Cruise Report
RRS *Discovery* Cruise DY080
6 June – 1 July 2017
Southampton to St Johns

Distribution and Ecology of Seabirds in the Sub-Polar Frontal Zone of the Northwest Atlantic

Principal Scientist
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2018

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<tr><td colspan="2">ABSTRACT

The core scientific objectives of DY080 were: (1) To estimate the distribution, abundance and behaviour of seabirds and cetaceans in an area centred on the sub-polar front, south of the Charlie Gibbs Fracture Zone (CGFZ) and on transit to and from the ports of embarkation (Southampton, UK) to and disembarkation (St Johns, Newfoundland). (2) To map major frontal features and nutrient regimes within the study area and along the survey track. (3) To refine non-lethal methods of sampling seabirds at sea. (4) To estimate the diet, stable isotope and contaminant loading, faecal nutrient and moult status of seabirds within the study area, with particular focus on the cephalopod component of seabird diet. (5) To determine the comparative habitat use of great and sooty shearwaters on and off-shelf and the timing of their movements between these areas. (6) To estimate rates of primary production phytoplankton community structure, the identity of the nutrients limiting productivity, and the effects of seabird faeces on phytoplankton growth within the study area. (7) To describe the zooplankton community above thermocline in the study area, and in particular the occurrence juvenile cephalopod stages. (8) To estimate the vertical distribution and biomass of mesopelagic nekton within the study area.

The study aimed to pay particular attention to four species of seabird: great shearwaters (Ardenna gravis), sooty shearwaters (Ardenna grisea), Cory's shearwaters (Calonectris diomedea) and northern fulmars (Fulmarus glacialis).

Most of the objectives were achieved and in addition the cruise track was modified to sample two mesoscale eddies identified during the cruise. Poor weather and low densities of birds hampered bird capturing within the CGFZ, with the result that no Cory’s or sooty shearwaters were caught and the majority of great shearwaters were caught on the Flemish Cap. In addition, nineteen Leach’s petrels were caught and sampled.</td></tr>
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A pdf of this report is available for download from http://eprints.gla.ac.uk/153574/</td></tr>
</table>

1. Contents

2. Personnel

2.1 Scientific and Technical Personnel

Surname	Name	Affiliation	Role
Wakefield	Ewan	University of Glasgow	PSO
Al-Hashem	Ali	GEOMAR Helmholtz Centre for Ocean Research	Scientist
Belkin	Igor	University of Rhode Island	Scientist
Bortolotto de Oliveira	Guilherme	Sea Mammal Research Unit	Scientist
Browning	Thomas	GEOMAR Helmholtz Centre for Ocean Research	Scientist
Carvalho	Paloma	University of Manitoba	Scientist
Catry	Paulo	ISPA – Instituto Universitário	Scientist
Hogan	Holly	Environment Canada	Scientist
Lacey	Claire	Sea Mammal Research Unit	Scientist
Laptihovsky	Vladimir	Centre for Environment, Fisheries and Aquaculture Science	Scientist
Miller	Julie	University of Glasgow	Scientist
Pinder	Simon	University of Glasgow	Scientist
Ramirez Martinez	Nadya	Sea Mammal Research Unit	Scientist
Tarzia	Marguerite	BirdLife International	Scientist
Thompson	Laura	University of Glasgow	Scientist
Cameron	Candice	National Marine Facilities	STO
Maltby	Mark	National Marine Facilities	SST

2.2 Ship's Personnel

Surname	Name	Role
Gatti	Antonio	Master
Voaden	Evelyn	C/O
Leggett	Colin	2/O
Williams	Thomas	3/O
Lewtas	Andrew	C/E
Kemp	Christopher	2/E
Franklin	Nicholas	3/E
Evans	Daniel	3/E
Brazier	Thomas	ETO
Bullimore	Graham	PCO
Fisher	Charles	ETO Cadet
Frost	George	Deck Cadet
Macdonald	John	CPOS
Cook	Stuart	CPOD
Gregory	Nathaniel	POD
Crabb	Gary	SG1A
Willcox	Simon	SG1A
Peppin	Christopher	SG1A
Dwyer	Andrew	SG1A
Clark	Thomas	ERPO
Lynch	Peter	H/Chef
Link	Walter	Chef
Carahillo	Clementina	Stwd
Williams	Denzil	A/Stwd

3. Scientific objectives

Ewan Wakefield
University of Glasgow

3.1 Background

Seabirds are thought to be major consumers of mesotrophic organisms and may therefore play an important role in oceanic ecosystems (Croxall and Prince 1987, Brooke 2004, Barrett et al. 2006). Furthermore, recent studies on functionally homologous cetaceans suggest that by rapidly resupplying nutrients, particularly iron, within the photic zone, they may also enhance marine primary production and possibly carbon drawdown in the ocean (Laidre et al. 2004, Nicol et al. 2010, Wing et al. 2014). Flying pelagic seabirds, such as petrels and shearwaters are very wide-ranging (Croxall et al. 2005, Shaffer et al. 2006, Wakefield et al. 2011). During the breeding season they may forage 100s to 1000s of km from their colonies, while in non-breeding stages some migrate across entire oceans following least-cost pathways, defined by wind patterns {Weimerskirch, 2000 #122}{Felicisimo, 2008 #600}. This tendency to range widely, trough remote areas of the ocean means that the diets, behaviours, niche partitioning and ecosystem functions of many pelagic seabirds remain poorly understood, especially in oceanic habitats.

The major fronts of the world's oceans support relatively high levels of primary and secondary production and therefore tend to be important foraging hotspots for wide-ranging higher predators, such as pelagic seabirds {Block, 2011 #1270}{Polovina, 2001 #1146}. For example, tracking data suggest that the sub-polar front (SPF) of the North Atlantic is an important foraging area for both migratory and locally-breeding seabirds (Belkin and Levitus 1996, Boertmann 2011). In particular, the complex region of the SPF south of the Charlie-Gibbs Fracture Zone (CGFZ), where the North Atlantic Current crosses the mid-Atlantic ridge, is targeted by seabirds from multiple populations (Egevang et al. 2010, Hedd et al. 2012, Wakefield and and 54 others 2012, Edwards et al. 2013). In addition, a small but growing body of evidence suggests that other wide-ranging taxa, including cetaceans, tuna and marine turtles, also aggregate south of the CGFZ (Skov et al. 2008, BirdLife International 2016). On the strength of these observations, Bird Life International have proposed that OSPAR designate this area as an Important Bird Area (BirdLife International 2016).

The physical oceanography of the SPF/CGFZ has been relatively well studied but questions remain - for example, regarding spatiotemporal variability in the SPF and the extent to which it is bathymetrically tied (Belkin and Levitus 1996, Miller et al. 2013). The biological oceanography of the region is less well understood but the recent ECOMAR project conducted studies on the adjacent mid-Atlantic ridge, focussing mainly on benthic communities (Priede et al. 2013). These communities, as well as those on seamounts to the west of the area, have now been afforded Marine Protected Area status in recognition of their importance and their sensitivity to deep water fishing.

Despite these advances, very few direct observations have been made of higher predators in the CGFZ (Boertmann 2011, Bennison and Jessopp 2015). As a result there is a paucity of information on their distribution, abundance and diet – information that is necessary for their effective management and protection, as well as to address fundamental ecological questions, such as how oceanic higher predators partition niches, how they connect disparate ecosystems and how these processes are affected by climate change. For example, many seabirds exploiting this area commute rapidly between there and continental shelves but little is known about the connectivity they may mediate between on and off-shelf ecosystems.

Cruise DY080 was part of a UK Natural Environment Research Council-funded project *Seabirds and wind - the consequences of extreme prey taxis in a changing climate*, which aims to quantify the past and future distributions and ecosystem roles of pelagic seabirds in the CGFZ and similar areas. These aims are to be met partially using tracking devices deployed at seabird colonies and partly by surveying and sample seabirds and their environment directly at sea. The main seabird species of interest were great shearwaters (*Ardenna gravis*), sooty shearwaters (*Ardenna grisea*), Cory's shearwaters (*Calonectris diomedea*) and northern fulmars (*Fulmarus glacialis*) but other species were to be sampled if possible.

