Brims Tidal Array

Marine Mammal and Basking Shark Boat Based Visual Survey Data Analysis

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1.1 Introduction

The Brims Tidal Array Agreement for Lease (AfL) area was identified as part of the Pentland Firth and Orkney Waters Leasing Round (PFOW) in 2009-10. The proposed development is located to the south of Hoy, off Brims Ness headland, and has a potential installed capacity of up to 200 MW. It is anticipated that construction would commence in 2019 (subject to all consents and licences being in place). It is anticipated that the Brims project will consist of:

- Offshore tidal generators;
- Inter-array cables;
- Potential for offshore hub(s) or substation;
- Export cable to shore; and
- Onshore cabling to onshore substation

In order to inform the Environment Impact Assessment (EIA), assess the presence of European Protect Species (EPS) and the relevance of the site to populations protected under Natura 2000 legislation it is important to characterise the AfL. Site specific boat based line transect surveys were completed between March 2012 and March 2014 to characterise the AfL. Surveys included the use of dedicated visual marine mammal observers (MMOs) surveying for marine mammals and basking sharks, European Seabird at Sea (ESAS) surveyors, and the use of a towed passive acoustic monitoring (PAM) array.

This report provides a summary of MMO and ESAS surveyor sightings, and the results of distance sampling analysis to estimate the density of marine mammals within the AfL and surrounding buffer area. The results of the PAM surveys are presented in (Gordon & Wittich, 2014).

1.2 Methods

1.2.1 Site specific surveys

The aims of the surveys were to establish the distribution, abundance and behaviour of birds, marine mammal and basking shark within the Survey Area and how these change seasonally.

The Afl is a remote location which is exposed to North Atlantic weather systems. Therefore the survey area has high exposure to winds as well as strong tidal currents. Both of these factors present a significant constraint to safely while undertaking boat-based surveys.

Details of the survey methodology have been previously presented, discussed and agreed during consultation with SNH and Marine Scotland following the production of interim survey reports (NRP, 2013); a brief summary is provided below.

The survey design was driven by the theoretical requirements of distance sampling (Buckland *et al*., 2001) and mediated by practical consideration affecting the safe operation of the vessel and disturbance of birds and marine mammals. The design followed SNH wet renewables survey guidance for bird surveys (Jackson and Whitfield, 2011). The survey was a zig-zag design composing 11 transect lines and covering the Development Area and a buffer that extends to a further 4km to the east, south and west and approximately 1km to the north (as far as the shore of Hoy/South Walls; **Figure 1**). When all transects were completed in a survey, approximately 56km of survey effort was accomplished. The surveys area included the AfL and a buffer zone, with a total survey area of approximately 79.5km^2.

