Strategic Regional Pre-Construction Marine Mammal Monitoring Programme Annual Report 2016

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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 two year pre-construction phase of the programme has been 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 focussed 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 aimed 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 annual report provides background on the programme aims and the methodologies used within each of these work packages, and provides key results from studies undertaken in 2014 and 2015.

Harbour seal work focused upon the breeding population in Loch Fleet NNR. In 2015, a total of 179 individuals were identified at Loch Fleet: 101 females, 75 males and 3 individuals of unknown sex. This included 55 reproductive females that were seen with a pup at Loch Fleet, providing a direct estimate for the 2015 fecundity rate of 0.81. Preliminary mark-recapture modelling using data from 2006 to 2015 estimated the reproductive rate at 0.68 for all females including juveniles. This method will be developed to provide modelled estimates of 2006-2015 fecundity rates for reproductive females for comparison with direct estimates. The median pupping date in 2015 was the 21st June, later than for the preceding nine years from 2006. Preliminary mark-recapture modelling using data from 2006 to 2015 estimated the survival rate at 0.96 (95% CI: 0.94-0.97) for females and 0.92 (95% CI: 0.89-0.94) for males. The mean count of adult harbour seals at Loch Fleet was 102 (± 4) during pupping and 129 (± 11) during the moult. Combining pupping counts with data on the proportion of low tides on which harbour seals hauled out produced an abundance estimate of 167 (95% CI: 146-187) for Loch Fleet in 2015. Estimated harbour seal abundance at Loch Fleet has been increasing since the mid-1990s. In September 2014 and February 2015, 25 harbour seals were captured at Loch Fleet and fitted with GPS/GSM tags. A state space model could be used to classify travelling and foraging locations for 19 of the 25 tagged individuals.

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 122 encounters. Using data from 2001 to 2015 the reproductive rate for females seen in the SAC appears to have increased from 0.14 to 0.30. The probability of apparent survival for dolphins using the SAC between 1990 and 2014 was preliminarily estimated to be 0.93 (95% CI: 0.91-0.94). However, this is likely to be negatively biased as evidence suggests this population has expanded its range outside the SAC and the method used cannot fully account for this. In 2015, a total of 53 well-marked individuals were seen in the SAC: 30 females, 16 males and 7 individuals of unknown sex. The estimated number of dolphins using the SAC in the summer of 2015 was 98 (95% CI: 83-116) and there was no evidence of a trend in the number of dolphins using the SAC between 1990 and 2015. Data from across the population's range suggests that the east coast of Scotland dolphin population is increasing, with annual estimates of 101 (95% HPDI: 70-129) in 1990 and 195 (95% HPDI: 164-224) in 2015. Although the proportion of the population using the SAC has declined, >50% of the population use the SAC in the majority of years. Passive acoustic monitoring with CPODs was used to determine baseline levels of occurrence in favoured areas. Dolphin occurrence was highest at the Sutors and Chanonry in the inner Moray Firth and lower at sites along the southern coast of the Moray Firth. Dolphin detections varied seasonally but were generally highest from May to August.

In summary, all proposed fieldwork in 2015 was successfully completed, the data have been archived and preliminary analyses used to address key project objectives.

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 seals, harbour porpoises and minke whales. 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 of 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. First, 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, a 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 key results from studies undertaken in 2014 and 2015.

Aims

The pre-construction MMMP aims to provide baseline data on two priority species (harbour seals and bottlenose dolphins) prior to construction.

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. reproductive rates);
- Female pupping dates;
- Sex specific survival rates.

Survey Design

Land-based photo-identification is being used to identify 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.

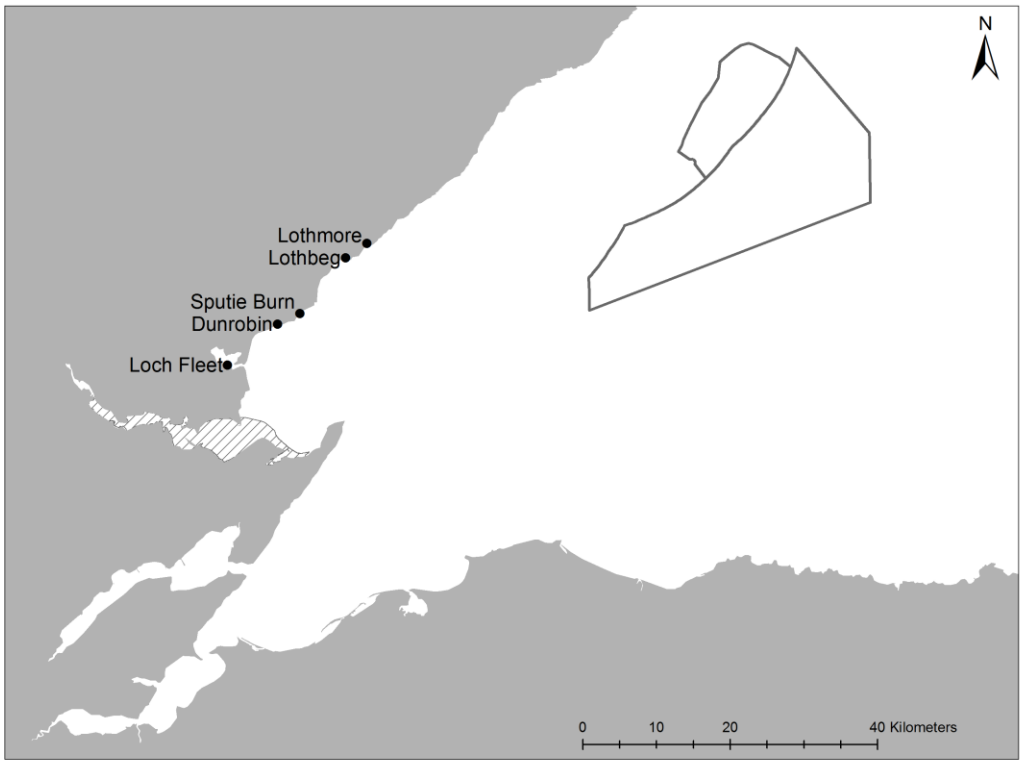


Figure 2. Map of the Moray Firth showing the position of the BOWL and MORL development areas and the five closest harbour seal haul-out sites. The Dornoch Firth and Morrich More SAC is hatched.

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 in close proximity to the female.

Data Analysis

All images were graded for photographic quality and the best quality pictures for each seal, each day, were matched to the existing photo-identification catalogue by an experienced analyst. These initial matches were confirmed by a second experienced analyst and archived with associated field data. Daily sightings of individual seals were used to create a capture history matrix, which included information on whether or not individual females were seen with a pup.

The annual fecundity rate was estimated directly by dividing the number of females seen with a pup each year by the total number of reproductive females seen that year. Females that had never been seen with a pup up to and including the year of analysis were defined as non-reproductive and excluded from the analysis, as juvenile females (< 3 years old) are unable to breed.

Data on the reproductive histories of females seen at Loch Fleet from 2006 to 2015 were used to provide unbiased estimates of reproductive rates using an open robust design multistate model accounting for uncertainty in breeding status, similar to the model used in Cordes & Thompson (2013) but including seasonality. The model included two states, namely breeders (females seen with a pup) and non-breeders (females seen without a pup). Females seen without pups could not be classed with certainty as non-breeders, as the pup may be on another sandbank, be obscured by the female, the female may have aborted, or the pup may have died or been abandoned prior to the sighting. Therefore the non-breeding state was not directly observable and females seen alone were recorded as uncertain (u) in the capture history. This model estimated the state transitions between years from non-breeder to breeder and breeder to breeder, which are the conditional reproductive rates (i.e. they are conditional on the state of the female). The model also estimates the proportion of females that breed in each year, which is the unconditional reproductive rate. A pupping probability is also produced, which is the probability that the pup is present with the female. Similarly a weaning probability is estimated, which is the probability that the pup is no longer present. For this preliminary analysis, all females were included in the analysis, therefore reproductive rates will be negatively biased due to the inclusion of younger and immature females. Analyses were carried out in R (R Core Team 2015) within the package RMark (Laake 2013) to construct models in MARK (White & Burnham 1999), and model selection conducted using Akaike's Information Criterion adjusted for small sample size (AICc) (Burnham & Anderson 2002).

Unless the birth was observed (n = 6 in 2015), pupping date was calculated as the mid-point between the day that the female was last seen alone and the day that she was first seen with a pup (Thompson & Wheeler 2008). If this period was longer than 3 days, the pupping date was excluded from analyses of timing of pupping (see Cordes & Thompson 2013).

The Cormack-Jolly-Seber (CJS) model described in Cordes and Thompson (2014) was used to estimate sex-specific survival. To avoid biasing the survival estimates, sightings of individuals of unknown sex were removed from the capture history. Similarly, sightings of known-sex individuals were removed from the capture history prior to the year sex was identified. Capture histories included sightings and non-sightings by year, and sex (male or female) was used as a covariate. Analyses were again carried out in R (R Development Core Team 2015) within the package RMark (Laake 2013) to construct models in MARK (White & Burnham 1999), and model selection conducted using AICc (Burnham & Anderson 2002).

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.

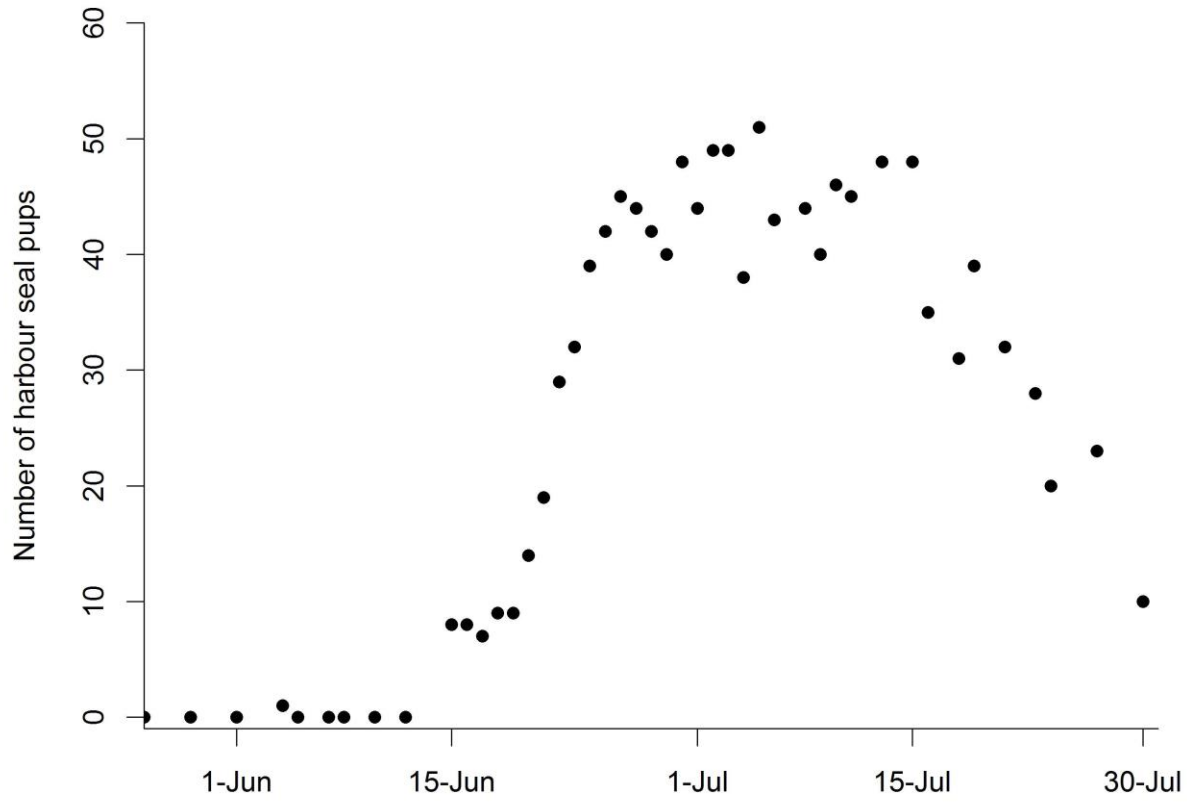


Figure 3. The number of harbour seal pups counted at Loch Fleet during the pupping period from the 26th May to the 30th July 2015.

Female Fecundity

Of 68 reproductive females seen at Loch Fleet in 2015, 55 females were seen with a pup (Table 1, Annex 3). The mean fecundity rate, estimated directly from the data, from 2006 to 2015 was 0.84 (SE = 0.02), ranging from 0.75 to 0.97 (Table 1). The reproductive histories of the females that were seen with a pup at Loch Fleet in 2015 are provided in Annex 3.

Table 1. Annual summary data on the number of pups born, the number of known reproductive females seen and the fecundity rate for harbour seals at Loch Fleet.

Year	Number of pups	Number of Reproductive Females	Fecundity Rate
2006	31	32	0.97
2007	32	37	0.86
2008	49	51	0.96
2009	46	59	0.78
2010	50	60	0.83
2011	43	57	0.75
2012	48	59	0.81
2013	44	57	0.77
2014	54	65	0.83
2015	55	68	0.81

Preliminary mark-recapture analysis of the reproductive histories of females seen at Loch Fleet from 2006 to 2015 revealed one top model that included constant survival, a linear time trend on the proportion of breeders and non-breeders, and an interaction between state and a linear time trend on the transition probabilities between states. The model suggested no evidence of a cost of reproduction with survival of breeders and non-breeders being equal (0.96; 95% CI: 0.94-0.97). Recapture rates of breeders were significantly higher than for non-breeders (Figures 4a & 4b). The conditional reproductive rates (the transition probabilities from breeder to breeder and non-breeder to breeder) were fairly stable over the study period (~0.82 and ~0.31 respectively; Figures 4c & 4d). The unconditional reproductive rate showed some indication of a decline over time although this was not significant, and the mean proportion of breeders was 0.68 (Figure 4e). The weaning probability showed a significant increase after secondary occasion ~25, which was equal to the last week of June (Figure 4f).