3.2 Objectives

The main objectives of DY080 were:

1. To estimate the distribution, abundance and behaviour of seabirds and cetaceans in an area centred on the sub-polar front, south of the Charlie Gibbs Fracture Zone (CGFZ) and on transit to and from the ports of embarkation (Southampton, UK) to and disembarkation (St Johns, Newfoundland).
2. To map major frontal features and nutrient regimes within the study area and along the survey track.
3. To refine non-lethal methods of sampling seabirds at sea.
4. To estimate the diet, stable isotope and contaminant loading, faecal nutrient and moult status of seabirds within the study area, with particular focus on the cephalopod component of seabird diet.
5. To determine the comparative habitat use of great and sooty shearwaters on and off-shelf and the timing of their movements between these areas.
6. To estimate rates of primary production, phytoplankton community structure, the identity of the nutrients limiting productivity, and the effects of seabird faeces on phytoplankton growth in the study area.
7. To describe the zooplankton community above thermocline in the study area, and in particular the occurrence juvenile cephalopod stages.
8. To estimate the vertical distribution and biomass of mesopelagic nekton in the study area.

4. Cruise overview

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4.1 General pattern of work

Weather permitting, the planned pattern of work was to:

1. Transit from Southampton to the study area along line 1 at 10 knots, carrying out underway survey and sampling.
2. Follow lines 2-7 (Figure 4.1), remaining underway at 10 knots throughout daylight hours (and at night if this was necessary to remain on schedule), carrying out underway survey and sampling, and stopping only to:
   (i) Catch birds, provisionally for 4 - 5 hours before dusk (approximately 15:30 to 20:00 local time) or as the opportunity arose.
   (ii) Carry out CTD casts, usually at dusk (i.e. after bird catching) and dawn but also at the end of each line.
   (iii) Make vertical zooplankton hauls, after dusk CTD casts.

The rationale for this pattern of work was: (1) To allow survey of seabirds and cetaceans and continuous seawater sampling along as much of the planned track as possible; (2) to allow visual survey of seabirds and cetaceans and bird catching to be carried out during daylight hours; and therefore (3) to carry out CTDs and plankton hauls at night. The bird-catching element of the cruise was rather experimental so flexibility was allowed in the program to develop and adapt the catching strategies as the cruise progressed.

4.2 Planned cruise track

The *off-shelf study area* (Figure 4.1) was defined primarily to encompass an area of high seabird diversity in the vicinity of the Charlie-Gibbs Fracture Zone (CGFZ) identified in an analysing of tracking data collected from 24 species (Wakefield et al. 2012, BirdLife International 2016). This area encompasses the sub-polar front, where it crosses the CGFZ, as well as the system of banded fronts to the south. Five survey lines (lines 2 – 6) were planned to cover the high seabird diversity area and the surrounding waters. These were aligned approximately meriodionally in order to run perpendicular to the dominant SST gradient and so that major fronts would be crossed at right angles. Lines 1 was planned in order to transit directly from Southampton to the study area, while lines 6 and 7 were aligned such that the Flemish Cap and adjacent shelf break front were sectioned on the return leg to St Johns. In general, the ship proceeded along the cruise track in from east to west. However, on several occasions it back-tracked some tens of nautical miles in order to attempt to catch birds in previously encountered areas of high abundance. Hence, continuously sampled data (e.g. SST) was collected twice on some segments of the track.

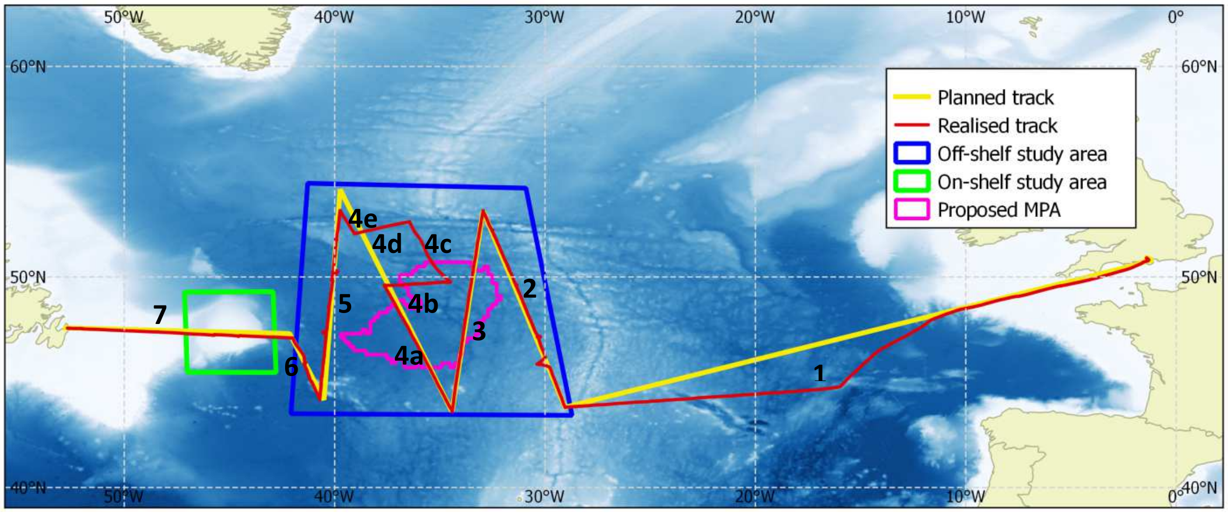

Figure 4.1 Planned and realised cruise track.

4.3 Amendments to the cruise track

The positions of fronts and other dynamic mesoscale features were monitored before and during the cruise using daily and weekly satellite images, provided by NERC Earth Observation Data Acquisition and Analysis Service. During the cruise, data on seabird distribution collected on lines 2 and 3 suggested that a nascent eddy apparent from in these images could be of particular interest (Figure 4.2). Therefore, a dogleg was introduced into line 4 so that this eddy could be traversed. This also allowed an additional opportunity to traverse the sub-polar front.

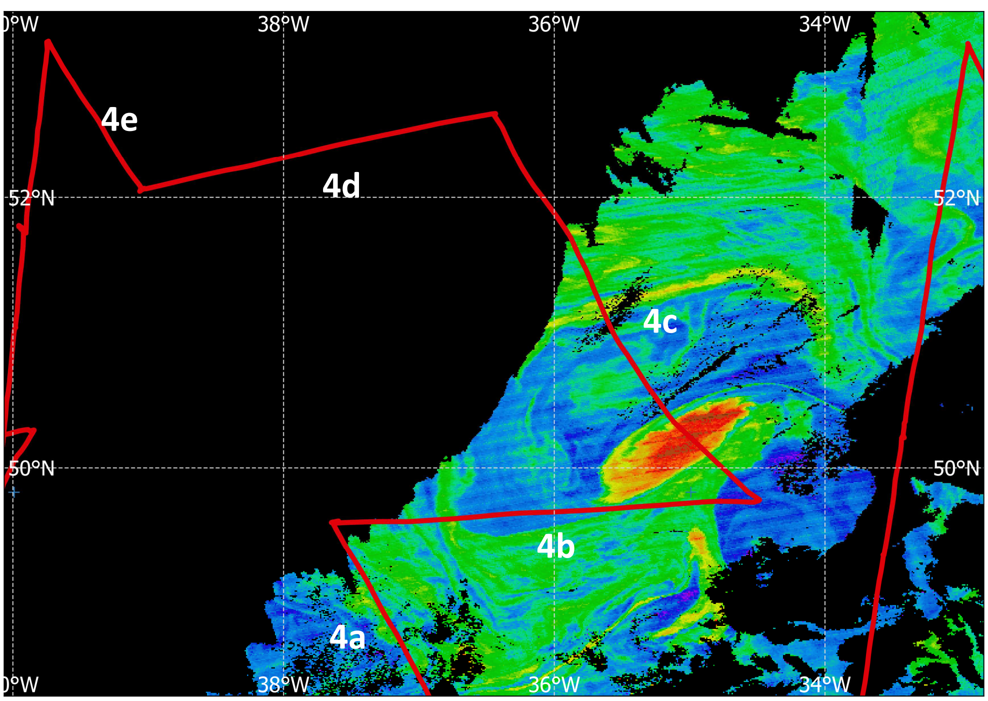

Figure 4.2 Cruise track relative to remotely sensed chlorophyll, showing the eddy and associated phytoplankton bloom bisected by line 4c.