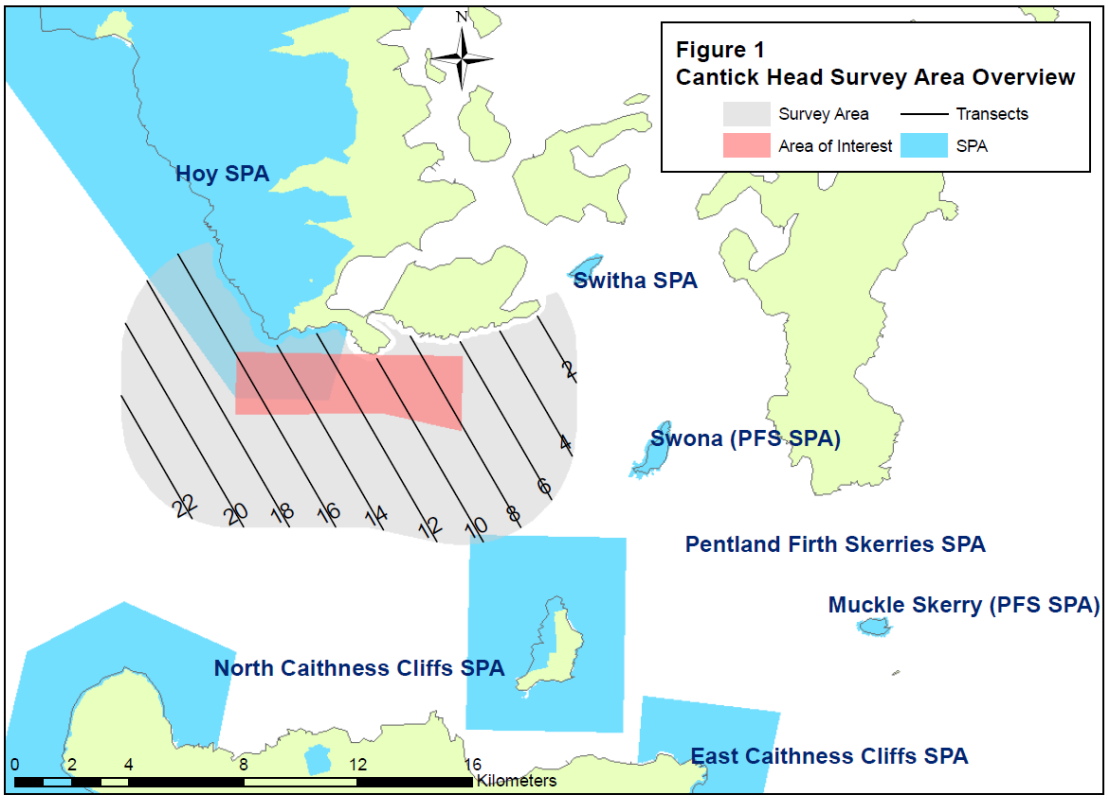

Figure 1: Brims Tidal Array survey area (reproduced from NRP, 2013)

The surveys consisted of boat based surveys (all but one survey, August 2012, was completed using the MV Karin) using both visual and acoustic observations using dedicated marine mammal observers (MMOs), as well as European Seabirds at Sea (ESAS) observers and a towed passive acoustic monitoring (PAM) hydrophone. Seabird and marine mammal surveys were carried out simultaneously from the same vessel using dedicated observers. For the seabird surveys the standard ESAS methodology was used which employed a 300m wide transect on one side of the vessel, with the location of sightings being recorded using predefined distance bands (Camphuysen *et al*., 2004, Jackson and Whitfield, 2011). The MMOs worked as a team of two, and searched from the ship to the horizon on both sides of the vessel, with estimates of the (radial) distance and direction of sightings from the observer being used to locate sightings (Macleod *et al*., 2011). The MMOs were experienced surveyors who were JNCC certified. Each MMO had a ranging stick, graticule binoculars and angle board to facilitate accurate determination of distance bands, as well as a digital camera to take advantage of any opportunities to photograph the dorsal fins of dolphin species for photo identification purposes. For both types of survey coverage extended from 90º abeam of the vessel forwards. ESAS surveys must be undertaken in conditions of sea

state 4 or below, and marine mammal surveys ideally require conditions to below sea state 3. For this reason flexibility was been built into the timing of visits. A survey of all 11 transects lines required approximately 8 hours on site with transit time from and to port additional to this.

Surveys were undertaken covering the period March 2012 to March 2014. An interim report of survey findings up to August 2012 was provided to Marine Scotland and SNH (NRP, 2013). The results of the PAM surveys will be analysed and reported by Marine Ecological Research (Gordon & Wittich, 2014), in an update to the previously submitted report Wittich & Gordon (2012).

1.2.2 Data analysis

Section 1.3 of this report provides a description of the marine mammal and basking shark sightings made by the ESAS surveyors and the MMOs. Distance sampling analysis (Buckland *et al*., 2001) was used to estimate density and abundance of individuals of each species where sufficient sightings were made.

1.2.3 Westray South tidal array

Between January 2012 and March 2014 Natural Research Projects Ltd also conducted comparable boat based surveys at the Westray South tidal array site using the same survey methods as at Brims. Whilst the two projects are independent, and are being taken forward by different developers, consideration was given to co-operation between the two sites in the form of data sharing to aid in distance sampling analysis.