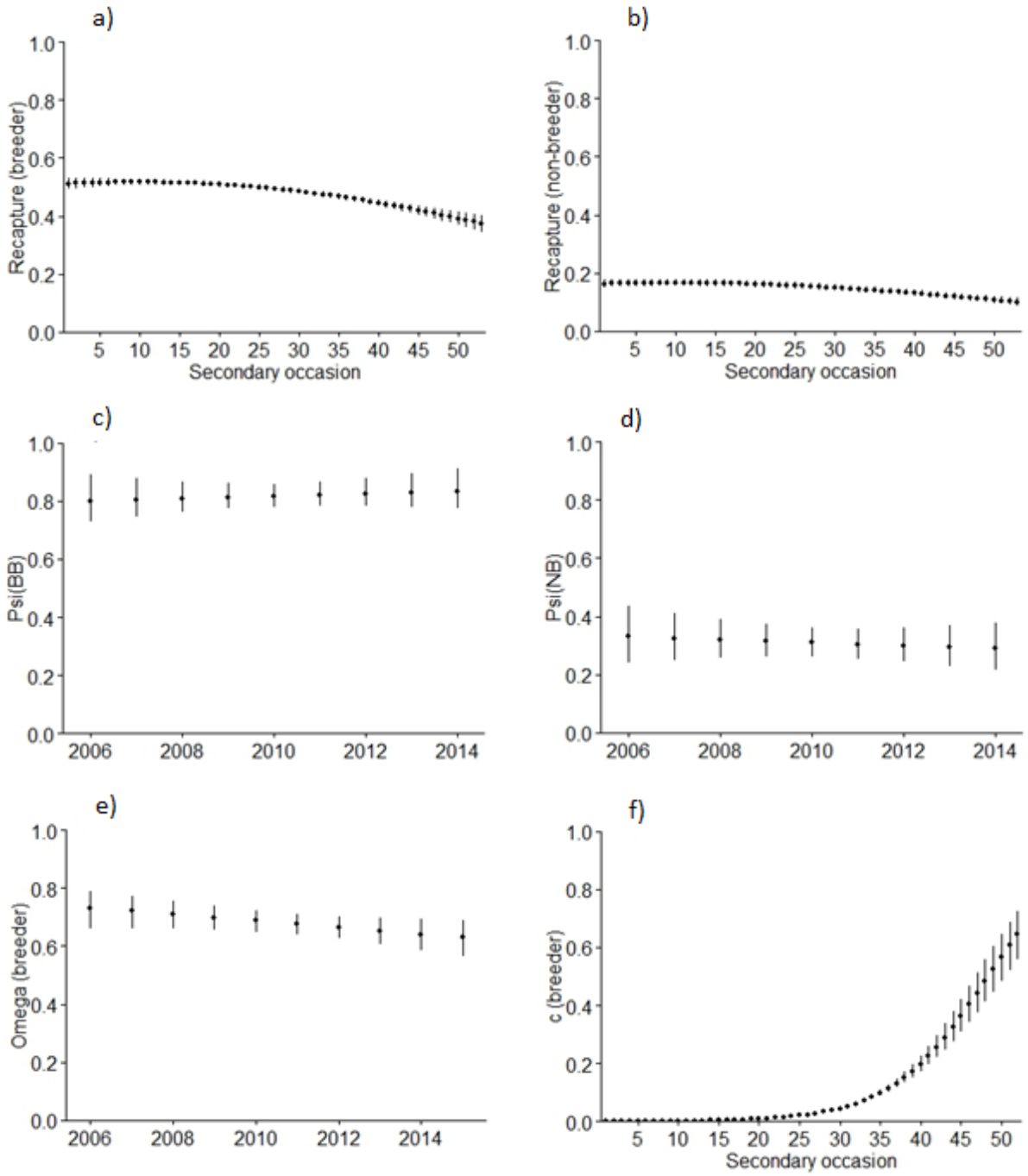


Figure 4. Results of the reproductive rate analysis using the open robust design multistate model with state uncertainty and seasonality: a) recapture rate (breeder); b) recapture rate (non-breeder); c) transition probability from breeder to breeder (psi(BB)); d) transition probability from non-breeder to breeder (psi(NB)); e) unconditional reproductive rate, i.e. proportion of breeders (omega); f) weaning probability (c).

Timing of Pupping

Thirty-six accurate pupping dates were obtained from the 55 females seen with a pup at Loch Fleet in 2015. The median pupping date in 2015, the 21st June, was later than the preceding nine years from 2006 to 2014 (Figure 5).

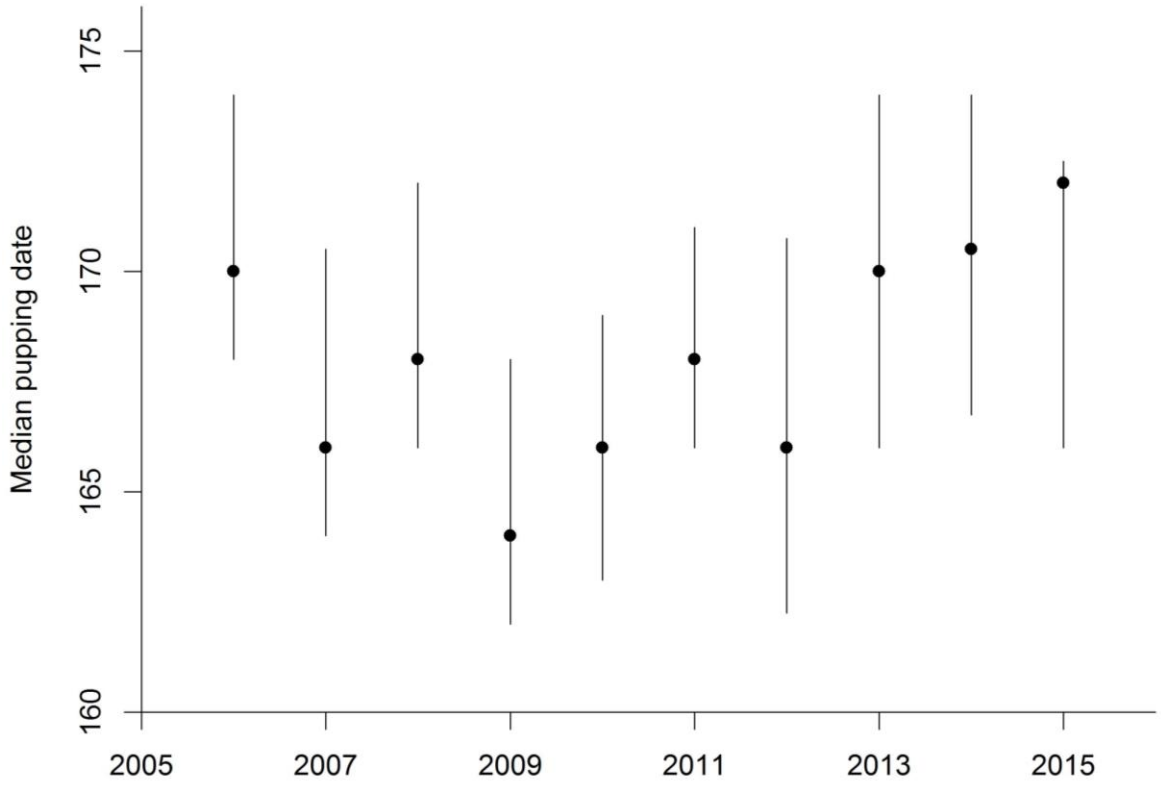


Figure 5. Annual variation in the timing of pupping at Loch Fleet. Points represent the median pupping date with interquartile ranges.

Sex Specific Survival

In 2015, a total of 179 individuals were identified at Loch Fleet: 101 females, 75 males and 3 individuals of unknown sex. The sighting histories of individual harbour seals seen in Loch Fleet in 2015 are provided in Annex 4.

Preliminary mark-recapture analysis of sightings of individual males and females at Loch Fleet from 2006 to 2015 revealed four models with good support from the data, all suggesting a sex-specific difference in survival as well as inter-annual variation in survival rates. Mean survival probability from 2006 to 2015 was higher for females (0.96, 95% CI: 0.94-0.97) compared to males (0.92, 95% CI: 0.89-0.94). Between year recapture rates were high and stable over the study period 0.95 (95% CI: 0.93-0.96) and showed no difference between males and females.

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 at five sites (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, on days with good sighting conditions (good visibility and an absence of rain). Counts were made from suitable vantage points by an experienced 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 and these are being processed using the same approaches outlined in WP 1.1.

Data Analysis

Total abundance was estimated by adjusting counts made during the pupping season following the approach described in Thompson *et al.* (1997). The estimated proportion of low tides on which male and female harbour seals haul out used to adjust counts was taken from Thompson *et al.* (1997) but will be revised using telemetry data from the 25 seals tagged in September 2014 and February 2015 (see WP 1.3). The matrix of photographic recaptures used to estimate survival (WP 1.1) will also be used to provide mark-recapture estimates of absolute abundance in Loch Fleet (Cordes 2011) and, potentially, at the other sites.

The mean annual pupping season and moult counts will be related to 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).

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 2 & 3, Figure 6). 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 2 & 4).

Table 2. Number of count trips made to each site in 2014 and 2015 during the 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 2015 to 30th April 2016).

		Lothmore	Lothbeg	Sputie Burn	Dunrobin	Loch Fleet
Pupping	2014	5	-	5	4	19*
	2015	4	4	4	4	28
Moult	2014	4	-	4	4	5
	2015	4	4	4	4	4
Winter	2014	9	1	9	9	19*
	2015	8	8	8	8	9*

* includes 1 trip (pupping 2014), 4 trips (winter 2014) and 1 trip (winter 2015) made to Loch Fleet for non-MMMP fieldwork activities

Table 3. Mean counts (± 1 SE) of adult harbour seals at each site during the 2014 and 2015 pupping season (15th June to 15th July) and moult (1st to 31st August).

		Lothmore	Lothbeg	Sputie Burn	Dunrobin	Loch Fleet
Pupping	2014	0.2 (0.2)	-	22.4 (1.33)	0 (0)	92.84 (4.21)
	2015	2 (0.41)	0.75 (0.48)	29 (2.2)	0 (0)	101.57 (4.11)
Moult	2014	6.25 (1.89)	-	38.75 (4.96)	0.25 (0.25)	123.2 (8.25)
	2015	3 (1.22)	1.75 (1.18)	37.5 (7.19)	2 (1.08)	128.75 (11.17)

Table 4. 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 2015 to 30th April 2016).

	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	0.5 (0.5)	3 (0.96)	30 (4.6)	1.13 (0.88)	76.44 (9.97)

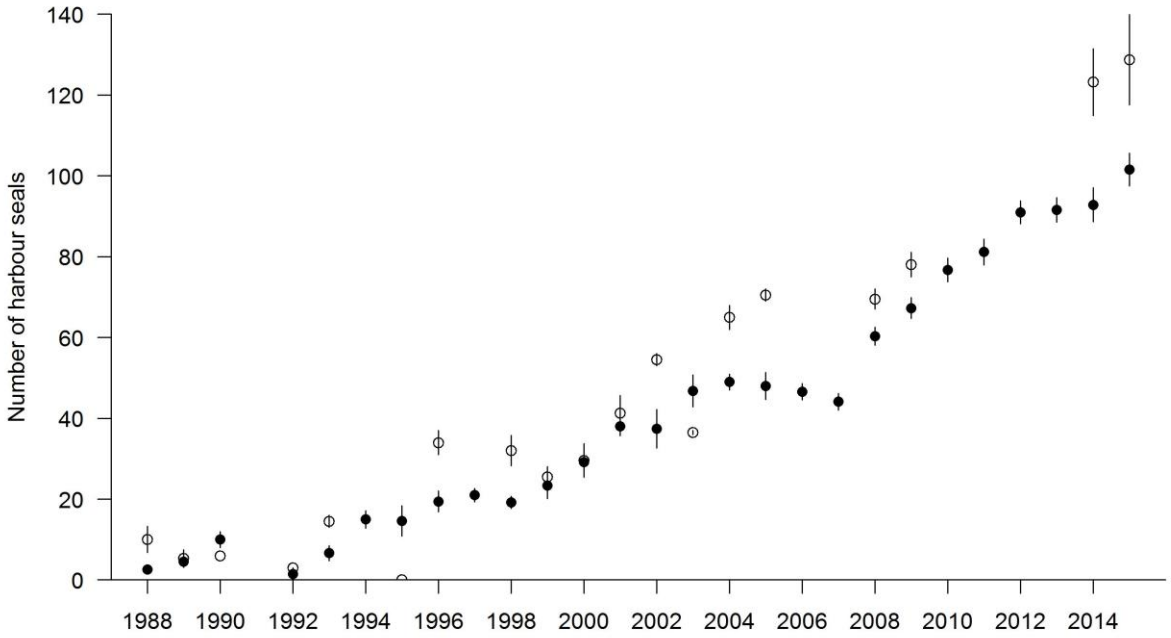


Figure 6. Counts of adult harbour seals at Loch Fleet, 1988-2015: filled circles are counts during the pupping season; open circles are counts during the moult. Plotted values are the means ± SE.

The estimated abundance of harbour seals using Loch Fleet in 2015 was 167 (95% CI: 146-187; Figure 7). The estimated number of harbour seals using Loch Fleet has been increasing since the mid-1990s (Figures 6 & 7).