4.4 Weather and downtime

Weather during the cruise was unusually unsettled for the area and time of year. The wind was generally from the SW to NW and > force 4, reaching force 9 on the 9^{th} of June (Figure 4.3). Swell height was generally above 2 m and reached at least 6 m on occasions. Although both swell height and wind speed declined slightly as the cruise progressed, fog was encountered more frequently in the west, with visibility decreasing to <50 m at times. This hampered visual seabird and cetacean observations (see sections 11 and 13).

The cruise track was altered in two respects due to poor weather: On the 8^{th} of June line 1 was altered south of the planned track in order to avoid a deep depression to the north. On the evening of the 13^{th} of June the weather deteriorated again and it was necessary to break off line 2 and steam slowly to the west into the swell. Line 2 was rejoined at 09:20 on the 14^{th}, 29 nm further north, leaving this section unobserved. These delays resulted in 2 days weather downtime.

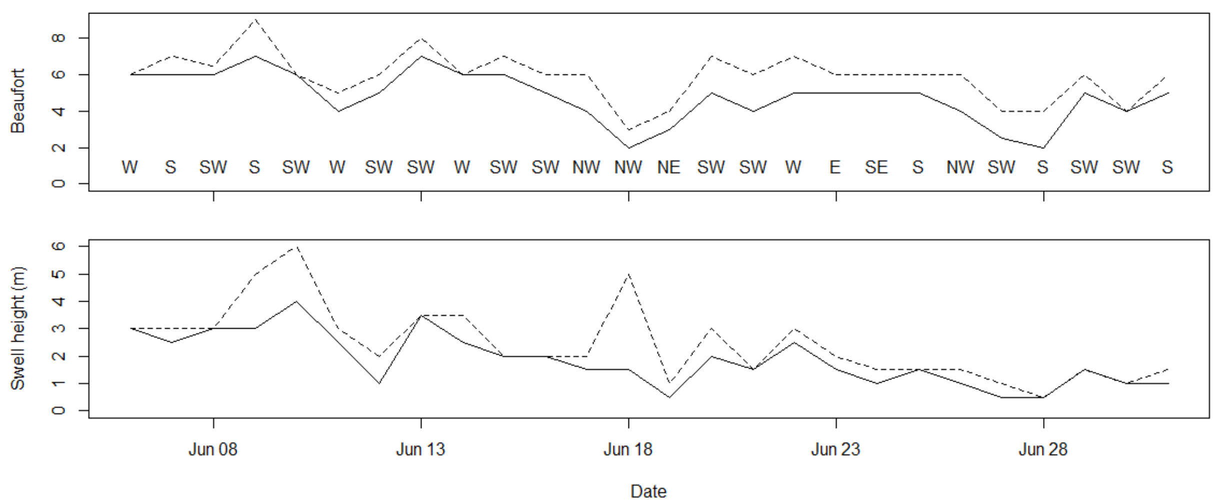

Figure 4.3 Wind speed and direction (top panel) and swell height (bottom panel) during DY080. Solid lines median values and dashed lines maxima.

5. Cruise Narrative

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<u>All times in this report are in UTC</u>

6 June: Wind W'ly 6 (range 6-7); Swell 3 m (range 3-4 m). Departed Southampton 10:10. Once clear of The Needles, commenced transit to study area along line 1. Too rough to deploy hydrophone or towed fish. Lifeboat drill for all crew and scientists.

7 June: Wind S'ly 6 (range 2-7); Swell 2.5 m (range 0.2-3 m). Proceeding along line 1, course 250°. Weather still poor but swell decreased over night. Towed fish and hydrophone deployed at approx. 10:45 on starboard and port sides respectively. Underway seabird survey commenced.

8 June: Wind SW'ly 6 (range 5-6.5); Swell 3 m (range 2-3 m). Proceeding along line 1 but altered course to 230°, south of intended track, to avoid deep depression and associated high winds and seas to the north. 17:00 towed fish and hydrophone swapped to port and starboard sides respectively.

9 June: Wind S'ly 7 (range 4-9); Swell 3 m (range 2-5 m). Proceeding along line 1. Weather improved in morning then deteriorated again in afternoon with swell building to 5 m. Towed fish and hydrophone recovered at 15:00. Survival suit drill for all scientists at 16:00.

10 June: Wind SW'ly 6 (range 5-6); Swell 4 m (range 2-6 m). Proceeding along line 1. By 08:15 cleared the depression to north, therefore adjusted course to 260°, towards south end of line 2. Wind decreased but swell still too large (up to 6 m) to redeploy hydrophone and towed fish.

11 June: Wind W'ly 4 (range 3-5); Swell 2.5 m (range 1-3 m). Proceeding along line 1. Wind and swell decreased over night. Hydrophone and towed fish redeployed at ~ 09:30.

12 June: Wind SW'ly 5 (range 4-6); Swell 1 m (range 1-2 m). Proceeding along line 1. Swell decreased to 1 – 2 m but wind increased from SW 4 to 6 during the day. Ships' speed increased to 10 knots for first time since clearing the English Channel. Over the mid-Atlantic Ridge at 23:40.

13 June: Wind SW'ly 7 (range 6-8); Swell 3.5 m (range 2-5 m). First CTD (CTD1, Figure 5.1), on western flank of mid-Atlantic Ridge at dawn, two days behind schedule, then began to proceed along line 2, course 344°. By 12:30, weather deteriorating again, with wind and swell increasing to SW 8 and 5 m respectively by dusk. At 21:30, it was necessary to break off line 2 to steam at 3 knots 300°, then 280° into the weather.

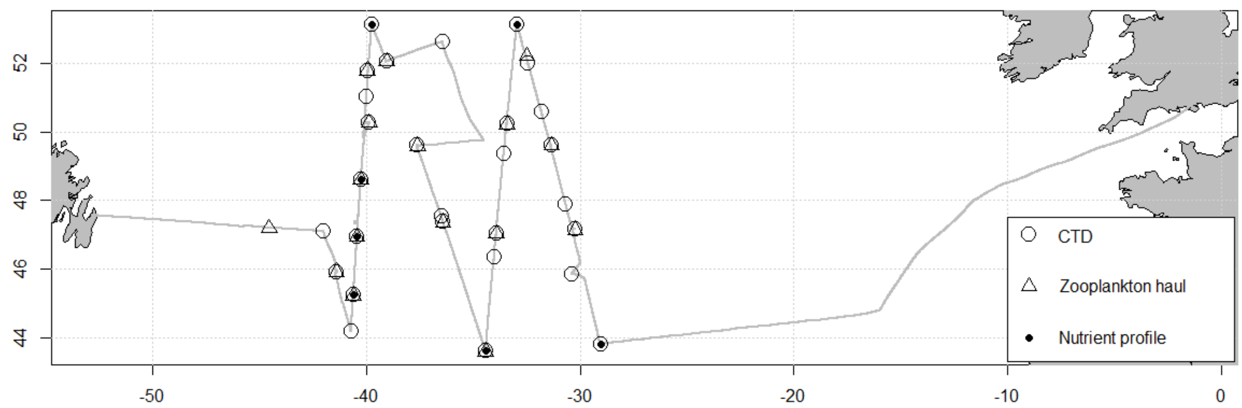

Figure 5.1 Locations of CTD casts and zooplankton hauls.