1.3 Results

1.3.1 Survey effort

Table 1 provides a summary of the survey effort at Brims. Surveys were undertaken on a total of 20 days between March 2012 and March 2014. Due to bad weather no surveys were completed during September 2012, October 2012, November 2012, January 2013, April 2013, August 2013, November 2013, December 2013, or January 2014. In addition surveys could not be completed for all transects in some months (August 2012, February 2013, May 2013, October 2013 and March 2014) see Table 1 for details, and a full survey was completed over two days in February 2014. This resulted in uneven temporal and seasonal coverage (Table 1). During the autumn

months; eight of the 20 surveys were conducted during spring (March – May), six during summer (June – August), only two surveys during the autumn (September – November) and four in winter (December – February).

In addition, due to inclement weather preventing surveys being attempted or completed in some months, a number of the surveys were undertaken in sea states greater than 3. These data, although included in the sighting summaries in **Section 1.3.2**, are not included in the data analysis (see **Section 3.3**). The use of surveys in sea state greater than 3 is not recommended for marine mammal surveys due to the reduced sighting probabilities.

Table 1: Details of Brims ESAS and marine mammal surveys

Year	Month	Survey ID	Survey date	Details of completed transects
2012	Mar	1	27th	All
	Apr	2	18th	All
	May	3	27th	All
	Jun	4	30th	All
	Jul	5	20th	All
	Aug	6	20th	Missing T22
	Sept	No survey		
	Oct	No survey		
	Nov	No survey		
	Dec	7	11th	All
2013	Jan	No survey		
	Feb	8	17th	T3-T8
	Mar	9 10 11	4th 5th 30th	Missing T16, T18, T20, T22 All All
	Apr	No survey		
	May	12	16th	Only surveyed T14
	Jun	13 14	3rd 25th	All All
	Jul	15	10th	All
	Aug	No survey		
	Sep	16	9th	All
	Oct	17	23rd	Missing T20, T22
	Nov	No survey		
	Dec	No survey		
2014	Jan	No survey		
	Feb	18 19	17th 19th	Missing T12, T14, T16, T18, T20, T22 Missing T2, T4, T6, T8, T10, T12, T14, T16

	Mar	20	12th	Missing T16, T18, T20, T22

1.3.2 Summary of survey data

The total number of individual marine mammals sighted in the water by the MMOs and ESAS observers when both on and off survey effort are summarised in **Table 2a** and **Table 2b** respectively. Based on these data the species of interest in the Brims AfL are:

- Harbour porpoise *Phocoena phoceona*;
- Grey seal *Halichoerus grypus*;
- Harbour seal *Phoca vitulina*;
- White-beaked dolphin *Lagenorhynchus albirostris;*
- Minke whale *Balaenoptera acutorostrat;* and
- Basking shark *Cetorhinus maximus*.

Harbour porpoise were the most frequently sighted individuals by both the MMOs and the ESAS surveyors. As would be expected, the on-effort encounter rates were higher for the MMOs, a total of 120 were seen, at a rate of approximate two harbour porpoise per hour of survey effort. Grey seal were the second most frequently seen individuals, with a total of 60 seen in all seasons and sea states by the MMOs, and 45 by the ESAS surveyors. Seals (which could not be identified to species) and then harbour seal were the next most common. In addition, the MMOs sighted one minke whale, 13 white-beaked dolphin and one marine mammal that could not be identified to species. The white-beaked dolphin sightings are clearly repeat sightings of the same individuals on multiple transects. Off-effort additional sightings included one further marine mammal that could not be identified to species, and one basking shark. The dedicated MMO surveyors sighted more individuals of each species than the ESAS surveyors.