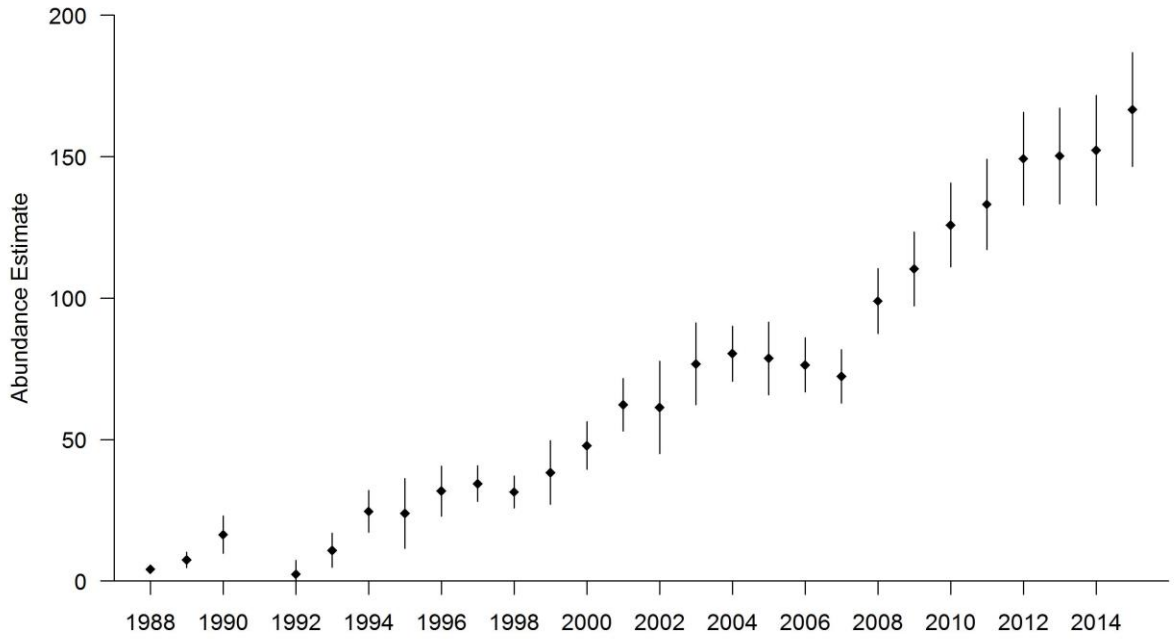


Figure 7. Estimated number of seals using Loch Fleet from 1988 to 2015 with 95% confidence intervals.

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. This study is using 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.

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.

The state-space model described in Russell *et al.* (2015) was used to classify travelling and foraging locations. Locations were assigned as travelling or foraging (area restricted search) where the probability of that state was greater than 0.9, excluding all locations within 1000 m of a haul-out site.

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-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.

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. Figure 8 shows the tracks for all 25 harbour seals captured in September and February. Two individuals used the wind farm sites. The state-space model successfully classified travelling and foraging locations for the data from 19 of the tagged seals. Figures 9 and 10 show the travelling and foraging locations assigned by the state-space model for those 19 seals.

Table 5 summarises the number and sex ratio of harbour seals captured and tagged in the Dornoch Firth and at Loch Fleet from 1989-2015, more detailed information on the data from individual harbour seals is provided in Annex 5.

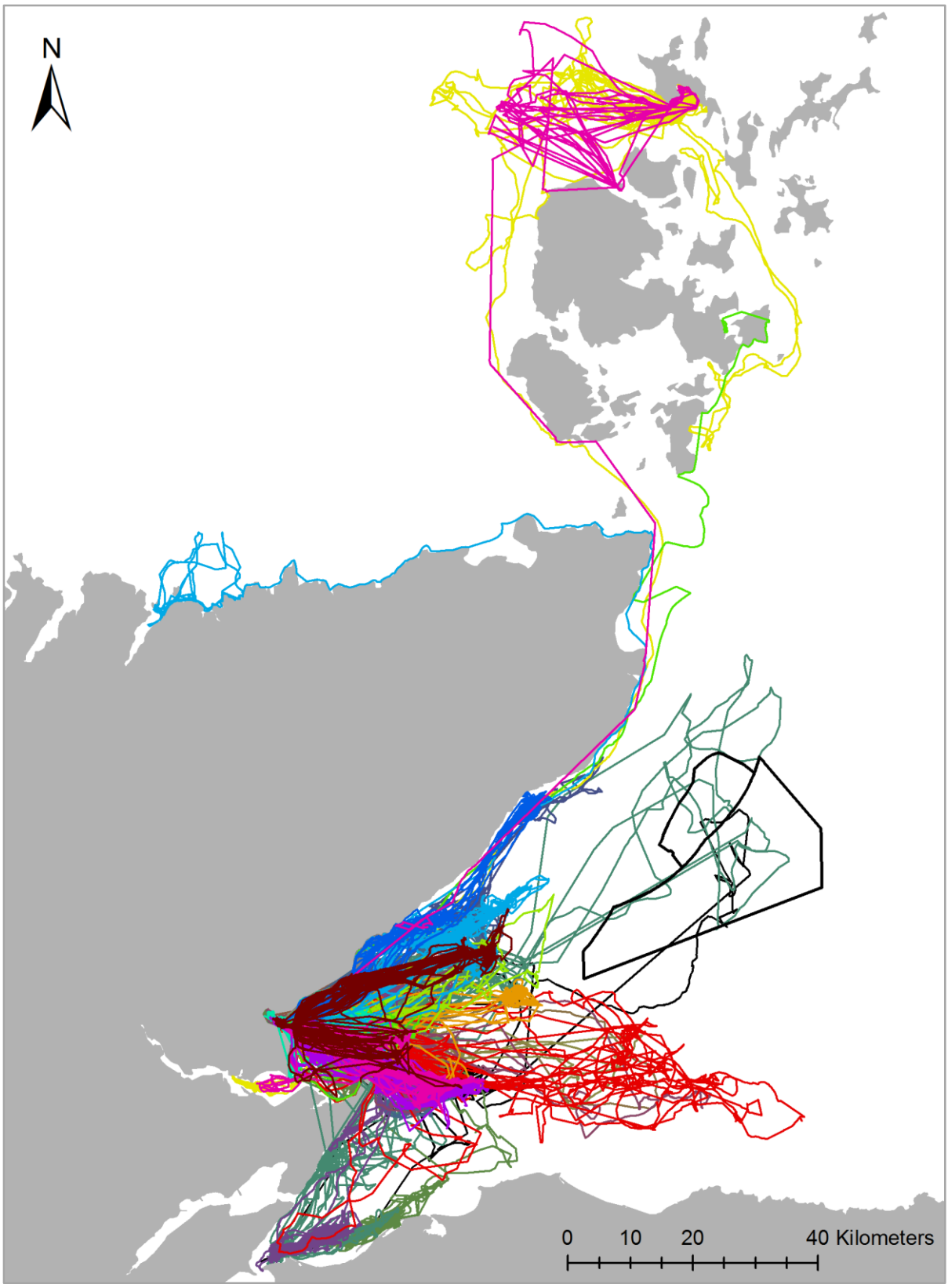


Figure 8. Raw GPS tracks from 25 harbour seals captured and tagged at Loch Fleet: each colour represents a different individual.

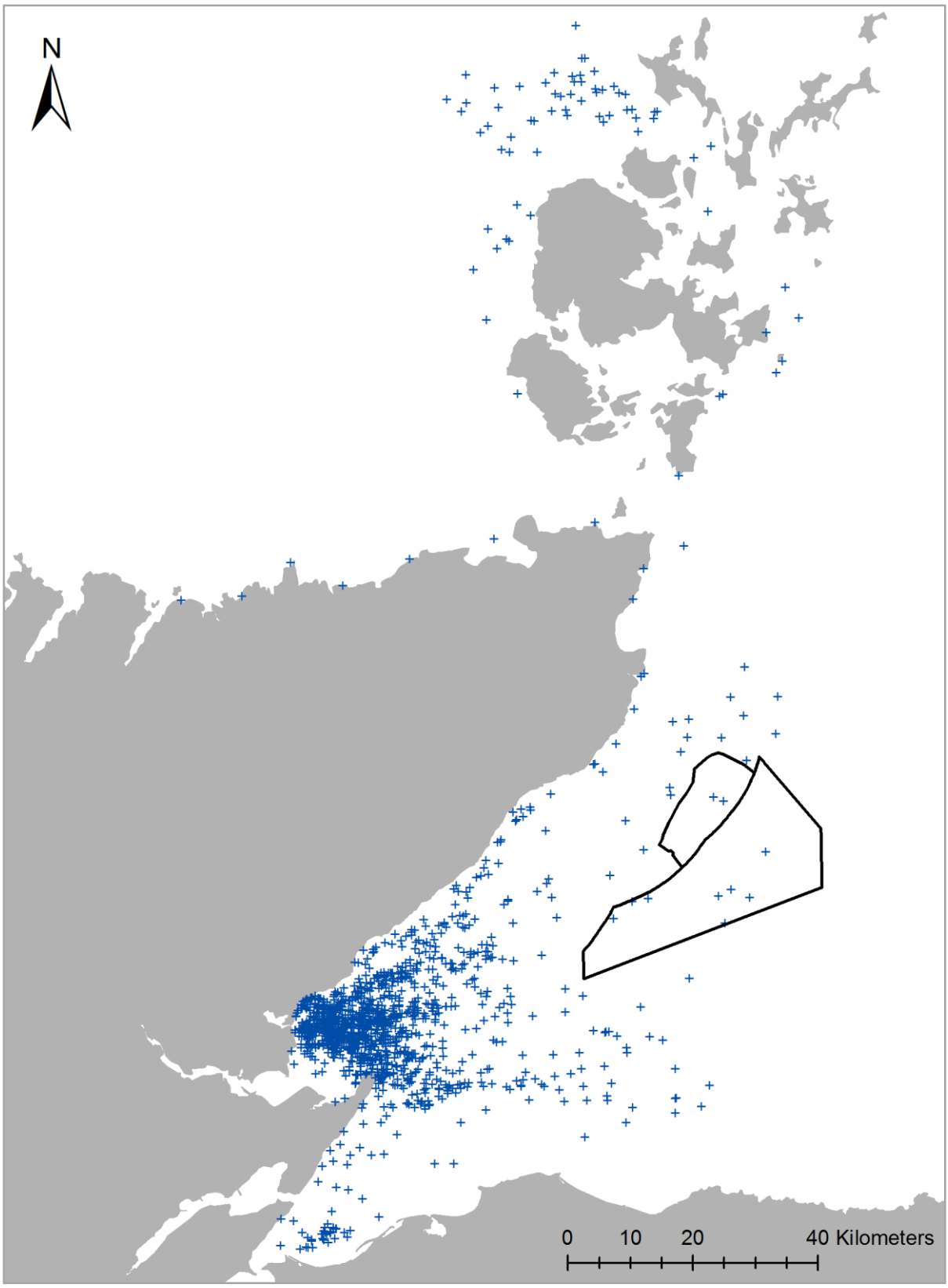


Figure 9. Travelling locations assigned by state-space model for 19 harbour seals tagged at Loch Fleet in 2014 and 2015.

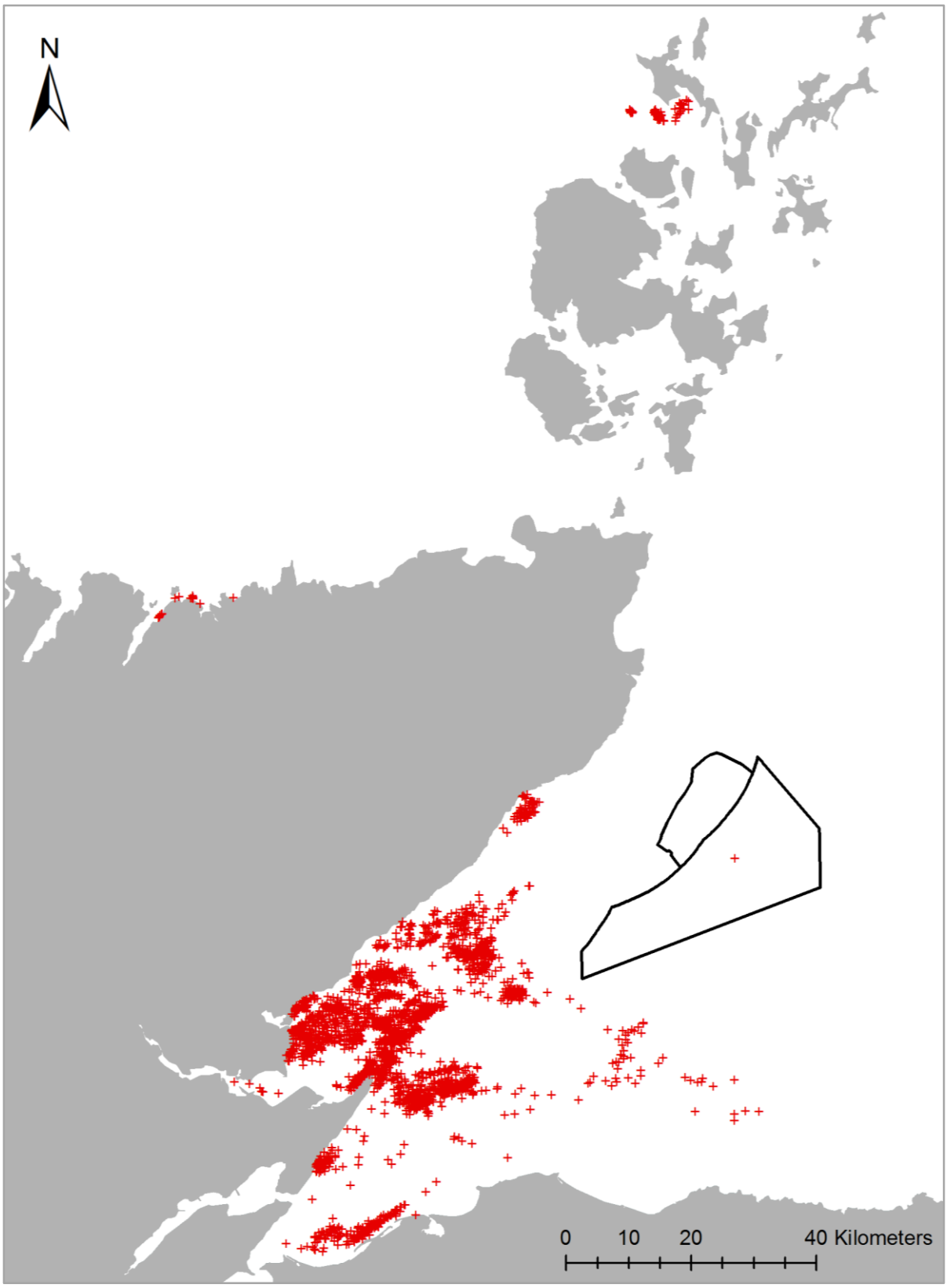


Figure 10. Foraging locations assigned by state-space model for 19 harbour seals tagged at Loch Fleet in 2014 and 2015.

