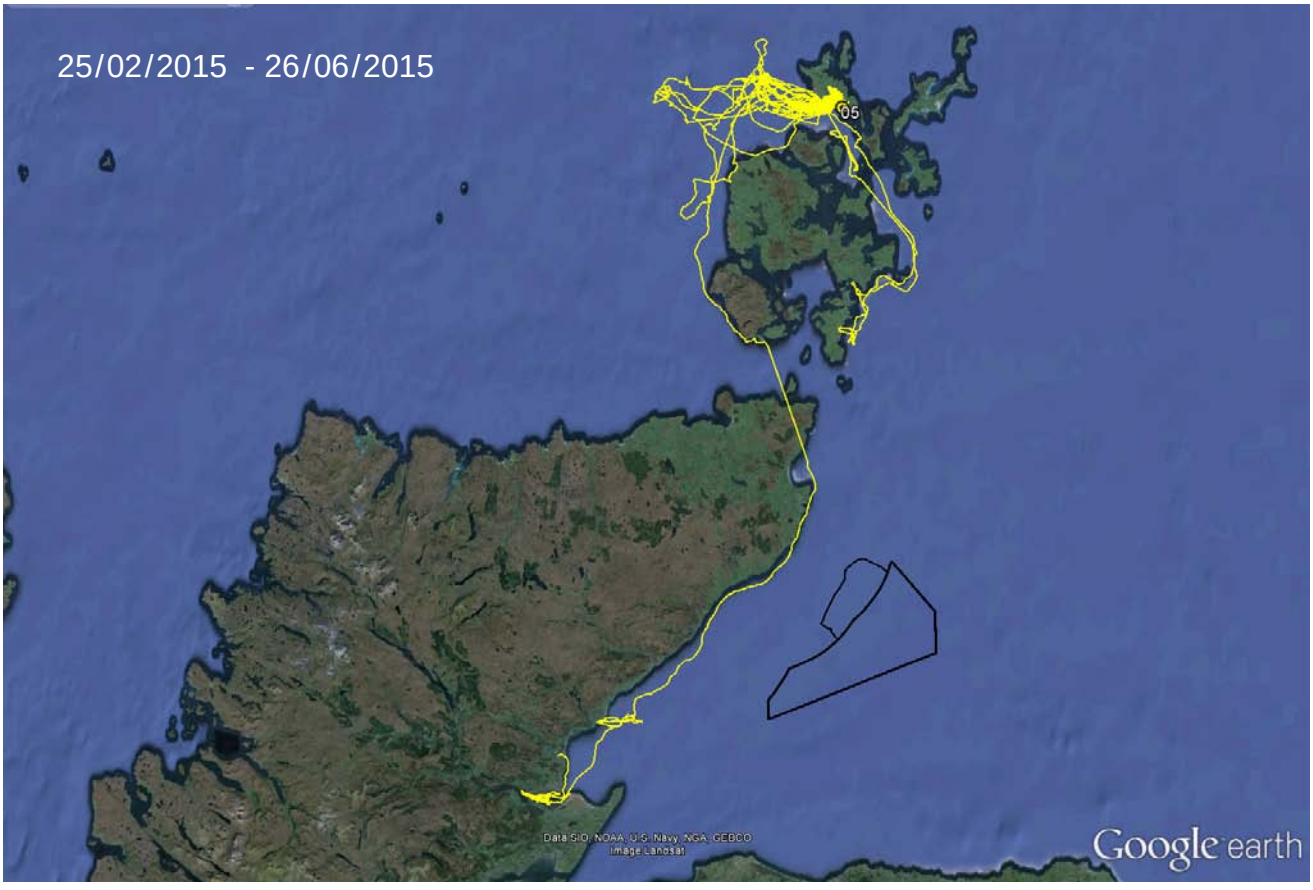
Best Left

- Before capture this seal had no ID number.