Table 2a: The number of marine mammal individuals sighted on (and off) effort by the dedicated MMOs in all sea states

Year	Month	Survey date	Harbour seal	Grey seal	Seal spp.	Harbour porpoise	Other
2012	Mar	27th	1	2	2	20	-
	Apr	18th	-	-	-	1	-
	May	27th	1	2	-	1	1 porpoise/dolphin species dead

Year	Month	Survey date	Harbour seal	Grey seal	Seal spp.	Harbour porpoise	Other
	Jun	30th	-	1	-	-	-
	Jul	20th	1	5	-	5 (+1 off effort)	1 minke whale, 13 white-beaked dolphin (+3 WBD off effort)
	Aug	20th	-	2 (+1 off effort)	-	11	(1 basking shark off effort)
	Sept	No survey					
	Oct	No survey					
	Nov	No survey					
	Dec	11th	1	3	4	- (+1 off effort)	(+1 marine mammal species off effort)
2013	Jan	No survey					
	Feb	17th	-	-	-	11	-
	Mar	4th	-	4	-	11	-
		5th	1	3	3	29	-
		30th	-	4	4	4	1 marine mammal species
	Apr	No survey					
	May	16th	-	-	-	-	-
	Jun	3rd	-	1	1	3	-
		25th	3	3	4	3	-
	Jul	10th	2	12	7	11	-
	Aug	No survey					
	Sep	9th	2	8	2	3	-
	Oct	23rd	1	4	1	-	-
	Nov	No survey					
	Dec	No survey					
2014	Jan	No survey					
	Feb	17th	-	1	-	1	-
		19th	-	-	-	4	-
	Mar	12th	-	5	1	2	-
TOTAL (on effort)			**13**	**60**	**29**	**120**	**1 minke 13 WBD 1 marine mammal species**
Average sighting rate (number of individuals			**0.22**	**0.99**	**0.48**	**1.99**	**0.02 (minke) 0.22 (WBD)**

Year	Month	Survey date	Harbour seal	Grey seal	Seal spp.	Harbour porpoise	Other
per hour on effort)							

Table 2b: The number of marine mammals individuals sighted on (and off) effort by the ESAS observers in all sea states

Year	Month	Survey date	Harbour seal	Grey seal	Seal spp.	Harbour porpoise	Other
2012	Mar	27th	-	2	-	6	-
	Apr	18th	-	-	1	1	-
	May	27th	1	4	1	-	-
	Jun	30th	-	1	-	-	-
	Jul	20th	-	-	2	2	1 minke (+1 minke off effort) 5 WBD (+3 WBD off effort)
	Aug	20th	-	1	-	2 (+1 off effort)	-
	Sept	No survey					
	Oct	No survey					
	Nov	No survey					
	Dec	11th	-	3	-	8 (+ 2 off effort)	-
2013	Jan	No survey					
	Feb	17th	-	-	-	3	-
	Mar	4th	-	1	-	5	-
		5th	-	5 (+1 off effort)	-	33 (+ 5 off effort)	1 small cetacean
		30th	1	-	1	1	-
	Apr	No survey					
	May	16th	-	-	-	-	-
	Jun	3rd	1	2	2	3	-
		25th	-	3	-	-	-
	Jul	10th	3	3	3	6	-
	Aug	No survey					
	Sep	9th	-	17	8	14	1 marine mammal species
	Oct	23rd	-	3	1	- (+6 off effort)	-
	Nov	No survey					
	Dec	No survey					

Year	Month	Survey date	Harbour seal	Grey seal	Seal spp.	Harbour porpoise	Other
2014	Jan	No survey					
	Feb	17th	-	-	-	-	-
		19th	-	-	-	4	-
	Mar	13th	-	-	-	2	-
TOTAL (on effort)			**6**	**45**	**19**	**90**	**1 minke 5 WBD 1 marine mammal species 1 small cetacean**
Average sighting rate (number of individuals per hour on effort)			**0.1**	**0.75**	**0.31**	**1.5**	**0.02 (minke) 0.08(WBD)**

1.3.3 Distance sampling analysis

Sightings summary

After 20 boat-based surveys, a total of 169 sightings of marine mammal individuals or groups were recorded by the MMOs, and 135 observations of marine mammals were recorded by the ESAS team (**Table 3**). It is likely that there are sightings which were seen and recorded by both teams, so it should not be considered that, for example, there were 125 harbour porpoise sightings in total. Duplicate sightings have not been examined for this analysis.