Table 5. Summary of the harbour seals captured and tagged in the Dornoch Firth and at Loch Fleet from 1989-2015. Telemetry techniques used were very high frequency (VHF) radio tracking, Argos satellite (SRDL), a Global Positioning System sensor combined with a mobile phone Global System for Mobile Communications modem to relay data ashore (GPS-GSM) and a Global Positioning System sensor combined with UHF telemetry (Pathtrack Ltd.) to transmit the data to fixed base stations ashore (GPS-UHF).

Tag Type	Deployment years	Number of tags	Sex ratio (Male:Female)
VHF	1989-1991	21	12:9
SRDL	2004-2005	10	6:4
GPS-GSM	2009, 2014-2015	30	12:18
GPS-UHF	2015	10	5:5
Total		**71**	**35:36**

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 identify individual bottlenose dolphins from their distinct dorsal fin markings (Figure 11) (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 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 11. 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

Sampling Techniques

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.

Data Analysis

Field data from each survey were archived in an access database. All images were graded for photographic quality (Wilson, Hammond & Thompson 1999; Cheney *et al.* 2014b). All high quality pictures were matched to our existing photo-identification catalogue by an experienced analyst. At the end of this process, all the initial matches were confirmed by a second experienced analyst and the data and photographs were archived.

To estimate fecundity we used data from 2001 to 2015, as during this time period the majority of calves could be associated with known females (e.g. calf seen in echelon position, consistently surfacing alongside the mother's dorsal fin), avoiding possible duplication. The year of birth of calves was estimated using foetal folds (vertical creases down their sides from their position in the womb, which fade over time), their paler colour and relative size. Females were included once they had been seen with a calf. The reproductive rate was estimated using an open robust design multistate model with state uncertainty (Kendall, Hines & Nichols 2003; Cordes & Thompson 2014). The model included three states, namely females with new-born calves, females with older calves (1 or 2 years old), and an uncertain state (females not seen with a calf; either non-breeders or breeders where the calf was not seen as it was born later in the year or may have died prematurely or before sighting or the female was seen infrequently). The model estimates state transitions from non-breeder to female with a new-born calf (conditional reproductive rate), transitions from female with new-born calf to female with older calf (first year calf survival), and also the unconditional reproductive rate of the proportion of females that have a new-born calf. Analyses were carried out in R (R Core Team 2015) within the package RMark (Laake 2013) to construct models in MARK (White & Burnham 1999), and model selection was conducted

using Akaike's Information Criterion (AIC) (Akaike 1998) adjusted for small sample size (AICc) (Burnham & Anderson 2002).

To estimate survival we used data collected between 1990 and 2014 within the Moray Firth SAC and Robust design models (Pollock 1982; Kendall, Pollock & Brownie 1995; Kendall, Nichols & Hines 1997). These models account for heterogeneity in capture probabilities due to temporary emigration and have previously been used to estimate survival for the entire east coast of Scotland population (see Arso Civil 2014 for full details). A series of robust design models were specified using the package RMark (Laake 2013) in R (R Core Team 2015) and implemented in program MARK (White & Burnham 1999). Again, the model with the lowest AICc (Burnham & Anderson 2002) was selected as having most support from the data. Analyses to estimate sex specific survival rates are ongoing.

Results

2015 Photo-Identification Surveys

In 2015, a total of 20 photo-identification surveys were conducted in the Moray Firth, from the 8th May to the 30th September (Table 6 and Figure 12). Of these, 1 survey went outside the SAC along the south coast of the Moray Firth (Figure 12).

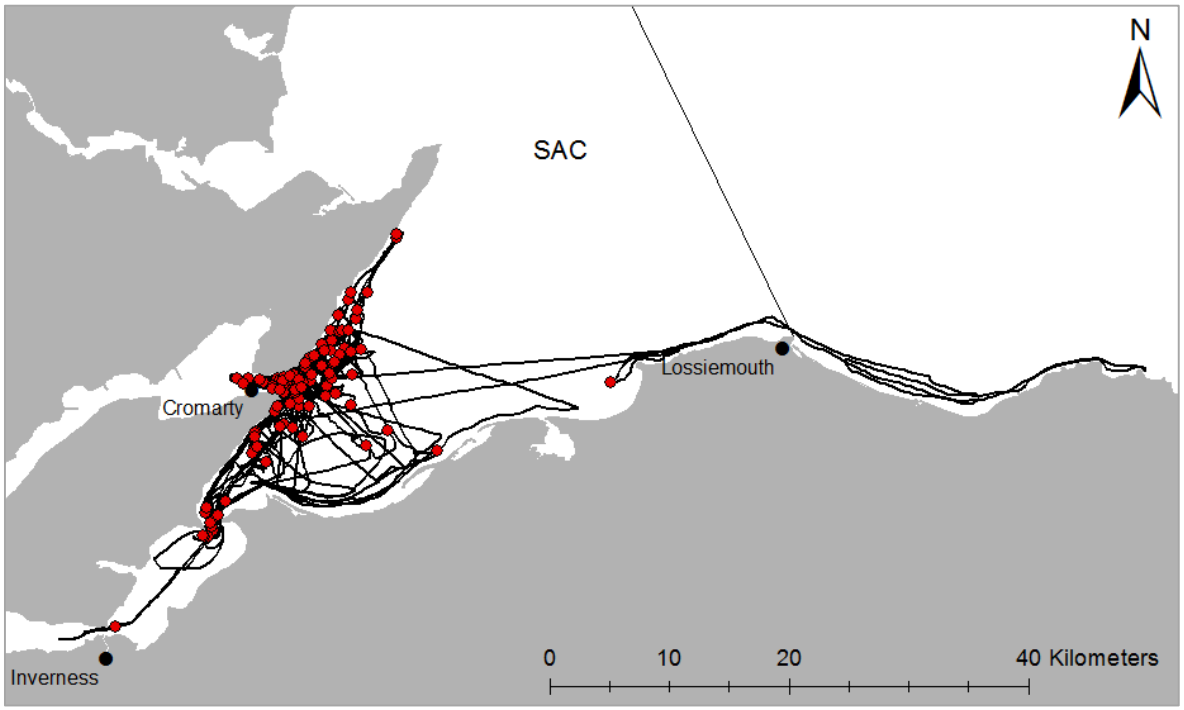


Figure 12. A map showing all the areas covered by photo-identification surveys (black lines) in 2015 and the location of all encounters with groups of bottlenose dolphins (red dots).

Over 124 hours were spent on photo-identification trips within the Moray Firth, with bottlenose dolphins seen on every trip. In total there were 122 encounters with bottlenose dolphins lasting on average 24 minutes each. This equates to a total of 49 hours spent with dolphins in the Moray Firth, approximately 39% of our survey time

(Table 6). All encounters were within the Moray Firth SAC (Figure 12). Estimates of group sizes ranged from 1 to 41 dolphins, with a median of 6 (interquartile range = 3 to 12) (Figure 13). In total, 13,403 photographs were taken during bottlenose dolphin photo-identification surveys in 2015.

Table 6. 2015 photo-identification survey details, by month, for the Moray Firth.

	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	25	11.07	36%
August	5	28.62	31	10.37	36%
September	4	25.05	26	10.52	42%
Total	**20**	**124.42**	**122**	**48.63**	**39%**

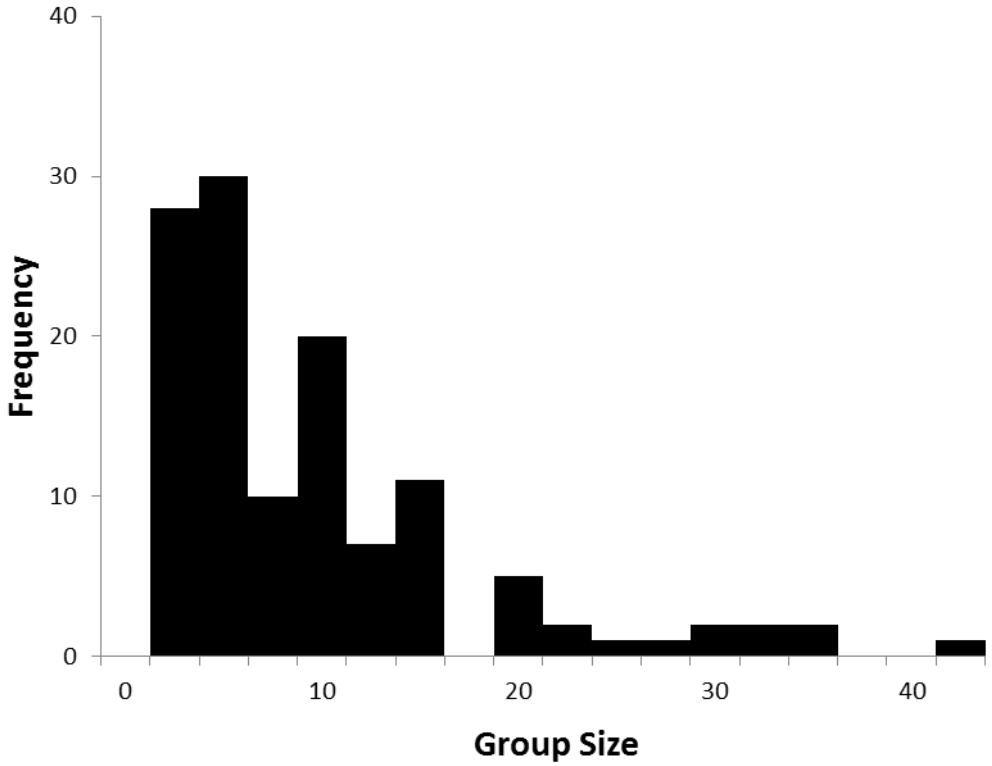


Figure 13. Frequency distribution of different dolphin group sizes during photo-identification surveys in 2015.

Female Fecundity

Reproductive histories were available for 56 known females with 106 calves seen in the SAC between 2001 and 2015. An average of 7 new-born calves (minimum=3, maximum=13) were identified each year during this time period. Annex 6 shows the reproductive history of females with calves born in 2015 and seen in the SAC.

Preliminary analysis revealed four models with good support from the data with the top model including a state effect on survival, a state and linear time trend on state transition probabilities and the proportions of animals occupying the different states. The probability of correctly classifying a female with a new-born calf increased over the summer (Figure 14a). The calving season of bottlenose dolphins is not synchronous, but there is some evidence of a peak in calving in late summer. The probability of transitioning from a female with a new-born calf to a female with an older calf was stable over the time period (0.84, 95% CI: 0.68-0.92), highlighting a high and stable survival of calves to 1 year of age (Figure 14b). The probability of transitioning from a female with an older calf in one year to a female with an older calf in the following year (a proxy for survival of older calves from 1 to 2 years of age) increased over the study period from 0.24 to 0.54 (Figure 14c). The top model highlighted a significant increase in the unconditional reproductive rate (number of females with a new-born calf ranging from 0.14 to 0.30, Figure 14d).

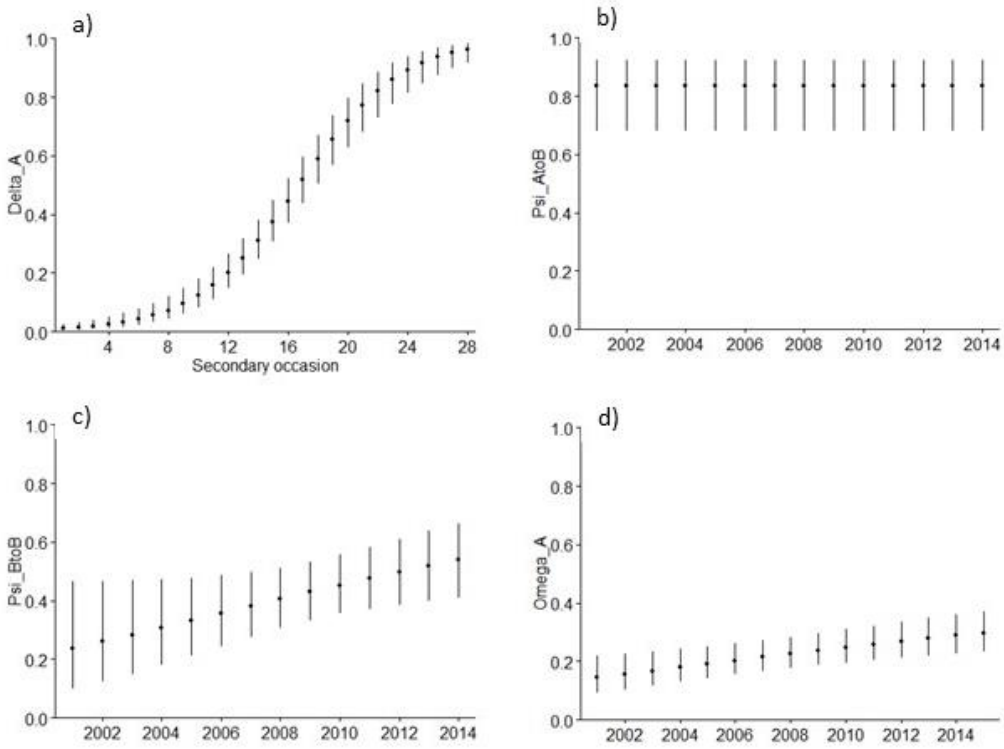


Figure 14. Results of the reproductive rate analysis using the open robust design model with state uncertainty, a) probability of correctly classifying a female with a new-born calf (Delta_A), b) transition probability from female with a new-born calf to with an older calf (Psi_AtoB), c) transition probability from female with an older calf one year to the next (Psi_BtoB) and d) unconditional reproductive rate for females with a new-born calf (Omega_A).