14 June: Wind W'ly 6 (range 5-6); Swell 2.5 m (range 2.5-3.5 m). By dawn wind and swell decreased sufficiently to allow CTD cast (CTD2) then steamed 43° to rejoin line 2 at 09:20, 29 nm north of the point at which it was left the night before. Proceeded along line 2 until 16:00, then hove-to in the vicinity of the mid-Atlantic Front for bird catching from back deck. CTD (CTD3) followed by vertical zooplankton plankton haul (PLK1) at dusk. Continued to steam along line 2 overnight.

15 June: Wind SW'ly 6 (range 5-7); Swell 2 m (range 2-3 m). Wind and swell similar to yesterday but fog reduced visibility until 18:00. CTD at dawn (CTD4), then proceeded along line 2 until 18:00, when hove-to for bird catching from back deck. CTD and zooplankton haul at dusk (CTD6 and PLK2), and then continued along line 2 overnight.

16 June: Wind SW'ly 5 (range 5-6); Swell 2 m (range 2-2 m). Wind and swell decreased overnight and visibility excellent. CTD (CTD6) at dawn, then proceeded along line 2 until 15:00, when CTD7 was made in order to have a CTD either side of the sub-Polar Front. Continued along line 2 until 18:00, and then hove to for bird catching from back deck. CTD (CTD8) and zooplankton haul (PLK3) at dusk then continued along line 2 through night, crossing sub-polar front at ~22:00.

17 June: Wind NW'ly 4 (range 4-6); Swell 1.5 m (range 1.5-2 m). Considerably calmer but fog reduced visibility at times. CTD8 at dawn at northern end of line 2, then commenced line 3, heading 187°. Crossed north sub-polar front at ~18:30. Still behind schedule and bird density low in afternoon so no bird catching attempts. CTD and zooplankton haul after dusk (CTD9 and PLK4). Continued along line 3 through night.

18 June: Wind NW'ly 2 (range 1-3); Swell 1 m (range 0.5-1.5 m). Weather further improved - light winds, low swell. CTD10 at dawn, then continued along line 3. Hove-to at 14:00 to attempt bird catching from Fast Rescue Craft (FRC). Resumed line 3 at 17:30. At 22:30 dusk CTD (CTD11), followed by zooplankton haul (PLK5). Also, bird catching with mist nets on foredeck. Continued along line 3 through night.

19 June: Wind NE'ly 3 (range 2-4); Swell 0.5 m (range 0.5-1 m). Relatively light winds and low swell. Dawn, CTD12 then proceeded along line 3. Bird density insufficient to attempt catching. At dusk, CTD13 and zooplankton haul PLK6 at southern end of line 3, then commenced line 4a at 23:00, heading 340°.

20 June: Wind SW'ly 5 (range 3-7); Swell 2 m (range 1-3 m). Proceeding along line 4a. Wind increased overnight, remaining SW 6-7 most of the day but decreased to 3 in late afternoon. Fog reduced visibility in afternoon, precluding use of FRC for bird catching.CTD14 and PLK7 and mist-netting for birds from back deck at dusk. Back on schedule so proceeded at 3 knots along line 4a through night to maximise daytime coverage of remaining lines.

21 June: Wind SW'ly 4 (range 3-7); Swell 1.5 m (range 1-1.5 m). Wind increased throughout the day, from SW 3 to 7. Fog restricted visibility to <300 m at times throughout the day. CTD15 at dawn, then continued on line 4a. Stopped at 19:00 for bird catching from back deck. CTD16 and zooplankton haul PLK8 at dusk.

22 June: Wind W'ly 5 (range 5-7); Swell 2.5 m (range 1-3 m). No CTDs or zooplankton hauls today. At 00:10, altered course eastwards to 85° to sample an eddy and associated transient phytoplankton bloom apparent from recently received satellite images (Figure 4.2) (new lines designated 4b, 4c, etc.). Wind W or SW 5-6 all day with fog patches reducing visibility until approx. 17:00. At 11:40 alerted course to 325° to bisect the eddy (line 4c). Centre of bloom reached at approx. 16:00.

23 June: Wind E'ly 5 (range 2-6); Swell 1.5 m (range 0.5-2 m). Wind backed SE and E in day, dropping to 2, then increasing again to 6. Fog and rain reduced visibility at times. Crossed sub-polar front at ~00:30, and carried out CTD17 at end of line 4c at 07:30. Headed 250° along line 4d, crossing sub-polar front again at ~15:40 and reaching end of line 4d at 18:25. Bird catching from back deck from 18:30, followed by CTD18 and PLK9 at dusk.

24 June: Wind SE'ly 5 (range 2-6); Swell 1 m (range 0.5-1.5 m). Wind veered from NE 2-3 to SE 5-6 during the day but swell low. Headed 340°, along line 4e at 00:30. Crossed sub-polar front at ~02:30, reaching northern end of line 4e at 08:00, where CTD19 carried out. At 09:15, headed 184°, along line 5, crossing sub-polar front again at ~13:30. Stopped at 18:00 for bird catching from back deck. At dusk, CTD20, followed by zooplankton haul PLK10.

25 June: Wind S'ly 5 (range 4-6); Swell 1.5 m (range 1-1.5 m). Resumed line 5 at 00:35. Stopped for TD21 at dawn, then resumed line 5. Fog restricted visibility in morning. At 13:35, back-tracked 25 nm north up line to return to an area of higher bird density. Bird catching from back deck from 16:00, followed by CTD22 and zooplankton haul PLK11 from dusk.

26 June: Wind NW'ly 4 (range 2-6); Swell 1 m (range 1-1.5 m). Relatively low swell. Wind decreased throughout day but intermittent fog reduced visibility at times. At 00:10, began steaming back down line 5, approaching a large cold-core eddy apparent from satellite imagery, which will be traversed over the next 48 hours (Figure 5.2). CTD23, followed by zooplankton haul PLK13, carried out from 11:00, 100 nm north of the centre of the eddy. Continued along line 5 until 19:00, then stopped for bird catching. FRC lowered but swell and issues with painters made boarding safely impossible. Hence, bird catching from back deck again. Resumed line 5 at 21:30, heaving to for night at 23:00 so that eddy could be crossed in daylight.

27 June: Wind SW'ly 2.5 (range 1-4); Swell 0.5 m (range 0.5-1 m). Light winds and low swell. Fog reduced visibility as low as 50 m at times in morning. Resumed line 5 at 07:00, stopping for CTD24 and PLK14 in centre of eddy from 09:30. Resumed line 5 at 11:00, stopping for bird catching from back deck at 20:30, followed by CTD25 and PLK15, 100 nm south of centre of eddy.

28 June: Wind S'ly 2 (range 1-4); Swell 0.5 m (range 0.5-0.5 m). Wind light and variable with little swell for much of day but increased to S 5 by nightfall, with intermittent fog in afternoon. Resumed line 5 at 00:45, crossing the Milne Seamounts at ~04:00. CTD26 at 09:00 at S end of line 5. Began line 6, heading 345° at 09:45. Hove to twice for bird catching from back deck - at 14:50 above seamount KW-13114 and at 20:50 in deep water. CTD27 and PLK16 carried out at dusk.

29 June: Wind SW'ly 5 (range 4-6); Swell 1.5 m (range 1-1.5 m). Wind increased relative to past few days. Intermittent fog all day, reducing visibility below 300 m at times. Resumed line 6 at 00:10. Final CTD (CTD28) 09:00 at N end of line 6, then began line 7, heading 270° up the continental rise. Stopped for bird catching from back deck at 20:10 on the E flank for the Flemish Cap. Final zooplankton haul (PLK17) at dusk.

30 June: Wind SW'ly 4 (range 4-5); Swell 1 m (range 1-1 m). Intermittent fog throughout the day but visibility generally >300 m. Between 02:10 and 09:00 followed line 7 to western flank of the Flemish Cap, where stopped for bird catching from the back deck until 19:00. Then proceeded along line 7, on passage direct to St Johns.

1 July: Wind S'ly 5 (range 3-6); Swell 1 m (range 1-1.5 m). On passage to St Johns along line 7. Intermittent fog all day. Bird and cetacean survey continued during passage but all other science activities completed. Arrived St Johns 22:00.