Harbour porpoise was the most frequently sighted cetacean species and comprise 39% of the data collected by the marine mammal survey team. Three sightings of a total of 13 white-beaked dolphin and one sighting of a single minke whale were also recorded by the MMOs. Group size of harbour porpoises ranged from one to six individuals, although single animals were most commonly sighted (56% of all sightings). Both grey and harbour seal were recorded. Most seal sightings were of single individuals (92%) although seals were occasionally sighted in groups of two.

Table 3: Numbers of sightings of marine mammal species seen by both the marine mammal survey team and the ESAS (seabird) observer teams. This does not represent number of marine mammal surveyor derived sightings available for analysis or the number of individuals sighted of each species

Species	Number of marine mammal surveyor sightings	Number of ESAS observer marine mammal sightings
Harbour seal	13	5
Grey seal	53	44
Seal sp.	30	20
Harbour porpoise	66	59
Minke whale	1	1
White-beaked dolphin	3	3
Marine Mammal sp.	2	1
Porpoise / dolphin	1	1

Sea state

Marine mammals can be particularly difficult to see in all but the calmest sea-states, and studies have shown that numbers of harbour porpoise sightings decline as sea-state increases above sea-state 2 (e.g. Palka *et al*., 1996). Equivalent studies have not been conducted for seal species, as vessel-based line transect sampling of at-sea animals is not the usual census technique for this species, however, when seen at sea, they do provide a similarly low profile at the surface. As a consequence of the influence of sea-state, it is not uncommon for data collected at higher states (3 and above) to be removed from analyses in order to reduce the likelihood of negatively biasing abundance estimates generated (e.g. Burt *et al*., 2007).

Environmental data (including sea-state) were recorded in two separate forms during the surveys, once by the ESAS surveyors and once by the MMOs. These data are not always the same, for example, during the March 2012 survey, the ESAS observer recorded sea-state 0-5, but the marine mammal surveyors recorded states 1-3. The reason for this discrepancy is not clear, and as a consequence only the marine mammal surveyor environmental data are used in the analysis.

Approximately 60 hours and 20 minutes was spent on effort at Brims (**Table 4**). Of this, almost 30 hours was conducted at sea-state 3 or above. As the number of sightings of animals at this site are relatively low, removing approximately half of the data collected is not desirable. As a consequence, distance analyses were conducted using data up to and including sea-state 3, but excluding sea-states 4 and 5. This resulted in the removal of two porpoise sightings from the analysis and one grey seal sighting.

Table 4: Breakdown of time spent on-transect at each sea-state (as recorded by the marine mammal surveyors) during surveys at Brims

Survey ID	Sea state					
	0	**1**	**2**	**3**	**4**	**5**
1	-	-	3:51:00	0:46:00	-	-
2	-	-	2:59:00	0:50:00	-	-
3	0:32:00	2:17:00	0:46:00	-	-	-
4	-	-	-	0:44:00	-	-
5	-	-	-	2:32:00	-	-
6	-	-	2:31:00	2:43:00	-	-
7	-	-	1:16:00	-	-	-
8	-	-	2:24:00	1:25:00	-	-
9	-	-	-	0:20:00	0:29:00	-
10	-	-	0:41:00	0:41:00	1:00:00	0:04:00
11	-	1:41:00	2:33:00	0:09:00	-	-
12	-	-	2:32:00	0:10:00	0:32:00	-
13	-	-	-	2:31:00	1:13:00	0:24:00
14	-	-	1:06:00	-	-	-
15	-	-	3:02:02	-	-	-
16	-	-	0:48:00	2:04:00	0:58:00	-
17	-	0:43:00	1:36:00	-	-	-
18	-	-	1:36:00	1:42:00	0:31:00	-
19	-	-	2:24:00	1:25:00	-	-
20	-	1:30:00	2:19:00	1:10:00	-	-
21	0:27:00	2:37:00	0:59:00	0:09:00	-	-
22	-	1:32:00	1:39:00	0:18:00	-	-
23	-	0:26:00	0:49:00	-	-	-
24	-	0:33:00	1:14:00	1:35:00	0:23:00	-
25	-	-	1:19:00	1:25:00	0:26:00	-
26	-	-	0:02:00	2:14:00	0:53:00	-
27	-	-	-	0:08:00	0:56:00	0:07:00
Total	**0:59:00**	**11:19:00**	**35:24:00**	**25:01:00**	**7:21:00**	**0:35:00**