Survival Rates

Sightings histories were available for 161 well-marked dolphins seen in the SAC between 1990 and 2014. Preliminary analyses suggested that the most supported robust design model included constant survival, time-specific Markovian emigration (i.e. the probability of temporary emigration depends on whether or not the animal was available in the study area during the previous sampling occasion) and a different capture probability for each capture occasion. Based on this model, the probability of apparent survival for dolphins within the SAC between 1990 and 2014 was estimated to be 0.93 (95% confidence interval (CI): 0.91-0.94). However, this estimate for individuals seen in the SAC is likely to be negatively biased. Arso Civil (2014) estimated the probability of apparent survival for the population as 0.95 (95% CI: 0.93-0.96). While robust design models can account for temporary emigration, they cannot account for permanent emigration (i.e. when animals leave the study area) nor adequately for situations where probability of capture of some animals has declined over time to a low level. This population's range has expanded outside the SAC over this time period (Wilson *et al.* 2004), with spatial and temporal variation in individual ranging patterns (Cheney *et al.* 2013; Quick *et al.* 2014). This type of movement cannot be fully separated from mortality and, consequently, leads to an underestimate of the probability 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 2015. 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 have 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 from 1990 to 2015.

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

Data Analysis

Abundance of dolphins using the Moray Firth SAC in each summer

Data from our photo-identification surveys in the Moray Firth SAC from 1990 to 2015 were used to create a capture matrix of well-marked individuals seen each year (Annex 7 has an example of these data and shows the SAC sightings history of all well-marked dolphins seen in the SAC in 2015). PROGRAM CAPTURE provided annual estimates 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 was also 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 were also investigated (see Cheney *et al.* 2014a for details).

Results

2015 Photo-Identification Surveys

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

Abundance of dolphins using the Moray Firth SAC in each summer

High quality pictures were obtained from 53 well-marked individuals during the 2015 surveys. The mark-recapture estimate of the total number of well-marked individuals was 55 (95% CI: 54-63). This estimate was inflated with the modelled proportion of well-marked individuals (0.5609, see Cheney *et al.* 2014a for full details). The resulting estimate of the number of dolphins using the SAC in the summer of 2015 was 98 (95% CI: 83-116).

Annual estimates of the number of dolphins using the SAC in summer show considerable variability from year to year (Figure 15). However, there is no significant linear trend in these annual estimates ($F_{1,24} = 0.152$, $p = 0.7$).

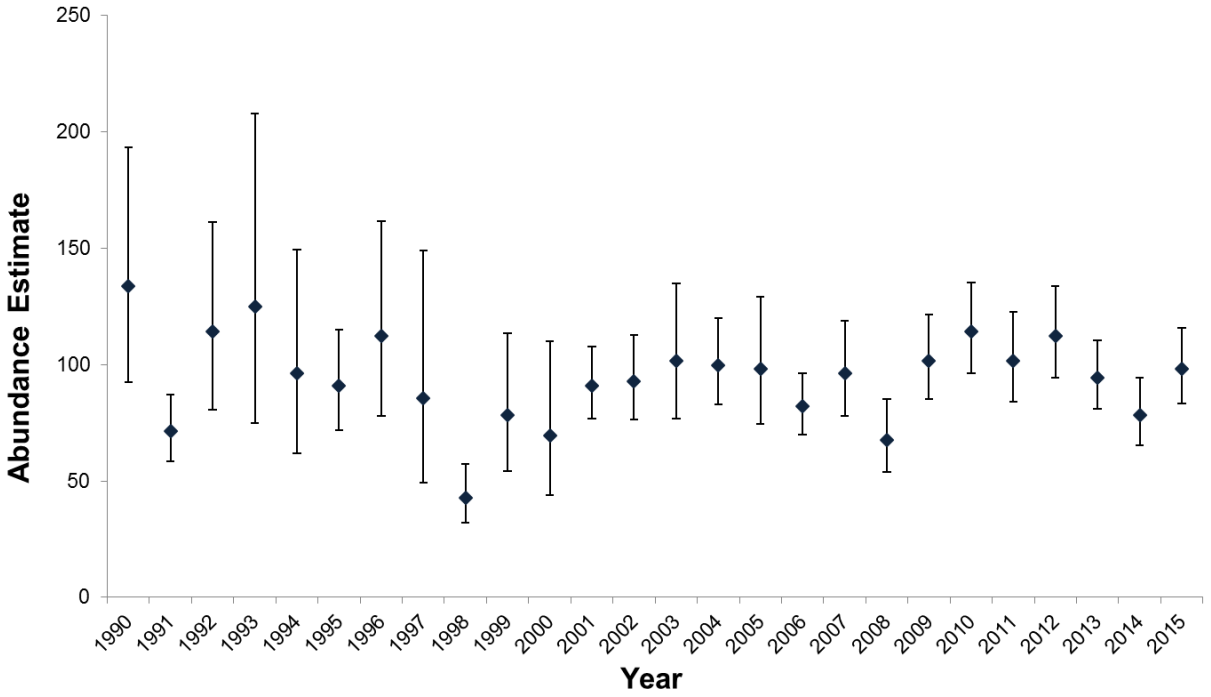


Figure 15. Annual estimates of the number of dolphins using the Moray Firth Special Area of Conservation from 1990 to 2015 with 95% confidence intervals.

Trends in overall population size.

A Bayesian linear regression suggests that the population of dolphins on the east coast of Scotland is increasing with annual estimates of 101 (95% HPDI: 70-129) in 1990 and 195 (95% HPDI: 164-224) in 2015 (Figure 16). Evidence suggests that the proportion of the population using the SAC has declined (mean slope = -0.08, SE= 0.0004). However, results indicate that >50% of the population use the SAC in most years.

These results suggest that, despite interannual variability, the number of dolphins using the SAC appears to be stable yet the east coast population is increasing. Although, there has therefore been a decline in the relative use of the SAC, the majority of the wider population continue to use this area to some extent.

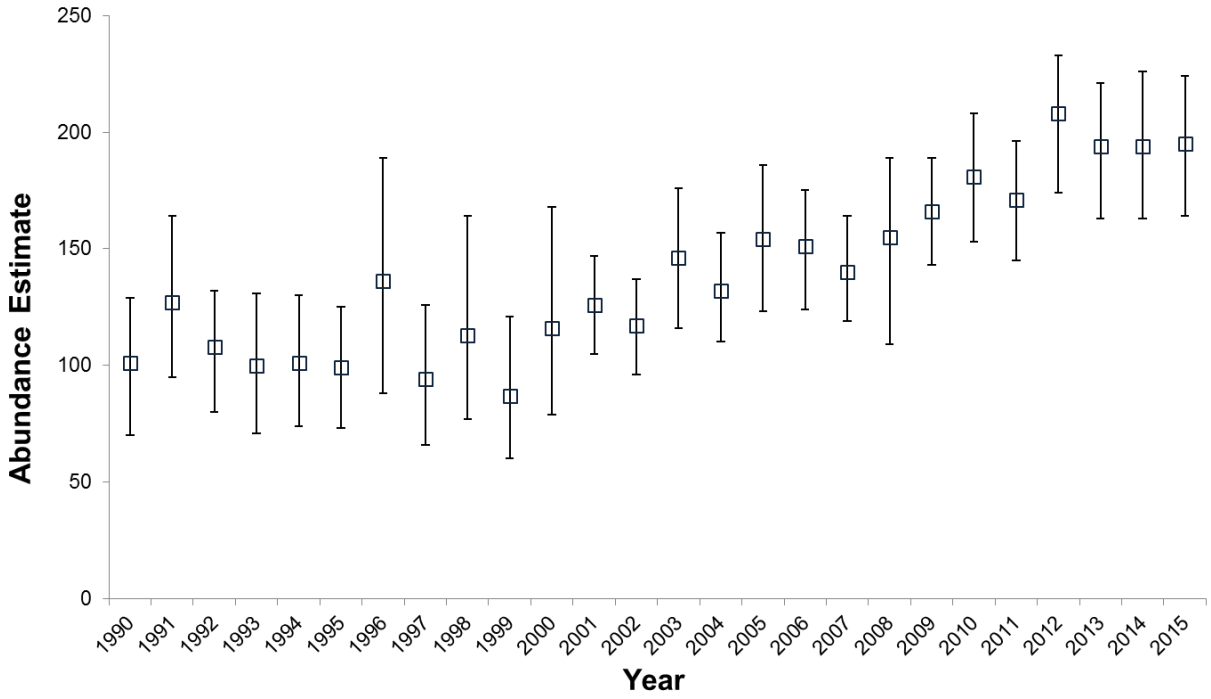


Figure 16. Annual estimates of the east coast of Scotland bottlenose dolphin population from 1990 to 2015 with 95% highest posterior density intervals (HPDI).

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 use established techniques for monitoring changes in the occurrence of dolphins in different parts of the SAC. This study design is based on previous work that has demonstrated that echolocation detections can be used to provide a robust index of occurrence for small cetaceans when compared to visual observations (Philpott *et al.* 2007; Bailey *et al.* 2010; Williamson *et al.* 2016). 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 have been collected at four long-term monitoring sites (Figure 17). Between May and September of each year, deployments were also made at four additional sites on the south coast of the Moray Firth (Figure 17). Data were collected using V0 and V1 CPODs using seabed moorings that have been optimised for deployments at these sites, licensed for scientific use by Marine Scotland (# 04860/14/0), and consented by the Crown Estate.

Deployments and recoveries were 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.

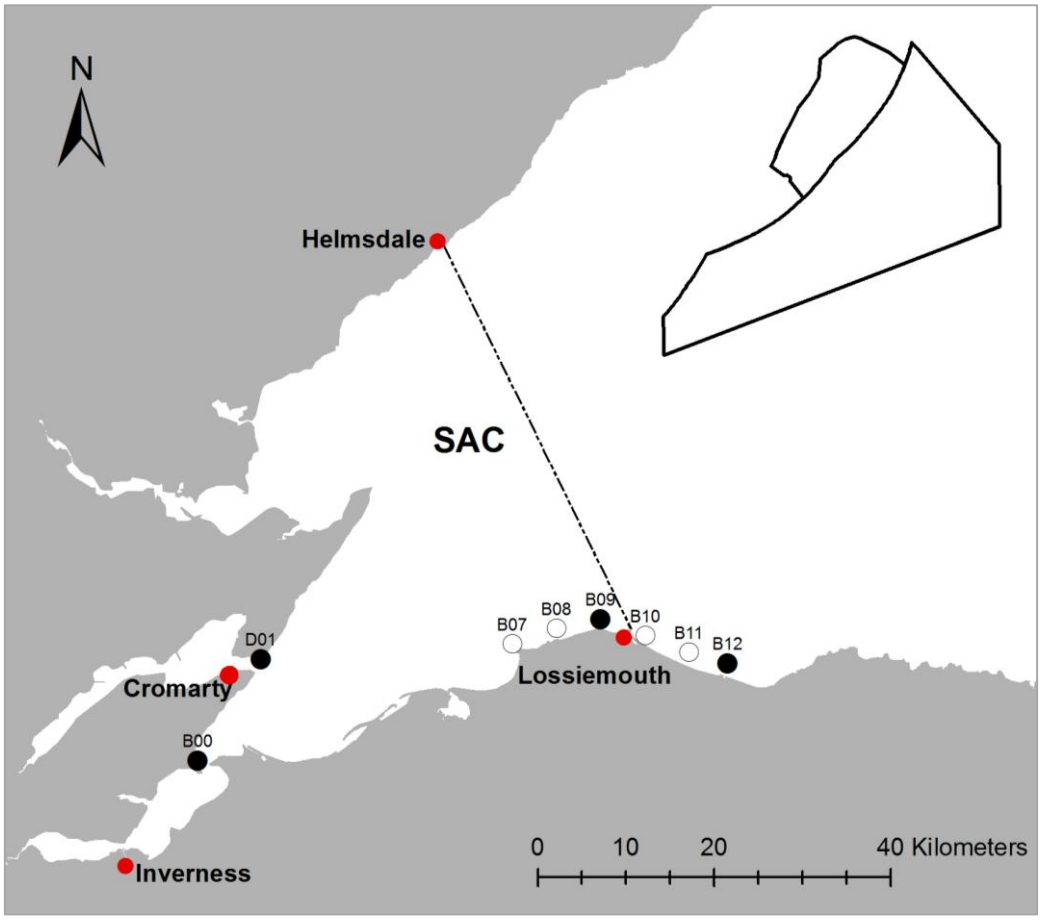


Figure 17. A map showing the CPOD locations (long-term sites = black circles; summer only sites = clear circles). The location of the Moray Firth SAC is shown.