Capture Information

Date captured	25/02/2015
Location	Loch Fleet - SB2
Weight	89.7 kg
Length	144.0 cm
Girth	103.0 cm
Sex	Female
Flipper tag #	00531
GPS/GSM tag attached	Yes
GPS/GSM tag #	13322

Latest GPS Tracks



Seal ID # 384

Vital Stats

- Adult
- Female
- No ID before capture
- Not captured before

Sightings and Pupping History

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seen	✘	✘	✘	✘	✘	✘	✘	✘	✘	✓
Pup	✘	✘	✘	✘	✘	✘	✘	✘	✘	-

Best Right

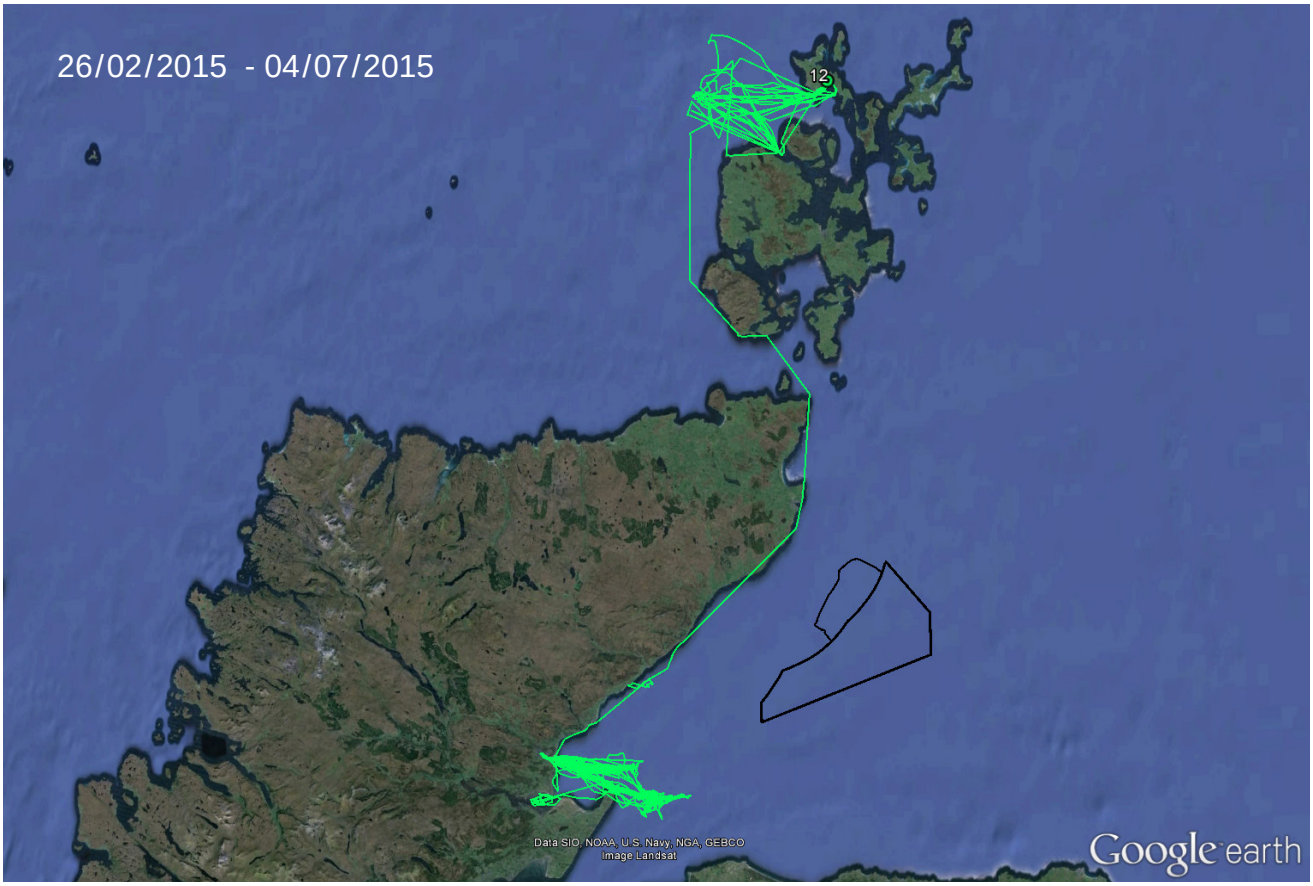
Best Left

- Before capture this seal had no ID number.