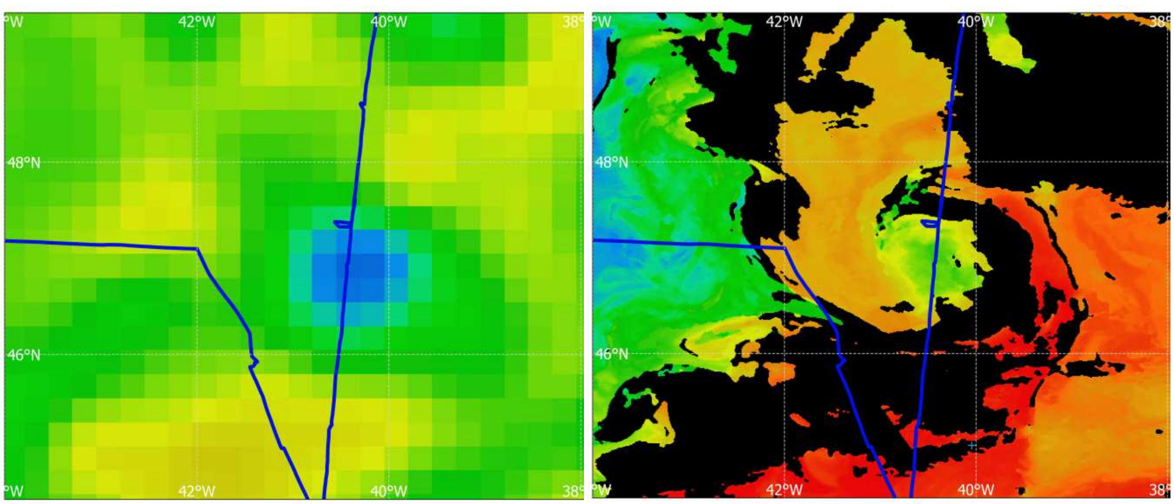

Figure 5.2. Cold core eddy on line 5. Left, mean sea level anomaly, right SST. Blue line, track of DY080.

6. Station/activities log

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Table 6.1 Sampling stations.

Event	Date	From	To	Lon (°)	Lat (°)	Type[1]	Station	Max. Depth (m)	Comments
1	13-Jun	05:38	06:38	-29.043	43.808	CTD, NUT	CTD1	500	Dawn
2		06:00	06:23	-30.376	45.860	CTD	CTD2	500	Dawn; No bottles
3		16:00	21:50	-30.358	47.150	BC	BC1	-	Cast net, back deck
4		22:21	22:47	-30.221	47.152	CTD	CTD3	500	Dusk
5		23:14	23:33	-30.220	47.152	PLK	PLK1	235	
6	15-Jun	05:46	06:15	-30.665	47.893	CTD	CTD4	500	Dawn; No bottles
7		18:00	20:40	-31.377	49.590	BC	BC2	-	Cast net, back deck
8		21:26	21:52	-31.338	49.611	CTD	CTD5	500	Dusk
9		22:10	22:26	-31.338	49.611	PLK	PLK2	250	
10	16-Jun	05:30	05:59	-31.795	50.578	CTD	CTD6	500	Dawn; No bottles
11		15:34	15:58	-32.425	52.003	CTD	CTD7	500	Dusk
12		18:00	20:50	-32.522	52.200	BC	BC3	-	Cast net, back deck
13		21:15	21:28	-32.494	52.221	PLK	PLK3	250	
14	17-Jun	04:12	04:54	-32.945	53.137	CTD, NUT	CTD8	500	Dawn
15		23:01	23:26	-33.420	50.232	CTD	CTD9	500	Dusk
16		23:25	23:43	-33.418	50.229	PLK	PLK4	217	
17	18-Jun	05:31	05:57	-33.571	49.354	CTD	CTD10	500	Dawn; No bottles
18		14:00	15:50	-33.786	47.941	BC	BC4	-	Cast net, back deck and FRC
19		22:30	01:40	-33.919	47.034	BC	BC5	-	Mist net, foredeck
20		22:33	23:01	-33.919	47.034	CTD	CTD11	500	Dusk
21		23:15	23:28	-33.919	47.032	PLK	PLK5	250	
22	19-Jun	05:29	05:54	-34.013	46.362	CTD	CTD12	500	Dawn; No bottles
23		21:41	22:20	-34.419	43.604	CTD, NUT	CTD13	500	Dusk
24		22:30	22:46	-34.416	43.605	PLK	PLK6	241	
25	20-Jun	22:20	01:50	-36.409	47.372	BC	BC6	-	Mist net, stbd side
26		22:27	22:53	-36.409	47.373	CTD	CTD14	500	Dusk
27		23:04	23:19	-36.409	47.374	PLK	PLK7	249	
28	21-Jun	05:32	05:56	-36.492	47.551	CTD	CTD15	500	Dawn; No bottles
29		19:00	22:30	-37.645	49.595	BC	BC7	-	Cast net, back deck
30		22:48	23:18	-37.610	49.602	CTD	CTD16	500	Dusk
31		23:23	23:44	-37.610	49.602	PLK	PLK8	227	
32	23-Jun	07:36	08:15	-36.436	52.615	CTD	CTD17	500	Dawn

33		18:30	22:43	-39.030	52.063	BC	BC8	-	Cast net, back deck
34		23:04	23:27	-39.053	52.067	CTD	CTD18	500	Dusk
35		23:40	00:09	-39.054	52.067	PLK	PLK9	250	
36	24-Jun	00:10	00:40	-39.054	52.067	PLK	PLK10	250	
37		08:12	08:50	-39.733	53.141	CTD, NUT	CTD19	500	Dawn
38		17:58	23:00	-39.904	51.738	BC	BC9	-	Cast net, back deck
39		23:21	23:44	-39.956	51.785	CTD	CTD20	500	Dusk
40	25-Jun	00:00	00:20	-39.956	51.785	PLK	PLK11	249	
41		05:26	05:49	-39.980	51.037	CTD	CTD21	500	Dawn; No bottles
42		16:00	21:40	-40.084	50.246	BC	BC10	-	Cast net, back deck
43		22:45	23:07	-39.871	50.271	CTD	CTD22	500	Dusk
44		23:20	23:38	-39.859	50.276	PLK	PLK12	192	
45	26-Jun	11:08	11:42	-40.260	48.600	CTD, NUT	CTD23	500	1mi N of front
46		11:50	10:39	-40.265	48.603	PLK	PLK13	246	
47		18:59	21:10	-40.370	47.544	BC	BC11	-	Cast net, back deck
48	27-Jun	09:36	10:15	-40.428	46.946	CTD, NUT	CTD24	500	Centre of front
49		10:20	09:08	-40.430	46.945	PLK	PLK14	250	
50		20:30	22:30	-40.599	45.290	BC	BC12	-	Cast net, back deck
51		23:27	00:01	-41.388	45.919	CTD, NUT	CTD25	500	1mi S of front
52	28-Jun	00:15	00:35	-40.618	45.233	PLK	PLK15	249	
53		09:02	09:25	-40.712	44.178	CTD	CTD26	500	Dawn
54		14:50	15:50	-41.100	45.026	BC	BC13	-	Cast net, back deck
55		20:50	22:20	-41.447	45.867	BC	BC14	-	Cast net, back deck
56		22:57	23:23	-39.867	50.273	CTD	CTD27	500	Dusk; No bottles
57		23:20	22:38	-41.391	45.918	PLK	PLK16	241	
58	29-Jun	09:03	09:26	-41.999	47.096	CTD	CTD28	500	Dawn
59		20:10	21:30	-44.528	47.202	BC	BC15	-	Cast net, back deck
60		23:45	22:59	-44.553	47.184	PLK	PLK17	249	
61	30-Jun	10:50	19:00	-45.693	47.251	BC	BC16	-	Cast net, back deck

[1.] NUT = Water samples collected using the CTD for nutrient analysis; PLK = vertical zooplankton hauls; BC = bird catching.

Table 6.2 Underway activities.