Data Analysis

Data were downloaded using the manufacturer's software, which is also used to identify click trains and categorise these as either porpoise or dolphin clicks with high, medium or low levels of confidence. Only click trains categorized with high or medium confidence were used in subsequent analyses (Brookes, Bailey & Thompson 2013). Data were processed using established routines and 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 is expressed in terms of detection positive hours per day, or distributions of waiting times. Further details of the analysis approaches are provided in Bailey *et al.* (2010); Thompson *et al.* (2010); Brookes, Bailey and Thompson (2013); Thompson *et al.* (2013a).

Results

Details of the CPOD deployments and recoveries for 2014 and 2015 are shown in Table 7. Dolphin occurrence during summer, June to September, 2015 varied between sites (Table 8 and Figure 18). Dolphins were detected more often and spent more time at the Sutors (D01) and Chanonry (B00) than at the other six sites on the south coast (Figure 18).

Table 7. Summary of the CPOD data for the four long-term and four additional sites on the south coast.

Location	Deployment Date	Data End Date	Data
Long-term sites:			
Sutors (D01)	04/04/14	03/07/14	✓
	03/07/14	08/08/14	✓
	08/08/14	Not found	×
	04/12/14	09/04/15	✓
	09/04/15	02/07/15	✓
	02/07/15	09/10/15	✓
	09/10/15	15/02/16	✓
	07/03/16		
Chanonry (B00)	18/03/14	05/07/14	✓
	05/07/14	08/11/14	✓
	08/11/14	No data	×
	19/03/15	02/07/15	✓
	02/07/15	09/10/15	✓
	09/10/15	25/12/15	✓
	07/03/16		
Lossiemouth (B09)	27/05/14	29/11/14	✓
	15/12/14	19/03/15	✓
	19/03/15	29/06/15	✓
	29/06/15	10/10/15	✓
	10/10/15	19/11/15	✓
	14/03/16		
Spey Bay (B12)	27/05/14	22/10/14	✓
	22/10/14	24/03/15	✓
	24/03/15	29/06/15	✓
	29/06/15	05/10/15	✓
	05/10/15	04/03/16	✓
	04/03/16		
Additional south coast sites:			
B07	27/05/14	10/11/14	✓
	23/05/15	08/10/15	✓
B08	27/05/14	Trawled	×
	23/05/15	08/10/15	✓
B10	27/05/14	22/10/14	✓
	23/05/15	05/10/15	✓
B11	27/05/14	14/10/14	✓
	23/05/15	05/10/15	✓

Table 8. Summary data on dolphin detections for the CPODs at all sites from June to September 2015.

Site	No. days sampled	% days dolphins detected	Median detection positive hrs/day	Interquartile range
D01	121	99.2	7	4-9
B00	121	97.5	5	3-7
B07	122	83.6	2	1-4
B08	122	76.2	2	1-3.75
B09	121	86.8	2	1-3
B10	122	88.5	2	1-4
B11	122	80.3	2	1-3.75
B12	121	85.1	2	1-5

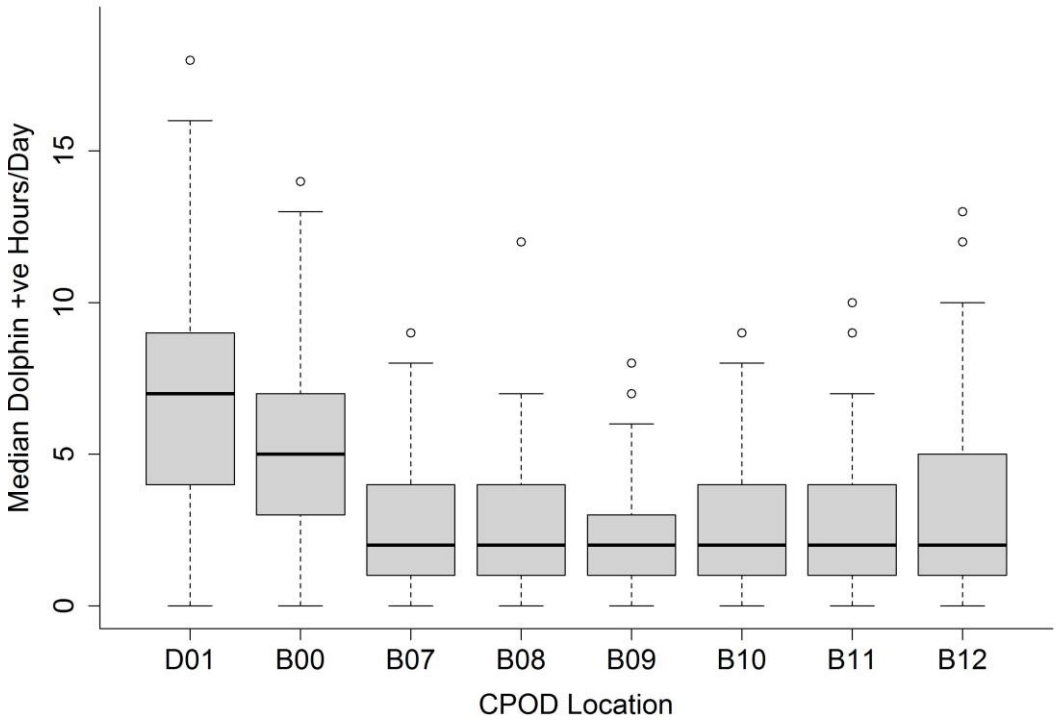


Figure 18. Site variation in the median number of hours/day (± interquartile ranges) that dolphins were detected on CPODs at all sites from June to September 2015.

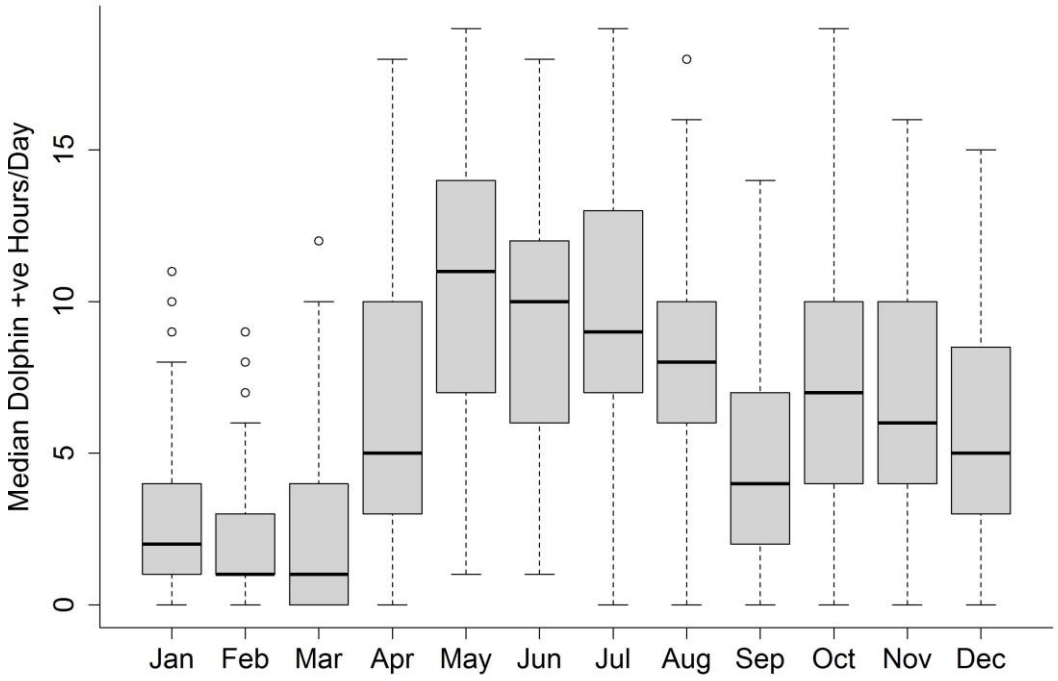
Table 9. Monthly variation in dolphin detections for the CPODs at the four long-term sites from 2011 to 2015. Months in which the number of days sampled was less than 10 were excluded.

	No. years with data	No. days sampled	% days dolphins detected	Median detection positive hrs/day	Interquartile range
Sutors:					
Jan	3	93	79.6	2	1-4
Feb	3	70	80	1	1-3
Mar	2	62	64.5	1	0-4
Apr	5	126	92.1	5	3-9.75
May	5	155	100	11	7-14
Jun	5	150	100	10	6-12
Jul	5	150	99.3	9	7-13
Aug	4	123	99.2	8	6-10
Sep	4	120	93.3	4	2-7
Oct	4	122	95.9	7	4-10
Nov	4	107	99.1	6	4-10
Dec	4	120	93.3	5	3-8.25
Chanonry:					
Jan	3	93	53.8	1	0-3
Feb	3	85	47.1	0	0-3
Mar	4	90	43.3	0	0-1.75
Apr	4	119	89.1	3	1-5
May	5	152	92.1	4	2-6.25
Jun	5	150	98.7	5	3.25-8
Jul	5	152	98.7	7	4-9
Aug	5	143	98.6	7	5-9
Sep	4	120	95.8	5	3-7
Oct	4	123	79.7	3	1-6
Nov	4	111	80.2	3	1-5
Dec	4	114	68.4	2	0-4
Lossiemouth:					
Jan	4	124	46.0	0	0-1
Feb	4	113	54.9	1	0-1
Mar	5	111	64.0	1	0-2
Apr	5	150	77.3	2	1-3
May	5	154	81.2	2	1-3
Jun	5	149	85.2	2	1-4
Jul	5	153	75.8	2	1-3
Aug	5	154	80.5	2	1-3
Sep	5	150	70.7	1	0-2
Oct	5	154	42.9	0	0-1
Nov	5	125	61.6	1	0-2
Dec	4	101	59.4	1	0-2

	No. years with data	No. days sampled	% days dolphins detected	Median detection positive hrs/day	Interquartile range
Spey Bay:					
Jan	4	124	19.4	0	0-0
Feb	4	111	27.0	0	0-1
Mar	4	93	39.8	0	0-1
Apr	5	150	72	2	0-3
May	5	154	90.9	4	2-6
Jun	5	149	94.6	4	2-7
Jul	5	148	89.9	3.5	2-5.25
Aug	4	124	83.9	3	1-5
Sep	4	120	82.5	2	1-4
Oct	4	122	62.3	1	0-3
Nov	4	118	55.1	1	0-2
Dec	4	124	52.4	1	0-2

Data on the seasonal variation in dolphin detections by the CPODs at the four long-term sites from 2011 to 2015 are presented in Table 9 and Figure 19. At all four sites dolphin occurrence tended to be highest from May to August, although at the Sutors dolphin occurrence was also relatively high from October to December (Figure 19).

a) Sutors



b) Chanonry

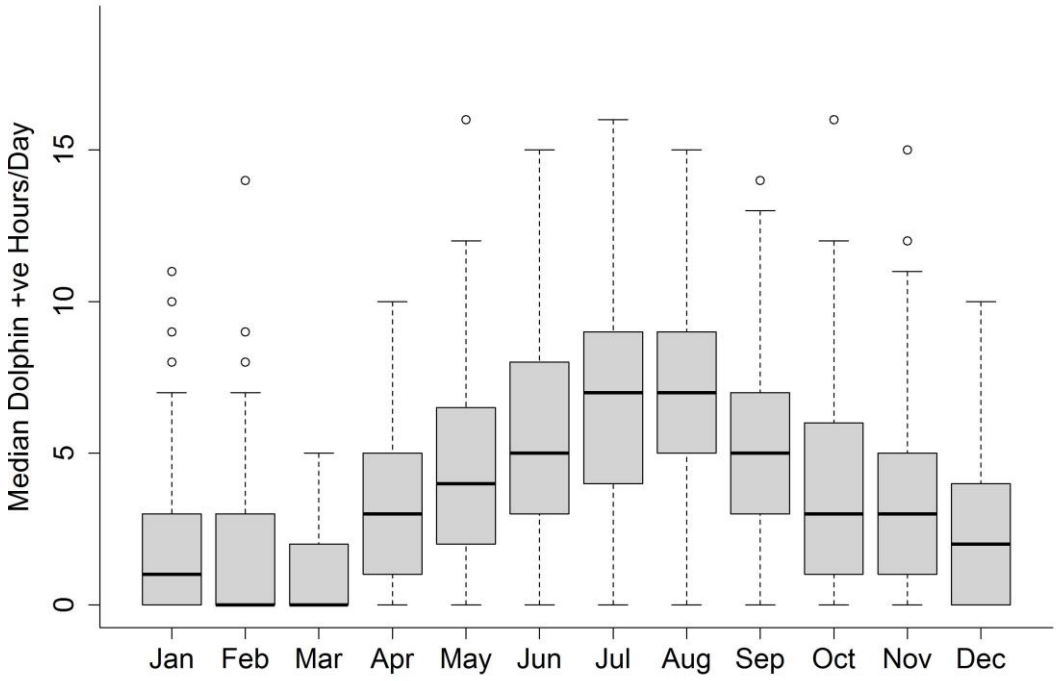
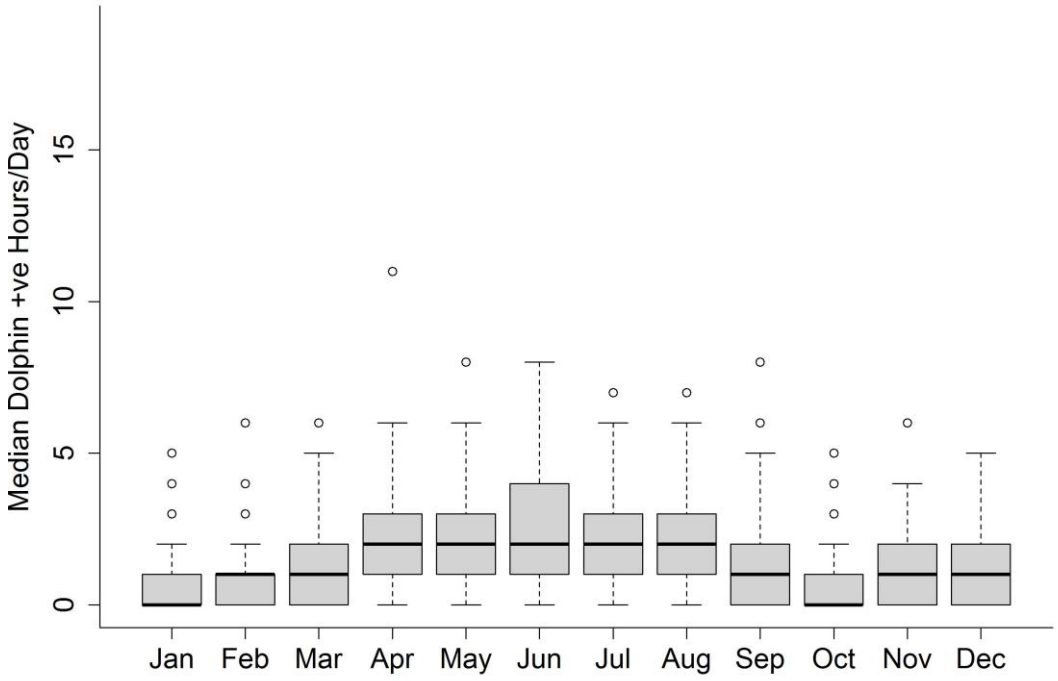