Capture Information

Date captured	26/02/2015
Location	Loch Fleet - SB2
Weight	94.0 kg
Length	143.0 cm
Girth	112.0 cm
Sex	Female
Flipper tag #	00555
GPS/GSM tag attached	Yes
GPS/GSM tag #	13320

Latest GPS Tracks



Seal ID # 072

Vital Stats

- Adult
- Male
- First seen 2006
- Not captured before

Sightings History

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seen	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

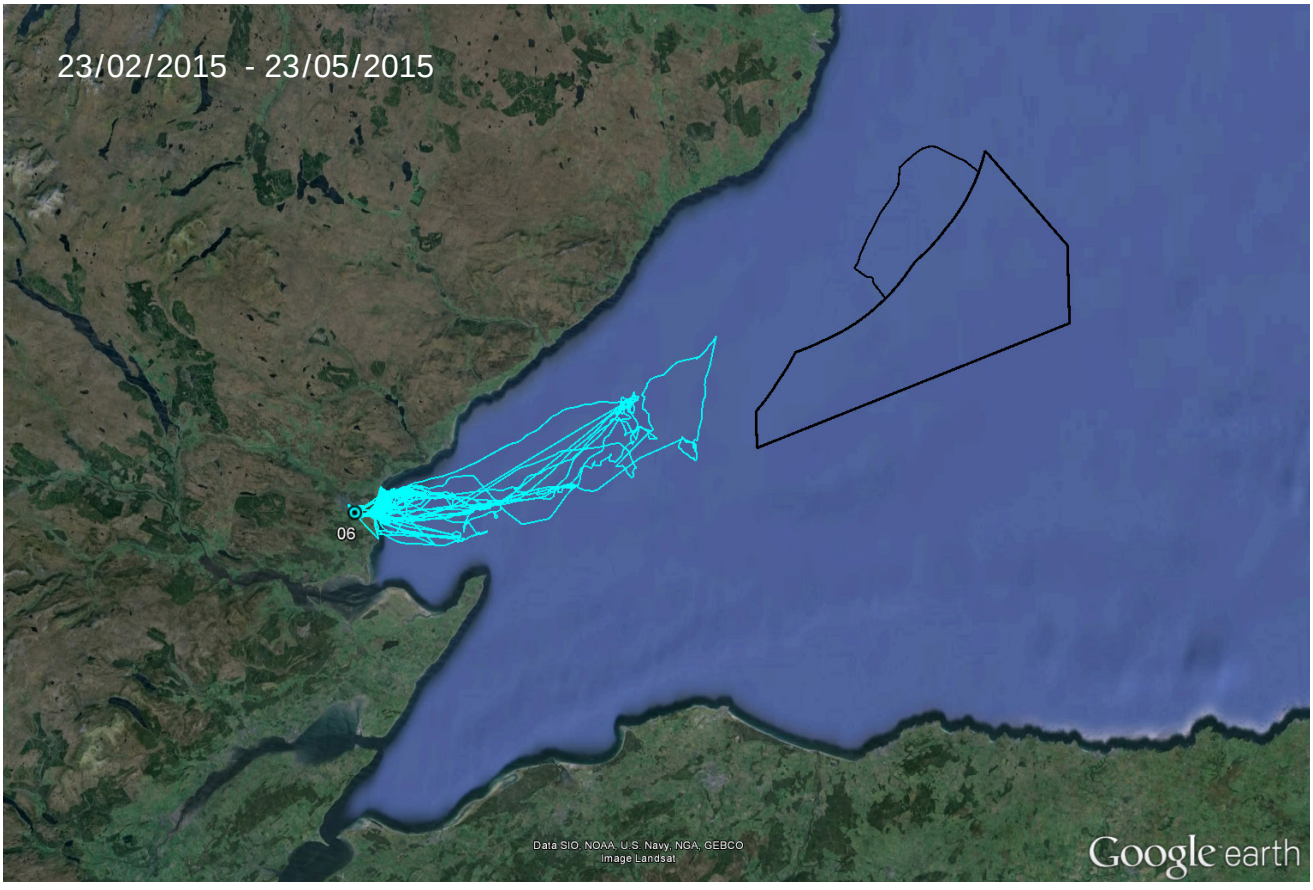
Best Right (2014)

Best Left (2014)

Capture Information

Date captured	23/02/2015
Location	Loch Fleet - SB2
Weight	83.4 kg
Length	142.0 cm
Girth	111.0 cm
Sex	Male
Flipper tag #	00544
GPS/GSM tag attached	Yes
GPS/GSM tag #	13282