Activity	Start				End			
	Date	Time	Lon (°)	Lat (°)	Date	Time	Lon (°)	Lat (°)
Seabird survey	06-Jun	15:50	-2.226	50.388	06-Jun	20:08	-2.784	50.229
Seabird survey	07-Jun	07:09	-4.821	49.704	07-Jun	19:40	-7.219	49.135
Towfish nutrient sample		12:26	-5.821	49.503	-	-	-	-
Cetacean survey		12:40	-5.843	49.494	07-Jun	16:30	-6.564	49.309
Towfish nutrient sample		17:40	-6.789	49.245	-	-	-	-
Towfish nutrient sample		22:42	-7.930	49.005	-	-	-	-
Cetacean survey	08-Jun	04:37	-8.988	48.740	08-Jun	06:30	-9.324	48.646
Seabird survey		05:05	-9.067	48.717	08-Jun	11:00	-10.234	48.456
Towfish nutrient sample		05:18	-9.102	48.707	-	-	-	-
Cetacean survey		07:51	-9.598	48.584	08-Jun	10:29	-10.130	48.478
Cetacean survey		11:21	-10.301	48.438	08-Jun	12:35	-10.512	48.367
Seabird survey		11:21	-10.301	48.438	08-Jun	12:17	-10.471	48.382
Cetacean survey		12:59	-10.554	48.353	08-Jun	14:14	-10.789	48.276
Seabird survey		13:06	-10.576	48.345	08-Jun	14:00	-10.752	48.288
Cetacean survey		14:58	-10.867	48.253	08-Jun	16:28	-11.109	48.163
Seabird survey		14:58	-10.867	48.253	08-Jun	15:40	-10.986	48.210
Towfish nutrient sample		15:18	-10.925	48.233	-	-	-	-
Seabird survey		15:42	-10.991	48.208	08-Jun	16:00	-11.038	48.191
Seabird survey		16:02	-11.044	48.189	08-Jun	16:30	-11.114	48.161
Seabird survey		16:33	-11.122	48.158	08-Jun	17:00	-11.193	48.129
Seabird survey		17:03	-11.201	48.126	08-Jun	17:56	-11.334	48.075
Cetacean survey		17:32	-11.273	48.098	08-Jun	19:30	-11.554	47.989
Seabird survey		18:01	-11.347	48.070	08-Jun	18:59	-11.489	48.018
Seabird survey		19:00	-11.491	48.017	08-Jun	20:34	-11.696	47.916
Towfish nutrient sample		20:16	-11.661	47.941	-	-	-	-
Towfish incubation sample		20:16	-11.661	47.941	-	-	-	-
Cetacean survey	09-Jun	04:44	-12.940	47.141	09-Jun	06:30	-13.255	46.980
Seabird survey		05:00	-12.987	47.116	09-Jun	06:03	-13.175	47.019
Towfish nutrient sample		05:40	-13.106	47.054	-	-	-	-
Seabird survey		06:05	-13.181	47.016	09-Jun	06:48	-13.309	46.953
Seabird survey		06:52	-13.320	46.947	09-Jun	08:02	-13.520	46.839
Cetacean survey		07:29	-13.427	46.890	09-Jun	08:58	-13.670	46.755
Seabird survey		08:05	-13.528	46.835	09-Jun	08:55	-13.662	46.759
Seabird survey		08:59	-13.672	46.754	09-Jun	10:00	-13.825	46.669
Seabird survey		10:02	-13.830	46.666	09-Jun	11:04	-13.982	46.586
Seabird survey		11:07	-13.989	46.583	09-Jun	12:04	-14.105	46.511
Towfish nutrient sample		11:13	-14.003	46.576	-	-	-	-

Seabird survey		12:06	-14.108	46.508	09-Jun	12:59	-14.196	46.440
Seabird survey		13:02	-14.201	46.436	09-Jun	14:01	-14.272	46.377
Seabird survey		14:08	-14.281	46.369	09-Jun	14:51	-14.341	46.321
Seabird survey		16:02	-14.430	46.246	09-Jun	17:02	-14.505	46.176
Seabird survey		17:07	-14.512	46.170	09-Jun	18:07	-14.598	46.092
Towfish nutrient sample		17:11	-14.517	46.165	-	-	-	-
Seabird survey		18:11	-14.604	46.087	09-Jun	19:00	-14.673	46.025
Seabird survey		19:04	-14.679	46.020	09-Jun	20:32	-14.812	45.903
Towfish nutrient sample		23:07	-15.075	45.656	-	-	-	-
Cetacean survey	10-Jun	05:12	-15.722	45.041	10-Jun	06:30	-15.842	44.910
Towfish nutrient sample	10-Jun	05:20	-15.734	45.027	-	-	-	-
Seabird survey	10-Jun	05:36	-15.759	45.000	10-Jun	06:06	-15.805	44.951
Seabird survey		06:09	-15.809	44.946	10-Jun	06:42	-15.861	44.890
Seabird survey		06:45	-15.866	44.884	10-Jun	09:04	-16.132	44.758
Seabird survey		09:09	-16.142	44.757	10-Jun	10:04	-16.259	44.739
Seabird survey		10:06	-16.263	44.738	10-Jun	11:00	-16.386	44.720
Seabird survey		11:03	-16.393	44.719	10-Jun	12:01	-16.534	44.700
Towfish nutrient sample		11:08	-16.405	44.717	-	-	-	-
Seabird survey		12:05	-16.544	44.698	10-Jun	12:59	-16.686	44.683
Cetacean survey		12:39	-16.632	44.689	10-Jun	16:32	-17.270	44.627
Seabird survey		13:05	-16.701	44.681	10-Jun	14:03	-16.856	44.665
Seabird survey		14:09	-16.872	44.663	10-Jun	14:25	-16.914	44.658
Seabird survey		14:30	-16.928	44.657	10-Jun	14:59	-17.009	44.648
Seabird survey		15:04	-17.022	44.647	10-Jun	16:02	-17.183	44.631
Seabird survey		16:05	-17.191	44.631	10-Jun	16:58	-17.344	44.623
Seabird survey		17:04	-17.361	44.622	10-Jun	18:05	-17.532	44.610
Towfish nutrient sample		17:15	-17.391	44.620	-	-	-	-
Cetacean survey		17:31	-17.437	44.617	10-Jun	20:30	-17.915	44.575
Seabird survey		18:06	-17.535	44.610	10-Jun	19:09	-17.705	44.594
Seabird survey		19:10	-17.708	44.594	10-Jun	20:12	-17.867	44.580
Seabird survey		20:15	-17.876	44.579	10-Jun	20:45	-17.955	44.571
Towfish nutrient sample		23:05	-18.333	44.544	-	-	-	-
Cetacean survey	11-Jun	05:23	-19.545	44.469	11-Jun	07:33	-19.999	44.428
Seabird survey		06:00	-19.673	44.457	11-Jun	07:00	-19.885	44.437
Towfish nutrient sample		06:23	-19.755	44.449	-	-	-	-
Seabird survey		07:05	-19.903	44.435	11-Jun	07:42	-20.031	44.425
Seabird survey		07:45	-20.041	44.425	11-Jun	08:55	-20.273	44.411
Cetacean survey		08:27	-20.185	44.417	11-Jun	08:54	-20.272	44.411
Seabird survey		09:06	-20.286	44.410	11-Jun	09:59	-20.457	44.399
Cetacean survey		09:16	-20.311	44.407	11-Jun	11:30	-20.768	44.380
Seabird survey		10:02	-20.468	44.399	11-Jun	11:02	-20.673	44.387