Density and abundance analysis

Observations that were made between transects, while 'off-effort', were excluded from the analysis, as well as any sightings of hauled out seals, and those in sea states higher than 3.

Ideally, a minimum of 60-80 individual observations across all surveys is considered as suitable for analysis in Distance (CREEM, 2011). Once off-effort data were removed, the only species available for individual analyses is harbour porpoise. Grey seal were seen in relatively high numbers, once off-effort data were removed, there were 50

observations during the Brims Tidal Array surveys and 46 observations at Westray South. Based on the combined sightings from the two tidal sites analysis was possible.

There were insufficient sightings of other species at Brims to produce site specific estimates or a combined estimate across the Brims and Westray South sites.

Harbour porpoise abundance and density

Radial distance and angle from the transect line (as recorded in the field) were converted to perpendicular distance. After truncation at 600m, there were a total 63 observations of harbour porpoise sightings over the 20 surveys available for analysis. The model chosen was a half normal key function with cosine adjustment term (**Figure 2**). The dip in sightings within 100m of the trackline may be indicative of responsive movement of harbour porpoises away from the survey vessel.

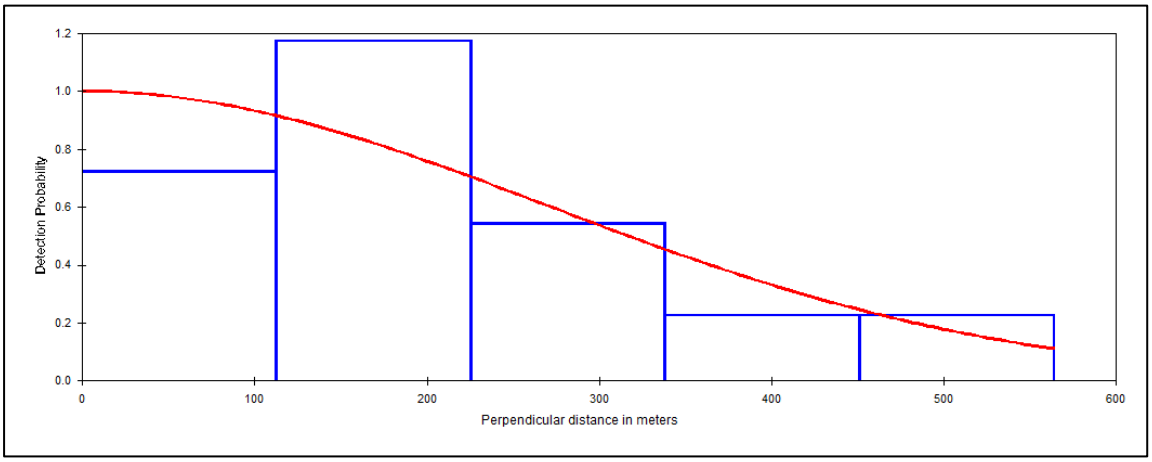

Figure 2: Detection probability curve for harbour porpoise observations, based on data from 20 days of survey at Brims Tidal Array, and using 100m data "bins"

The probability of detecting an animal on the transect line, g(0), is normally assumed to be 1 (certain detection), but for marine mammals, which spend a proportion of the time below the surface, this assumption is not generally valid, resulting in an under-estimate of abundance. Double observer methods are needed to accurately calculate the g(0) value specific to each species and survey vessel, which was not conducted at this site. There are published estimates for g(0) for boat-based harbour porpoise surveys; for example SCANS surveys estimated g(0)=0.34 (Hammond *et al*., 2002) and SCANS-II g(0) = 0.22 (Hammond *et al*., 2013). The true g(0) in this study has not been estimated and it is likely to be quite different from the SCANS surveys given the differences in the

habitat, scale of study area, observation platforms and protocols being used. However, the value of g(0) on these surveys is certainly less than 1. Consequently, as the actual g(0) value is unknown for this study site/vessel, results are presented using g(0)=1 and g(0)= 0.22 for comparison (**Table 5**).