Latest GPS Tracks



Seal ID # 099

Vital Stats

- Adult
- Male
- First seen 2006
- Not captured before

Sightings History

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seen	✓	✓	✓	✓	✓	✗	✗	✗	✓	✓

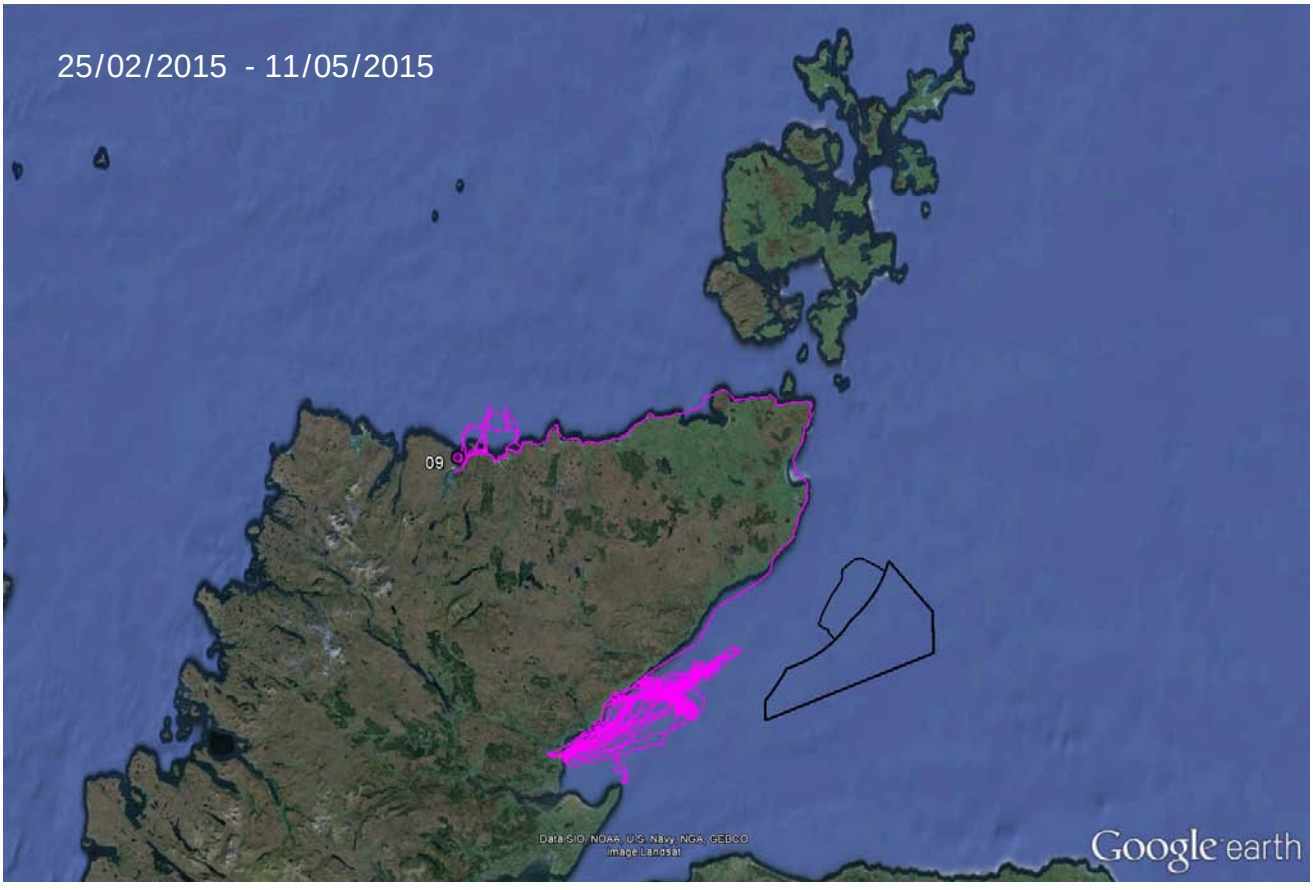
Best Right (2014)

Best Left (2014)

Capture Information

Date captured	25/02/2015
Location	Loch Fleet - SB2
Weight	94.9 kg
Length	154.0 cm
Girth	115.0 cm
Sex	Male
Flipper tag #	00543
GPS/GSM tag attached	Yes
GPS/GSM tag #	13313