Figure 19 a & b. Seasonal variation in the median number of hours/day (± interquartile ranges) that dolphins were detected on CPODs at a) the Sutors and b) Chanonry from 2011 to 2015.

c) Lossiemouth



d) Spey Bay

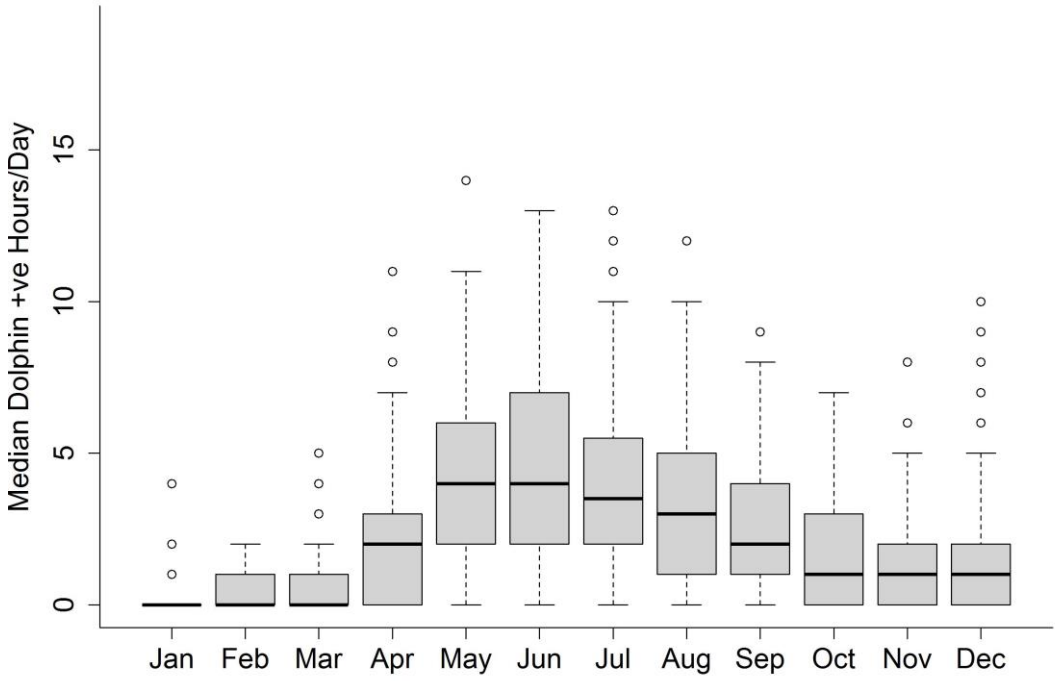


Figure 19 c & d. Seasonal variation in the median number of hours/day (± interquartile ranges) that dolphins were detected on CPODs at c) Lossiemouth and d) Spey Bay from 2011 to 2015.

REFERENCES

Akaike, H. (1998) Information Theory and an Extension of the Maximum Likelihood Principle. *Selected Papers of Hirotugu Akaike* (eds E. Parzen, K. Tanabe & G. Kitagawa), pp. 199-213. Springer New York, New York, NY.

Arso Civil, M. (2014) Population Ecology of Bottlenose Dolphins (*Tursiops truncatus*) off the East Coast of Scotland. PhD thesis, University of St Andrews.

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.

Burnham, K.P. & Anderson, D.R. (2002) *Model selection and multimodel inference: a practical information-theoretic approach,* Second edn. Springer, New York, USA.

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. (2011) Demography and breeding phenology of a marine top predator. PhD Thesis, University of Aberdeen.

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.

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 thesis, University of St. Andrews.

Kendall, W.L., Hines, J.E. & Nichols, J.D. (2003) Adjusting multistate capture-recapture models for misclassification bias: Manatee breeding proportions. *Ecology,* **84,** 1058-1066.

Kendall, W.L., Nichols, J.D. & Hines, J.E. (1997) Estimating temporary emigration using capture-recapture data with Pollock's robust design. *Ecology,* **78,** 563-578.

Kendall, W.L., Pollock, K.H. & Brownie, C. (1995) A Likelihood-Based Approach to Capture-Recapture Estimation of Demographic Parameters under the Robust Design. *Biometrics,* **51,** 293-308.

Laake, J.L. (2013) RMark: An R Interface for Analysis of Capture-Recapture Data with MARK. *AFSC Processed Report* (ed. N. Alaska Fisheries Science Centre, National Marine Fisheries Service). Seattle, WA.

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.

Pollock, K.H. (1982) A Capture-Recapture Design Robust to Unequal Probability of Capture. *Journal of Wildlife Management,* **46,** 752-757.

Quick, N., Arso, M., Cheney, B., Islas, V., Janik, V., Thompson, P.M. & Hammond, P.S. (2014) The east coast of Scotland bottlenose dolphin population: Improving understanding of ecology outside the Moray Firth SAC. UK Department of Energy and Climate Change.

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.

R Core Team (2015) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Russell, D.J., McClintock, B.T., Matthiopoulos, J., Thompson, P.M., Thompson, D., Hammond, P.S., Jones, E.L., MacKenzie, M.L., Moss, S. & McConnell, B.J. (2015) Intrinsic and extrinsic drivers of activity budgets in sympatric grey and harbour seals. *Oikos,* **124,** 1462-1472.

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.

White, G.C. & Burnham, K.P. (1999) Program MARK: Survival estimation from populations of marked animals. *Bird Study,* **46,** 120-138.

Williamson, L.D., Brookes, K.L., Scott, B.E., Graham, I.M., Bradbury, G., Hammond, P.S. & Thompson, P.M. (2016) Echolocation detections and digital video surveys provide reliable estimates of the relative density of harbour porpoises. *Methods in Ecology and Evolution*.

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. *Reproductive histories of female harbour seals seen with pups in Loch Fleet in 2015 (navy box with white tick = seen with pup, light blue box = seen without pup, white box = not seen).*

IDNO	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
4	✓	✓	✓	✓	✓	✓		✓	✓	✓
5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
7	✓	✓	✓	✓	✓		✓	✓	✓	✓
10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
12	✓	✓	✓	✓	✓	✓	✓	✓		✓
13	✓	✓	✓	✓	✓	✓	✓	✓		✓
14	✓	✓	✓	✓	✓		✓	✓	✓	✓
16	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
20	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
23	✓		✓	✓	✓	✓	✓	✓	✓	✓
28	✓	✓	✓	✓	✓	✓	✓	✓		✓
33	✓	✓	✓	✓	✓	✓	✓		✓	✓
35	✓	✓	✓	✓	✓	✓	✓	✓		✓
42	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
59	✓	✓	✓	✓		✓	✓	✓	✓	✓
61		✓	✓	✓	✓		✓	✓	✓	✓
62		✓	✓		✓	✓	✓		✓	✓
63		✓	✓	✓	✓	✓	✓	✓	✓	✓
70			✓						✓	✓
75				✓	✓		✓	✓	✓	✓
78	✓			✓	✓		✓	✓	✓	✓
81			✓	✓	✓		✓	✓	✓	✓
93								✓	✓	✓
101			✓	✓	✓	✓	✓	✓	✓	✓
103			✓	✓	✓	✓	✓	✓	✓	✓
105			✓	✓	✓	✓	✓	✓	✓	✓
127	✓		✓		✓	✓	✓	✓	✓	✓
149			✓	✓	✓	✓	✓	✓	✓	✓
158			✓	✓	✓		✓		✓	✓
164			✓		✓	✓		✓	✓	✓
167				✓	✓	✓	✓	✓	✓	✓
172				✓	✓		✓	✓	✓	✓
174						✓	✓	✓	✓	✓
181			✓		✓	✓	✓	✓	✓	✓
184						✓	✓		✓	✓
223					✓	✓	✓	✓	✓	✓
224				✓	✓	✓	✓	✓	✓	✓
242							✓	✓	✓	✓
243								✓	✓	✓
244									✓	✓
246									✓	✓

IDNO	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
247									✓	✓
250									✓	✓
251										✓
252									✓	✓
268									✓	✓
269										✓
273									✓	✓
276										✓
278									✓	✓
283										✓
285									✓	✓
294										✓
295										✓
314										✓

ANNEX 4. *Sighting histories of all well-marked harbour seal individuals seen in Loch Fleet in 2015 (male = 1, female = 2, unknown sex = 3).*

IDNO	SEX	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	2										
4	2										
5	2										
7	2										
8	2										
10	2										
12	2										
13	2										
14	2										
16	2										
17	2										
20	2										
23	2										
27	2										
28	2										
30	2										
33	2										
35	2										
42	2										
46	2										
52	2										
53	2										
56	2										
59	2										
61	2										
62	2										
63	2										
67	2										
70	2										
72	1										
73	1										
75	2										
76	2										
78	2										
80	2										
81	2										
82	1										
83	2										
84	2										
86	1										
90	1										

IDNO	SEX	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
93	2	■	■	■	■	■	■	■	■	■	■
99	1	■	■	■	■	■				■	■
101	2	■	■	■	■	■	■	■	■	■	■
103	2	■	■	■	■	■	■	■	■	■	■
105	2	■	■	■	■	■	■	■	■	■	■
107	3	■	■	■	■						■
109	1	■	■	■	■	■	■	■	■	■	■
118	2	■	■	■	■	■	■	■	■	■	■
120	1	■	■	■	■	■	■		■	■	■
122	1	■	■	■	■	■	■	■	■	■	■
127	2	■	■	■	■	■	■	■	■	■	■
132	1	■	■	■	■	■	■	■	■	■	■
139	2	■	■	■				■			■
149	2	■	■	■	■	■	■	■	■	■	■
158	2	■	■	■	■	■	■	■	■	■	■
161	1	■	■	■	■	■	■	■	■	■	■
164	2	■	■	■	■	■	■	■	■	■	■
165	1	■	■	■	■	■	■	■	■	■	■
167	2	■	■	■	■	■	■	■	■	■	■
168	2	■		■	■	■	■	■	■		■
169	1	■	■	■	■	■	■	■	■	■	■
172	2	■	■	■	■	■	■	■	■	■	■
174	2			■	■	■	■	■	■	■	■
178	1			■	■	■	■	■	■	■	■
181	2	■	■	■	■	■	■	■	■	■	■
184	2			■	■	■	■	■	■	■	■
186	2	■		■		■		■			■
187	1			■		■	■	■	■	■	■
190	1	■	■	■	■	■	■	■	■	■	■
191	1			■	■	■	■	■	■	■	■
202	1		■	■	■	■	■	■	■	■	■
207	1				■	■	■	■	■	■	■
216	2			■	■	■	■		■		■
219	1			■	■	■				■	■
222	2			■	■	■	■	■	■	■	■
223	2			■	■	■	■	■	■	■	■
224	2			■	■	■	■	■	■	■	■
229	1				■	■		■	■	■	■
230	1				■		■	■	■	■	■
234	1					■	■	■	■	■	■
242	2					■		■	■	■	■
243	2							■	■	■	■
244	2							■	■	■	■
246	2							■	■	■	■

IDNO	SEX	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
247	2										
249	1										
250	2										
251	2										
252	2										
253	2										
254	2										
255	2										
256	1										
257	1										
258	1										
259	2										
260	1										
262	2										
263	1										
264	1										
265	1										
267	1										
268	2										
269	2										
270	1										
271	1										
272	1										
273	2										
274	1										
275	1										
276	2										
277	1										
278	2										
279	1										
280	1										
282	1										
283	2										
284	1										
285	2										
286	1										
287	2										
288	2										
289	2										
290	2										
291	1										
292	1										
293	1										
294	2										