The most robust of density for harbour porpoise is 0.137 (CV19.50) individuals per km^2, this estimate is based on the entire survey area. Estimates of abundance and density are also provided for the AfL and survey area excluding the AfL, but it should be noted, particularly that for the AfL only, the estimates are not reliable and resulted in error warnings during analysis, due to low numbers of data. These values are provided for interest, but should not be taken forward in any assessment.

Table 5: Estimates of density (no. per km^2) and abundance (no. per stated stratum) of harbour porpoise within the survey area for the Brims Tidal Array. Corrected abundance estimates represent estimates calculated assuming g(0)=0.22 (after Hammond *et al.*, 2013). Shaded values are not reliable estimates due to low data numbers

Stratum	Animal Density (%CV)	Abundance (%CV)	95% Confidence Intervals	Corrected Abundance (%CV)
Whole survey area	0.137 (19.50)	14 (19.5)	10-20	63 (19.5)
AfL only	0.09 (80)	1 (80)	0-5	5 (80)
Survey area without AfL	0.14 (20.5)	13 (20.5)	9-19	59 (20.5)

Grey seal abundance and density

Radial distance and angle from the transect line (as recorded in the field) were converted to perpendicular distance. After truncation at 500m, there were a total 96 observations of grey seals over the 20 surveys available for analysis, with both sites, Westray South and Brims, combined. The model chosen was a half normal key function with cosine adjustment term (**Figure 3**). Due to limited sample sizes across the Brims and Westray South survey sites, all observations were used to produce a 'global' detection function (**Figure 3**). Post-stratification was then used to produce density and abundance estimates for the two survey sites separately. In addition due to the low number of sightings it was not possible to provide estimates of abundance (and therefore density) for the Brims AfL site, and the whole survey area (development site plus buffer).

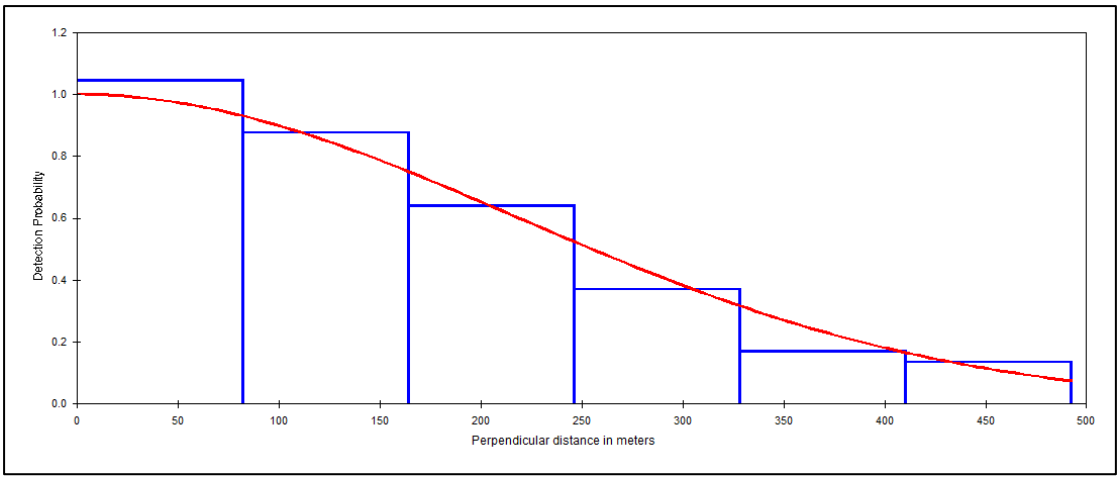

Figure 3: Detection probability curve for grey seal observations, based on data from survey at both Westray South and Brims Tidal Array, and using 50m data "bins"