Latest GPS Tracks



Seal ID # 230

Vital Stats

- Adult
- Male
- First seen 2009
- Not captured before

Sightings History

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seen	✘	✘	✘	✓	✘	✓	✓	✓	✓	✓

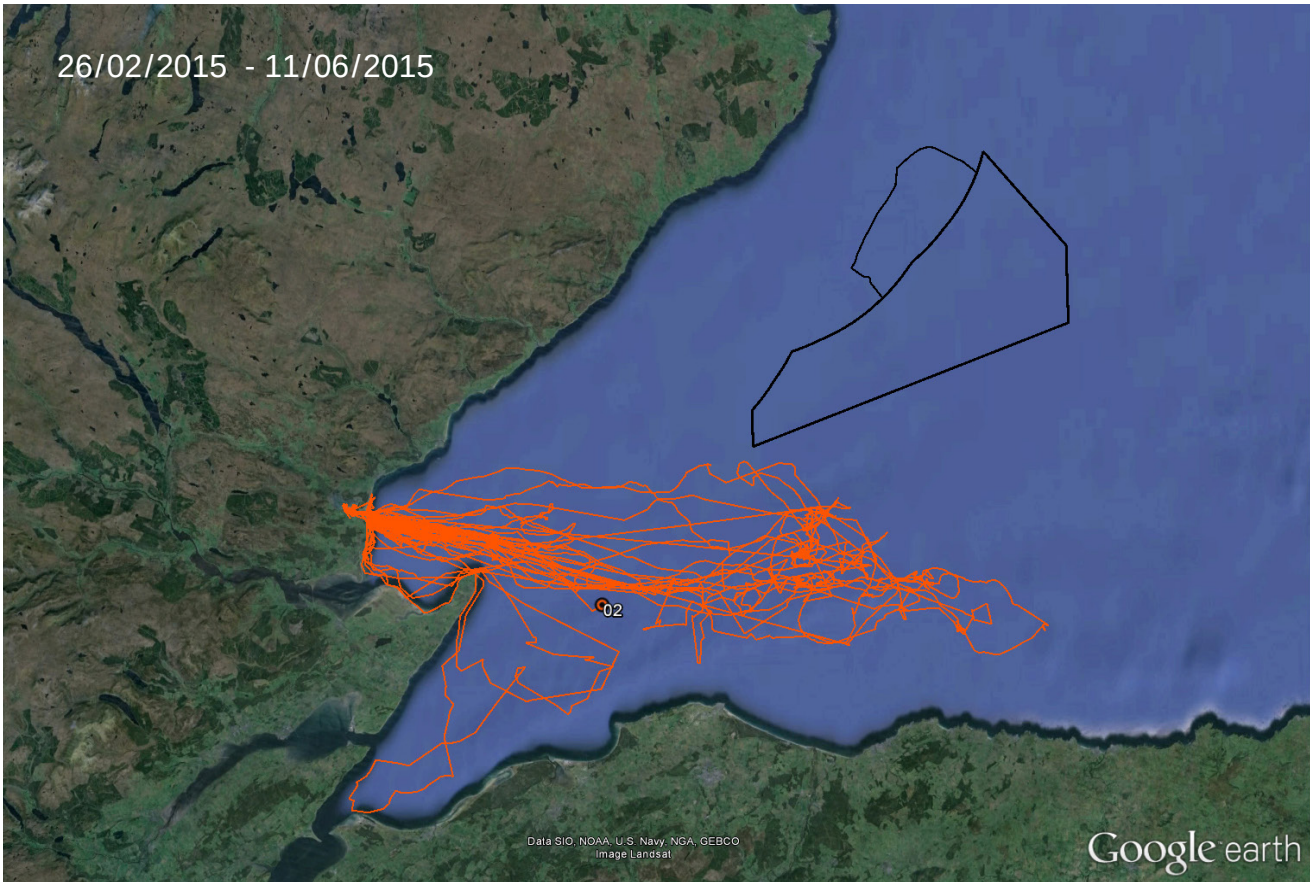
Best Right (2014)

Best Left (2014)

Capture Information

Date captured	26/02/2015
Location	Loch Fleet - SB2
Weight	90.6 kg
Length	149.0 cm
Girth	115.0 cm
Sex	Male
Flipper tag #	00553
GPS/GSM tag attached	Yes
GPS/GSM tag #	13284