Seabird survey		11:05	-20.683	44.387	11-Jun	12:00	-20.869	44.371
Seabird survey		12:03	-20.879	44.370	11-Jun	12:58	-21.068	44.354
Towfish nutrient sample		12:07	-20.892	44.369	-	-	-	-
Cetacean survey		12:31	-20.974	44.362	11-Jun	17:30	-22.046	44.297
Seabird survey		13:00	-21.075	44.353	11-Jun	14:00	-21.288	44.338
Seabird survey		14:05	-21.306	44.337	11-Jun	14:59	-21.496	44.330
Seabird survey		15:00	-21.500	44.330	11-Jun	15:58	-21.711	44.317
Seabird survey		16:00	-21.718	44.317	11-Jun	17:00	-21.937	44.304
Seabird survey		17:02	-21.944	44.304	11-Jun	18:01	-22.160	44.291
Seabird survey		18:03	-22.167	44.291	11-Jun	19:06	-22.398	44.275
Towfish nutrient sample		18:15	-22.211	44.289	-	-	-	-
Cetacean survey		18:30	-22.266	44.285	11-Jun	20:30	-22.706	44.255
Towfish incubation sample		18:56	-22.361	44.278	-	-	-	-
Seabird survey		19:09	-22.409	44.275	11-Jun	19:59	-22.592	44.265
Seabird survey		20:02	-22.603	44.264	11-Jun	21:00	-22.812	44.245
Seabird survey		21:01	-22.816	44.245	11-Jun	21:27	-22.909	44.234
Towfish nutrient sample	12-Jun	00:13	-23.487	44.187	-	-	-	-
Seabird survey		05:44	-24.719	44.105	12-Jun	06:45	-24.958	44.091
Cetacean survey		05:54	-24.760	44.103	12-Jun	07:30	-25.129	44.074
Towfish nutrient sample		06:14	-24.839	44.099	-	-	-	-
Seabird survey		06:46	-24.962	44.090	12-Jun	07:43	-25.179	44.070
Seabird survey		07:47	-25.195	44.069	12-Jun	08:59	-25.474	44.055
Cetacean survey		08:32	-25.370	44.059	12-Jun	09:41	-25.628	44.050
Seabird survey		09:01	-25.482	44.055	12-Jun	09:53	-25.671	44.048
Seabird survey		09:55	-25.678	44.047	12-Jun	11:32	-26.011	44.023
Seabird survey		11:45	-26.054	44.019	12-Jun	12:03	-26.113	44.014
Seabird survey		12:05	-26.120	44.013	12-Jun	13:06	-26.320	44.000
Towfish nutrient sample		12:15	-26.153	44.011	-	-	-	-
Cetacean survey		12:37	-26.226	44.006	12-Jun	17:32	-27.187	43.932
Seabird survey		13:08	-26.327	44.000	12-Jun	14:00	-26.495	43.990
Seabird survey		14:03	-26.505	43.990	12-Jun	14:59	-26.678	43.977
Seabird survey		15:10	-26.713	43.973	12-Jun	16:00	-26.877	43.957
Seabird survey		16:03	-26.887	43.956	12-Jun	16:58	-27.068	43.941
Seabird survey		17:00	-27.075	43.940	12-Jun	17:58	-27.281	43.927
Seabird survey		18:04	-27.303	43.926	12-Jun	18:59	-27.498	43.920
Towfish nutrient sample		18:28	-27.388	43.924	-	-	-	-
Cetacean survey		18:32	-27.403	43.924	12-Jun	20:30	-27.820	43.894
Seabird survey		19:00	-27.502	43.920	12-Jun	19:59	-27.711	43.904
Seabird survey		20:01	-27.718	43.903	12-Jun	20:53	-27.902	43.886
Seabird survey		20:56	-27.913	43.885	12-Jun	21:15	-27.983	43.880
Seabird survey		21:16	-27.986	43.880	12-Jun	21:24	-28.015	43.878

Towfish nutrient sample		22:12	-28.186	43.864	-	-	-	-
Towfish nutrient sample	13-Jun	04:50	-29.003	43.810	-	-	-	-
Towfish nutrient sample		05:45	-29.043	43.808	-	-	-	-
Seabird survey		06:37	-29.043	43.812	13-Jun	06:57	-29.055	43.843
Seabird survey		07:04	-29.057	43.849	13-Jun	07:45	-29.096	43.922
Seabird survey		07:48	-29.098	43.928	13-Jun	08:53	-29.149	44.068
Seabird survey		08:54	-29.150	44.071	13-Jun	09:58	-29.198	44.215
Seabird survey		10:03	-29.202	44.227	13-Jun	11:01	-29.253	44.357
Seabird survey		11:03	-29.255	44.362	13-Jun	12:00	-29.308	44.489
Towfish nutrient sample		12:00	-29.308	44.489	-	-	-	-
Seabird survey		12:02	-29.310	44.494	13-Jun	13:00	-29.360	44.626
Seabird survey		13:03	-29.363	44.633	13-Jun	14:00	-29.411	44.761
Seabird survey		14:05	-29.415	44.772	13-Jun	15:00	-29.461	44.891
Seabird survey		15:03	-29.464	44.898	13-Jun	16:01	-29.511	45.025
Seabird survey		16:05	-29.514	45.034	13-Jun	17:03	-29.564	45.160
Seabird survey		17:05	-29.566	45.165	13-Jun	18:00	-29.614	45.283
Seabird survey		18:04	-29.617	45.292	13-Jun	18:55	-29.659	45.399
Towfish nutrient sample		18:37	-29.645	45.361	-	-	-	-
Seabird survey		19:00	-29.662	45.409	13-Jun	20:00	-29.703	45.535
Seabird survey		20:04	-29.705	45.543	13-Jun	20:22	-29.720	45.580
Seabird survey		20:24	-29.722	45.584	13-Jun	20:46	-29.741	45.628
Seabird survey		20:50	-29.744	45.636	13-Jun	21:06	-29.758	45.668
Towfish nutrient sample		23:53	-29.967	45.791	-	-	-	-
Seabird survey	14-Jun	06:31	-30.371	45.861	14-Jun	06:37	-30.364	45.861
Seabird survey		06:43	-30.360	45.866	14-Jun	07:46	-30.201	45.981
Towfish nutrient sample		06:58	-30.332	45.885	-	-	-	-
Cetacean survey		07:45	-30.204	45.979	14-Jun	08:35	-30.076	46.081
Seabird survey		07:48	-30.196	45.985	14-Jun	08:46	-30.053	46.106
Seabird survey		08:48	-30.049	46.110	14-Jun	09:57	-30.008	46.270
Cetacean survey		09:04	-30.010	46.145	14-Jun	10:27	-30.033	46.344
Seabird survey		09:58	-30.009	46.273	14-Jun	10:58	-30.063	46.420
Seabird survey		11:00	-30.065	46.425	14-Jun	12:25	-30.157	46.636
Cetacean survey		11:31	-30.099	46.502	14-Jun	12:31	-30.164	46.651
Seabird survey		12:27	-30.159	46.641	14-Jun	12:59	-30.193	46.722
Towfish nutrient sample		13:00	-30.194	46.725	-	-	-	-
Seabird survey		13:01	-30.195	46.728	14-Jun	13:30	-30.220	46.803
Cetacean survey		13:06	-30.200	46.740	14-Jun	15:49	-30.345	47.153
Seabird survey		13:36	-30.225	46.819	14-Jun	14:02	-30.245	46.888
Seabird survey		14:03	-30.246	46.891	14-Jun	15:00	-30.294	47.035
Seabird survey		15:02	-30.296	47.040	14-Jun	15:49	-30.345	47.153
Towfish incubation sample	15-Jun	00:17	-30.263	47.157	-	-	-	-