Table 6: Estimates of density (no. per km^2) and abundance (no. per stated stratum) of grey seal within the survey area. Corrected abundance estimates represent estimates calculated assuming g(0)=0.22 (after Hammond *et al.* ,2013)

Stratum	Animal Density (%CV)	Abundance (%CV)	95% Confidence Interval
Combined area	0.09 (15.65)	18 (15.7)	13-24
Westray South	0.09 (24.79)	8 (24.79)	5-14
Brims Tidal Array	**0.09 (19.24)**	**9 (19.24)**	**7-19**

The probability of detecting an animal on the transect line, g(0), is normally assumed to be 1 (certain detection), but for marine mammals, which spend a proportion of the time below the surface, this assumption is not generally valid, resulting in an under-estimate of abundance. Double observer methods are needed to accurately calculate the g(0) value specific to each species and survey vessel, which was not conducted at this site. There are no published estimates for g(0) for boat-based grey seal surveys; as this is not the usual mechanism for conducting a census of this species. However, the value of g(0) on these surveys is certainly less than 1, and numbers presented should be treated as a under estimate of true abundance (**Table 6**).

1.4 Discussion

Despite the ability to estimate site specific abundance and density at the site; poor weather in the region prevented surveys being completed in some months, particularly in the autumn and winter. It is therefore not possible to provide an indication of whether the limited survey effort provides density estimates that are representative of the whole year.

Due to limited sighting rates, harbour porpoise was the only species where site specific estimates of density could be estimated. The density of 0.137 individuals per km^2 (CV19.50) is lower than the density estimate for the SCANS II survey block J, which encompasses the Brims site (density estimate of 0.274 individuals per km^2 (CV 0.36)).

Due to the small size of the AfL the amount of survey effort conducted within the AfL compared with the survey area (including the buffer) is low, approximately 10km per survey. The limitations of this survey method were discussed and agreed in consultation. However, the small area of the AfL and the low number of sightings with the AfL means that insufficient data were collected for production of AfL specific survey abundance estimates for harbour porpoise. The estimates could only be generated for the whole Brims survey area.

Grey seal data were combined across the Westray South and Brims surveys to produce stratified estimates for each site individually. However, due to the low number of sightings of this species the estimate of density is not very precise. Caution should also be used in assuming the detection function is comparable between the two sites due the different ecology at each site.

It should also be noted that boat-based visual surveys are not usually used to obtain a density estimate for grey seal and certainly will be an under-estimate of the true number of animals present at the site.

ESAS surveyor and MMOs abundance estimates cannot be pooled together as the effort and searching protocol for the two teams of observers is very different. A separate density estimate could be calculated using the ESAS data for harbour porpoises at Brims Tidal Array, but since there are fewer sightings than for the marine mammal surveyor data this was not considered to be worthwhile.

As presented in **Section 1.3.1** a number of surveys could not be completed, especially during the autumn and winter, due to poor weather. Grey seal breed in the autumn, and the number of grey seal in the vicinity of breeding sites in the Pentland Firth will increase. However, there are no grey seal breeding sites along the coastline in closest proximity to the Brims AfL. Therefore, the density of grey seals in the AfL may not show an increase during this time of the year.

Despite the limited surveys during the autumn, coverage was high in the summer months, when harbour seal abundance may be higher in coastal waters around haul out sites due to the breeding season and moult. However, there were still a low number of sightings of this species. As for grey seal, boat based line transect surveys are not the usual survey methods for this species. The sightings rates may be low in this region, but the observed rates using this survey method are likely to under-represent the true density. Other estimates of density, such at the SMRU at sea usage data (Jones *et al*., 2013) are likely to present a more robust estimate of density in this region (although these data also have some limitations).

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