Latest GPS Tracks



Seal ID # 264

Vital Stats

- Adult
- Male
- First seen 2012
- Not captured before

Sightings History

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seen	✘	✘	✘	✘	✘	✘	✓	✓	✓	✓

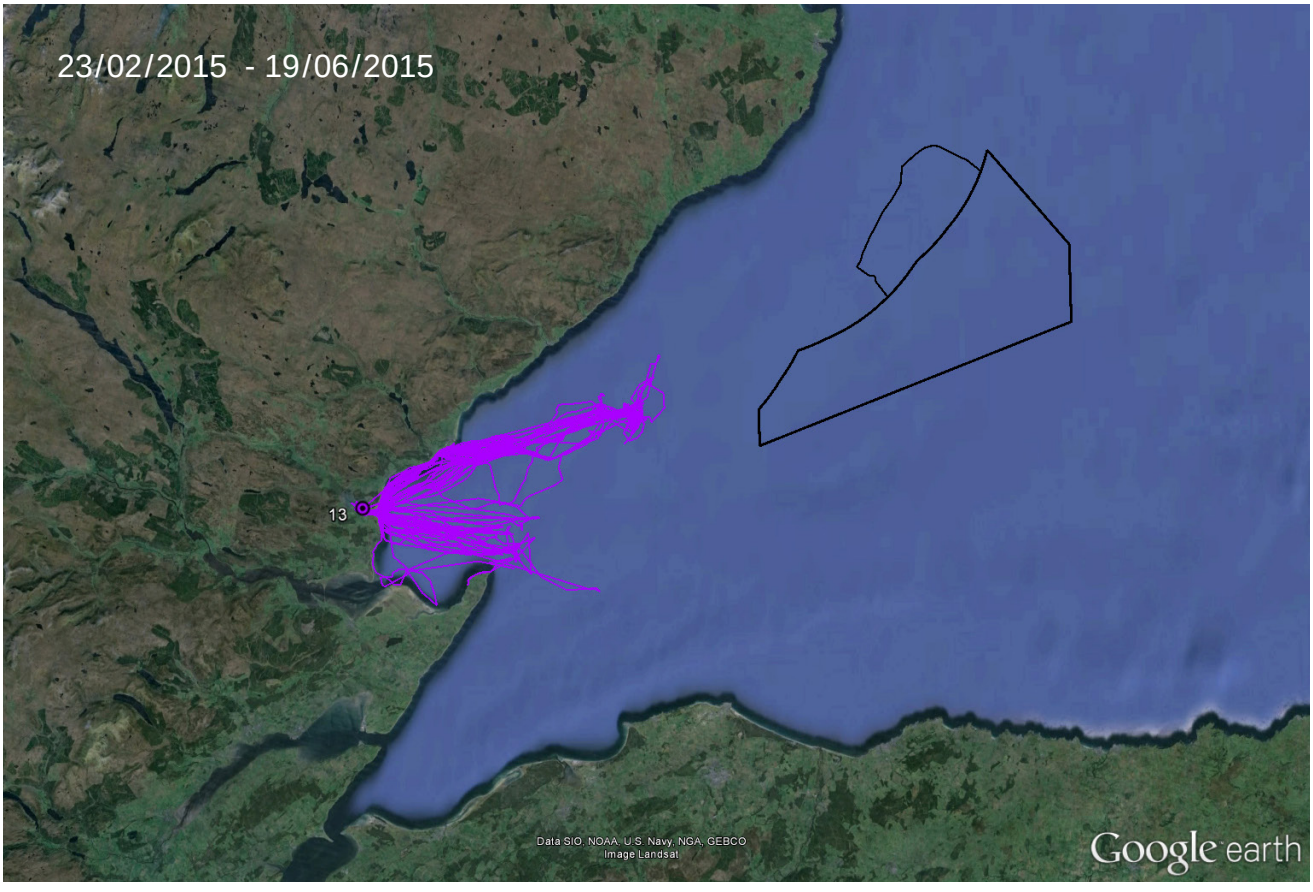
Best Right (2014)

Best Left (2014)

Capture Information

Date captured	23/02/2015
Location	Loch Fleet - SB2
Weight	64.2 kg
Length	140.0 cm
Girth	99.0 cm
Sex	Male
Flipper tag #	00541
GPS/GSM tag attached	Yes
GPS/GSM tag #	13255