IDNO	SEX	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
295	2							■	■	■	■
297	1							■	■	■	■
298	1							■	■	■	■
299	1							■	■	■	■
300	2								■	■	■
301	1								■	■	■
302	1								■	■	■
303	1								■	■	■
304	1								■	■	■
305	2								■	■	■
306	2								■	■	■
307	1								■	■	■
308	1								■	■	■
309	1								■	■	■
310	2								■	■	■
311	2								■	■	■
312	1								■	■	■
313	2								■	■	■
314	2								■	■	■
315	1								■	■	■
316	1								■	■	■
317	2								■	■	■
318	1								■	■	■
319	1								■	■	■
322	1									■	■
323	1								■	■	■
324	1								■		■
325	1								■	■	■
327	3									■	■
328	1									■	■
330	2									■	■
331	1									■	■
333	1								■	■	■
334	1									■	■
335	1								■	■	■
336	1								■	■	■
337	2								■	■	■
338	1									■	■
339	2									■	■
340	2									■	■
341	2									■	■
342	1								■	■	■
376	1										■
386	2										■

IDNO	SEX	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
388	2										
389	2										
390	2										
394	2										
396	1										
420	3										

ANNEX 5. *Harbour seals captured and tagged in the Dornoch Firth and Loch Fleet (navy box = at least 7 days of data for that time period, light blue box = less than 7 days of data in total for that tag, no shading = no data). One individual has been captured and tagged on two separate occasions: recaptures of the same individual are indicated by superscript numbers in the Sex column.*

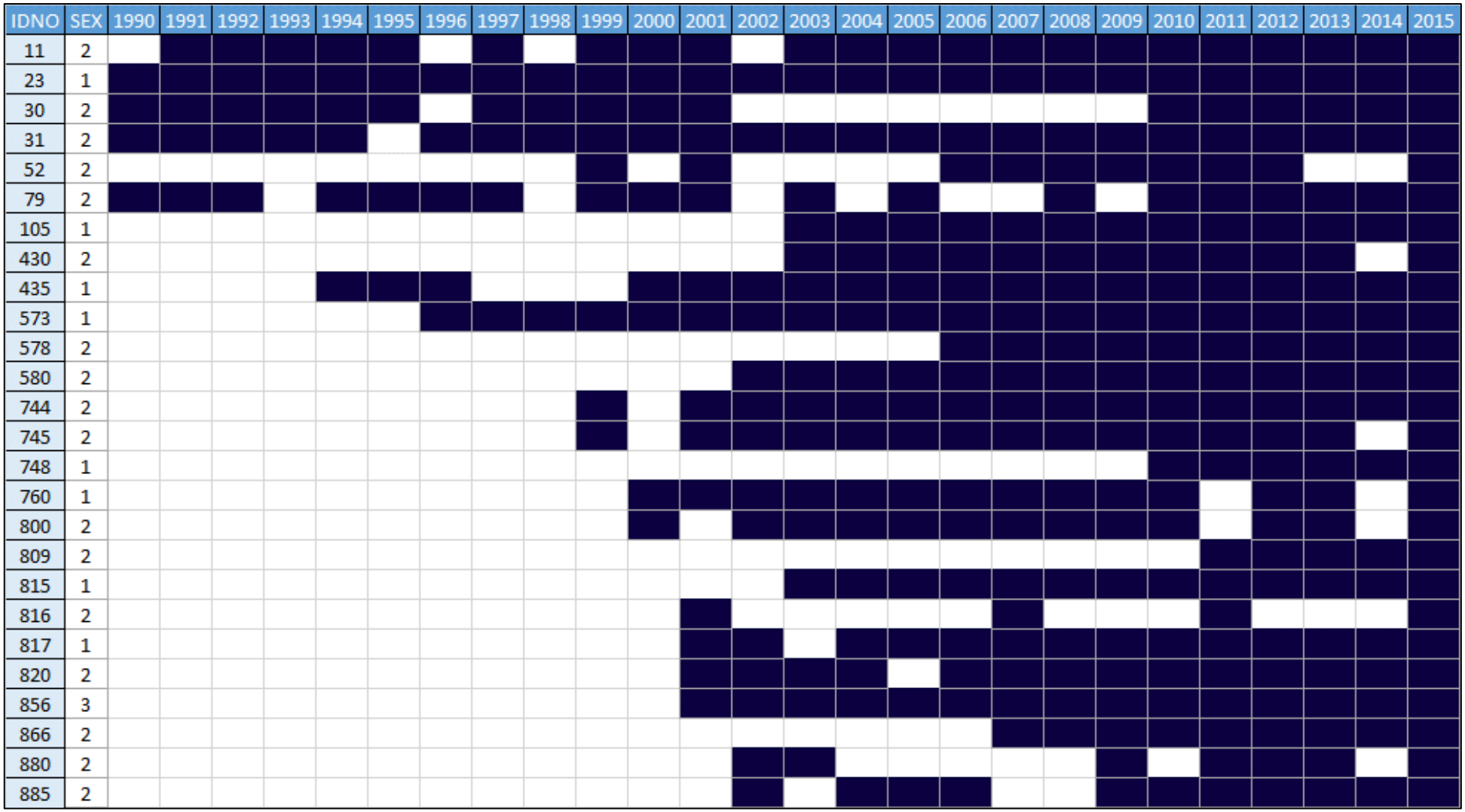
Deployment Year	Capture Site	Tag ID	Sex	Data type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	Dornoch	103	F	VHF												
1989	Dornoch	100	F	VHF												
1989	Dornoch	101	F	VHF												
1989	Dornoch	102	F	VHF												
1989	Dornoch	107	F	VHF												
1989	Dornoch	108	F	VHF												
1989	Dornoch	70	F	VHF												
1989	Dornoch	131	M	VHF												
1989	Dornoch	132	M	VHF												
1989	Dornoch	140	M	VHF												
1989	Dornoch	133	F	VHF												
1991	Dornoch	181	M	VHF												
1991	Dornoch	179	M	VHF												
1991	Dornoch	193	M	VHF												
1991	Dornoch	183	M	VHF												
1991	Dornoch	194	M	VHF												
1991	Dornoch	185	M	VHF												
1991	Dornoch	198	M	VHF												
1991	Dornoch	184	M	VHF												
1991	Dornoch	180	M	VHF												
1991	Dornoch	199	F	VHF												
2004	Dornoch	43861	M	SRDL												
2004	Dornoch	43866	M	SRDL												
2004	Dornoch	43867	M	SRDL												
2004	Dornoch	43868	M	SRDL												
2004	Dornoch	43864	F	SRDL												
2005	Dornoch	33257	M	SRDL												
2005	Dornoch	33185	F	SRDL												
2005	Dornoch	33869	F	SRDL												
2005	Loch Fleet	33843	M	SRDL												
2005	Loch Fleet	33255	F	SRDL												
2009	Loch Fleet	11167	F	GPS-GSM												
2009	Loch Fleet	11188	F	GPS-GSM												
2009	Loch Fleet	11169	F	GPS-GSM												
2009	Loch Fleet	11173	F	GPS-GSM												
2009	Loch Fleet	11161	F[1]	GPS-GSM												

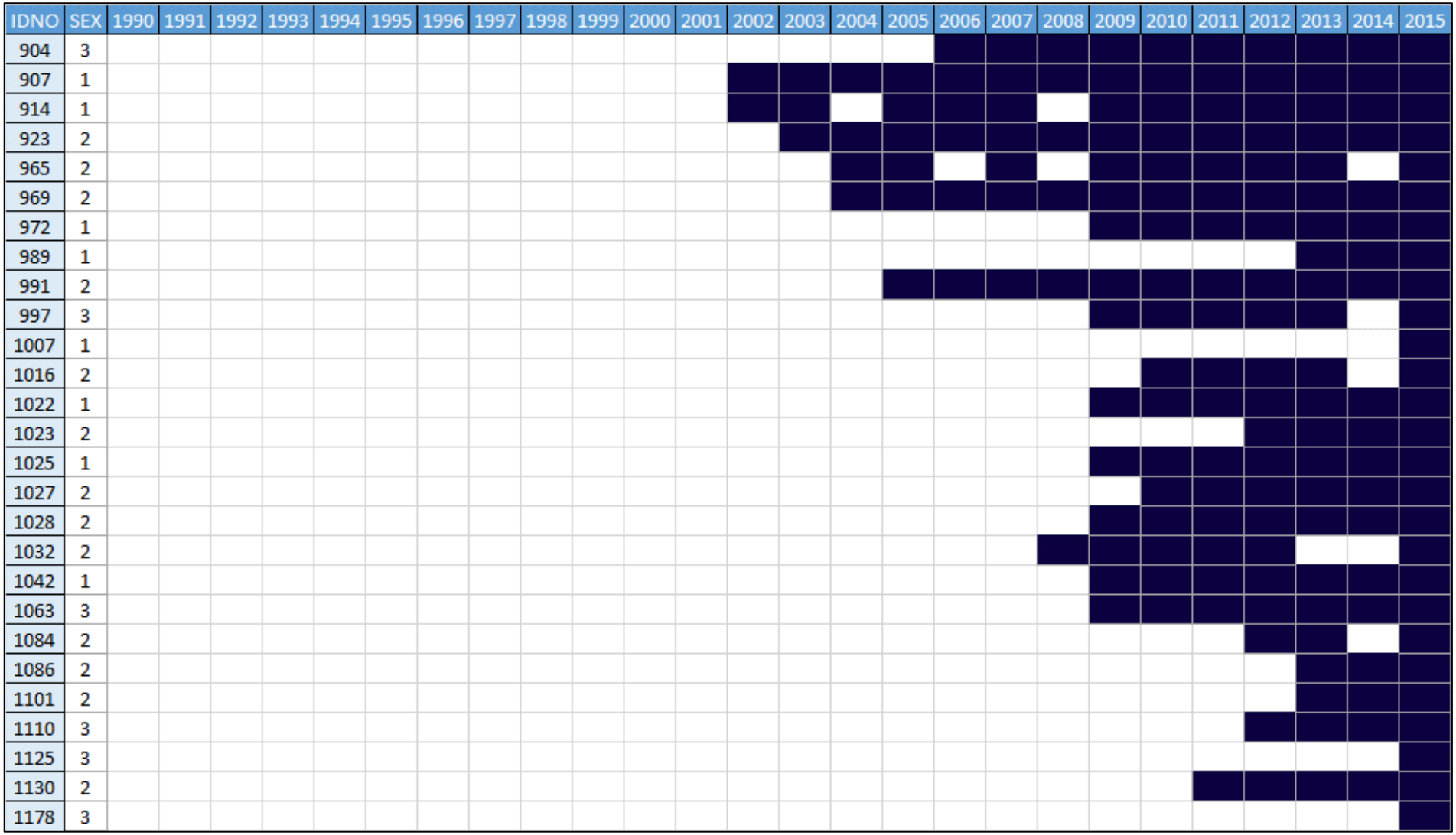
Deployment Year	Capture Site	Tag ID	Sex	Data type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	Loch Fleet	13207	F	GPS-GSM												
2014	Loch Fleet	13210	F	GPS-GSM												
2014	Loch Fleet	12921	F	GPS-GSM												
2014	Loch Fleet	13208	M	GPS-GSM												
2014	Loch Fleet	12915	F	GPS-GSM												
2014	Loch Fleet	13214	M	GPS-GSM												
2014	Loch Fleet	12919	M	GPS-GSM												
2014	Loch Fleet	13209	M	GPS-GSM												
2014	Loch Fleet	13213	M	GPS-GSM												
2014	Loch Fleet	13115	M	GPS-GSM												
2014	Loch Fleet	13212	F	GPS-GSM												
2014	Loch Fleet	12922	F	GPS-GSM												
2015	Loch Fleet	13282	M	GPS-GSM												
2015	Loch Fleet	13255	M	GPS-GSM												
2015	Loch Fleet	13313	M	GPS-GSM												
2015	Loch Fleet	13322	F	GPS-GSM												
2015	Loch Fleet	13286	F	GPS-GSM												
2015	Loch Fleet	13314	F	GPS-GSM												
2015	Loch Fleet	13203	F	GPS-GSM												
2015	Loch Fleet	13284	M	GPS-GSM												
2015	Loch Fleet	13316	M	GPS-GSM												
2015	Loch Fleet	13320	F	GPS-GSM												
2015	Loch Fleet	13318	F	GPS-GSM												
2015	Loch Fleet	13204	M	GPS-GSM												
2015	Loch Fleet	13120	F[1]	GPS-GSM												
2015	Dornoch Firth	65241	F	GPS-UHF												
2015	Dornoch Firth	65249	F	GPS-UHF												
2015	Dornoch Firth	65258	F	GPS-UHF												
2015	Dornoch Firth	65226	M	GPS-UHF												
2015	Dornoch Firth	65234	M	GPS-UHF												
2015	Dornoch Firth	65255	M	GPS-UHF												
2015	Dornoch Firth	65233	M	GPS-UHF												
2015	Dornoch Firth	65208	F	GPS-UHF												
2015	Dornoch Firth	65232	M	GPS-UHF												
2015	Dornoch Firth	65259	F	GPS-UHF												

ANNEX 6. *Reproductive histories of female bottlenose dolphins seen with new-born calves in the SAC in 2015 (ticks = year a calf was born, green box = calf survived to at least age 3, red tick = calf died).*

IDNO	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
240				✓					✓			✓			✓
578			✓				✓				✓				✓
809					✓						✓				✓
866									✓				✓		✓
973													✓		✓
1024															✓
1027											✓				✓
1084															✓

ANNEX 7. *Sighting histories of all well-marked (dorsal fin nick) bottlenose dolphins seen in the SAC in 2015 (male = 1, female = 2, unknown sex = 3). Sightings from 1990 to 2015 in the SAC once an individual received its first dorsal fin nick.*





IDNO	SEX	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
904	3																										
907	1																										
914	1																										
923	2																										
965	2																										
969	2																										
972	1																										
989	1																										
991	2																										
997	3																										
1007	1																										
1016	2																										
1022	1																										
1023	2																										
1025	1																										
1027	2																										
1028	2																										
1032	2																										
1042	1																										
1063	3																										
1084	2																										
1086	2																										
1101	2																										
1110	3																										
1125	3																										
1130	2																										
1178	3																										