Latest GPS Tracks



Seal ID # 270

Vital Stats

- Adult
- Male.
- First seen 2012
- Not captured before

Sightings History

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seen	✘	✘	✘	✘	✘	✘	✓	✓	✓	✓

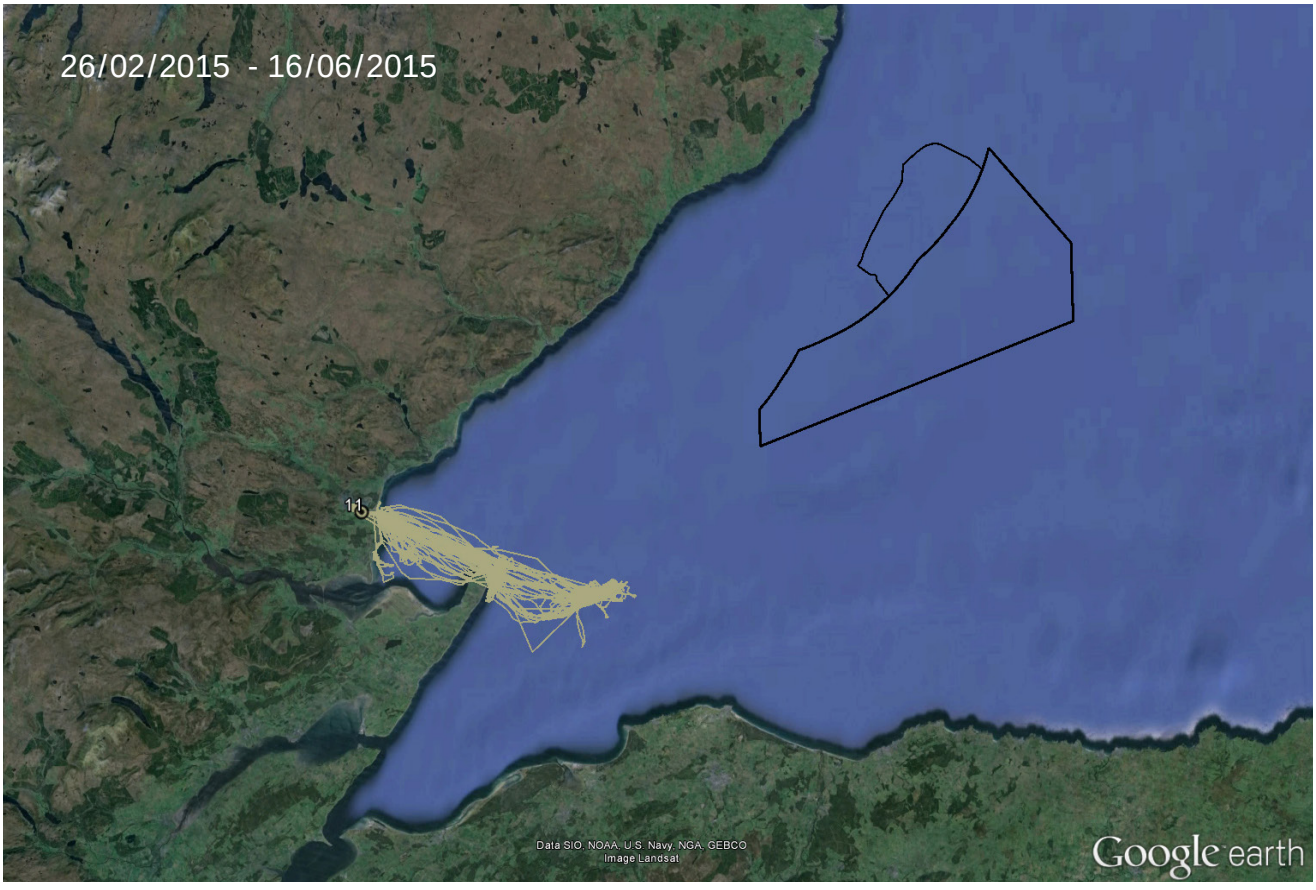
Best Right (2014)

Best Left (2014)

Capture Information

Date captured	26/02/2015
Location	Loch Fleet - SB2
Weight	76.3 kg
Length	142.0 cm
Girth	105.0 cm
Sex	Male
Flipper tag #	00556
GPS/GSM tag attached	Yes
GPS/GSM tag #	13316

Latest GPS Tracks



Seal ID # 338

Vital Stats

- Adult
- Male
- First seen 2014
- Not captured before

Sightings History

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seen	✘	✘	✘	✘	✘	✘	✘	✘	✓	✓

Best Right (2014)

Best Left (2014)

Capture Information

Date captured	27/02/2015
Location	Loch Fleet - SB2
Weight	100.6 kg
Length	157.0 cm
Girth	118.0 cm
Sex	Male
Flipper tag #	00551
GPS/GSM tag attached	Yes
GPS/GSM tag #	13204

Latest GPS Tracks