Seabird survey		06:44	-30.666	47.900	15-Jun	07:42	-30.728	48.034
Towfish nutrient sample		07:00	-30.682	47.934	-	-	-	-
Seabird survey		07:43	-30.729	48.037	15-Jun	08:47	-30.797	48.193
Seabird survey		08:50	-30.800	48.200	15-Jun	10:00	-30.868	48.375
Seabird survey		10:02	-30.870	48.380	15-Jun	11:00	-30.928	48.525
Seabird survey		11:05	-30.933	48.538	15-Jun	12:01	-30.991	48.677
Seabird survey		12:02	-30.992	48.680	15-Jun	13:01	-31.053	48.832
Seabird survey		13:02	-31.054	48.834	15-Jun	14:00	-31.116	48.987
Towfish nutrient sample		13:13	-31.064	48.863	-	-	-	-
Seabird survey		14:02	-31.118	48.992	15-Jun	15:00	-31.180	49.147
Seabird survey		15:03	-31.183	49.155	15-Jun	16:00	-31.253	49.305
Seabird survey		16:01	-31.254	49.308	15-Jun	17:00	-31.322	49.469
Seabird survey		17:03	-31.325	49.477	15-Jun	17:45	-31.377	49.590
Towfish nutrient sample		23:02	-31.358	49.592	-	-	-	-
Towfish nutrient sample	16-Jun	06:38	-31.815	50.623	-	-	-	-
Seabird survey		06:55	-31.839	50.670	16-Jun	08:43	-31.975	50.968
Cetacean survey		07:00	-31.846	50.684	16-Jun	15:07	-32.428	52.002
Seabird survey		08:47	-31.979	50.979	16-Jun	10:02	-32.070	51.188
Seabird survey		10:05	-32.073	51.197	16-Jun	11:05	-32.142	51.361
Seabird survey		11:06	-32.143	51.364	16-Jun	12:06	-32.215	51.531
Towfish nutrient sample		11:58	-32.205	51.509	-	-	-	-
Seabird survey		12:08	-32.218	51.536	16-Jun	13:00	-32.281	51.679
Seabird survey		13:09	-32.291	51.703	16-Jun	14:00	-32.349	51.840
Seabird survey		14:05	-32.355	51.853	16-Jun	15:04	-32.424	51.999
Cetacean survey		16:25	-32.434	52.012	16-Jun	17:38	-32.519	52.199
Seabird survey		16:29	-32.437	52.021	16-Jun	16:59	-32.470	52.099
Seabird survey		17:01	-32.472	52.104	16-Jun	17:37	-32.518	52.199
Towfish nutrient sample		17:08	-32.481	52.123	-	-	-	-
Towfish nutrient sample	17-Jun	04:12	-32.945	53.137	-	-	-	-
Towfish nutrient sample		04:12	-32.945	53.137	-	-	-	-
Seabird survey		06:00	-32.963	53.022	17-Jun	07:43	-33.006	52.769
Cetacean survey		07:18	-32.995	52.830	17-Jun	18:48	-33.307	50.921
Towfish nutrient sample		07:43	-33.006	52.769	-	-	-	-
Seabird survey		07:44	-33.006	52.766	17-Jun	08:43	-33.032	52.619
Seabird survey		08:45	-33.033	52.614	17-Jun	11:00	-33.093	52.254
Seabird survey		11:02	-33.094	52.249	17-Jun	12:00	-33.125	52.090
Seabird survey		12:02	-33.126	52.084	17-Jun	13:03	-33.151	51.913
Towfish nutrient sample		13:00	-33.149	51.921	-	-	-	-
Seabird survey		13:08	-33.153	51.898	17-Jun	14:03	-33.186	51.741
Seabird survey		14:09	-33.190	51.723	17-Jun	15:00	-33.216	51.579
Seabird survey		15:05	-33.217	51.565	17-Jun	16:00	-33.234	51.406

Seabird survey		16:01	-33.234	51.403	17-Jun	16:59	-33.260	51.238
Seabird survey		17:01	-33.261	51.233	17-Jun	17:59	-33.282	51.063
Seabird survey		18:01	-33.283	51.058	17-Jun	18:56	-33.311	50.897
Seabird survey		19:01	-33.314	50.882	17-Jun	20:01	-33.352	50.706
Cetacean survey		19:40	-33.340	50.768	17-Jun	21:30	-33.395	50.446
Seabird survey		20:04	-33.354	50.697	17-Jun	21:00	-33.382	50.533
Towfish incubation sample		20:35	-33.369	50.606	-	-	-	-
Seabird survey		21:03	-33.384	50.525	17-Jun	22:00	-33.406	50.355
Seabird survey	18-Jun	06:35	-33.577	49.288	18-Jun	07:35	-33.610	49.102
Cetacean survey		07:04	-33.593	49.198	18-Jun	13:53	-33.782	47.952
Towfish nutrient sample		07:05	-33.594	49.195	-	-	-	-
Seabird survey		07:38	-33.611	49.093	18-Jun	08:45	-33.640	48.881
Seabird survey		08:50	-33.642	48.865	18-Jun	09:51	-33.671	48.676
Seabird survey		09:53	-33.672	48.669	18-Jun	11:08	-33.700	48.444
Seabird survey		11:09	-33.701	48.441	18-Jun	12:00	-33.728	48.289
Seabird survey		12:01	-33.729	48.286	18-Jun	12:58	-33.758	48.114
Towfish nutrient sample		12:15	-33.736	48.244	-	-	-	-
Seabird survey		13:00	-33.759	48.108	18-Jun	13:49	-33.780	47.960
Seabird survey		17:32	-33.801	47.907	18-Jun	18:12	-33.812	47.785
Cetacean survey		17:38	-33.802	47.889	18-Jun	18:30	-33.820	47.730
Seabird survey		18:16	-33.813	47.773	18-Jun	18:58	-33.833	47.644
Seabird survey		19:02	-33.835	47.632	18-Jun	19:59	-33.863	47.455
Cetacean survey		19:23	-33.845	47.567	18-Jun	21:31	-33.905	47.171
Seabird survey		20:00	-33.863	47.452	18-Jun	21:00	-33.892	47.266
Seabird survey		21:02	-33.892	47.260	18-Jun	22:06	-33.916	47.065
Seabird survey		22:07	-33.916	47.062	18-Jun	22:15	-33.918	47.041
Seabird survey	19-Jun	06:15	-34.011	46.351	19-Jun	07:13	-34.042	46.170
Towfish nutrient sample		06:49	-34.027	46.246	-	-	-	-
Cetacean survey		07:01	-34.034	46.208	19-Jun	21:07	-34.408	43.655
Seabird survey		07:14	-34.042	46.167	19-Jun	08:28	-34.083	45.932
Seabird survey		08:29	-34.083	45.929	19-Jun	08:43	-34.089	45.884
Seabird survey		08:47	-34.091	45.871	19-Jun	10:03	-34.129	45.630
Seabird survey		10:10	-34.133	45.608	19-Jun	11:00	-34.157	45.452
Seabird survey		11:02	-34.158	45.446	19-Jun	12:05	-34.185	45.251
Towfish nutrient sample		11:55	-34.180	45.282	-	-	-	-
Seabird survey		12:07	-34.186	45.245	19-Jun	12:57	-34.211	45.094
Seabird survey		13:00	-34.212	45.085	19-Jun	14:00	-34.239	44.906
Seabird survey		14:01	-34.240	44.903	19-Jun	15:00	-34.266	44.729
Seabird survey		15:04	-34.268	44.717	19-Jun	15:58	-34.285	44.556
Seabird survey		16:02	-34.287	44.545	19-Jun	16:56	-34.310	44.385
Towfish nutrient sample		16:33	-34.300	44.453	-	-	-	-

Seabird survey		18:00	-34.332	44.196	19-Jun	19:00	-34.353	44.022
Seabird survey		19:05	-34.355	44.008	19-Jun	19:59	-34.376	43.851
Seabird survey		20:00	-34.376	43.848	19-Jun	21:05	-34.407	43.661
Seabird survey		21:07	-34.408	43.655	19-Jun	21:09	-34.410	43.649
Seabird survey		21:10	-34.410	43.647	19-Jun	21:24	-34.418	43.609
Towfish nutrient sample		21:13	-34.412	43.638	-	-	-	-
Towfish nutrient sample		21:43	-34.419	43.604	-	-	-	-
Towfish nutrient sample	20-Jun	01:10	-34.583	43.921	-	-	-	-
Towfish nutrient sample		06:15	-35.037	44.781	-	-	-	-
Seabird survey		06:41	-35.076	44.856	20-Jun	07:50	-35.175	45.057
Cetacean survey		07:02	-35.107	44.916	20-Jun	13:35	-35.672	46.018
Seabird survey		07:55	-35.181	45.071	20-Jun	08:45	-35.252	45.214
Seabird survey		08:47	-35.255	45.220	20-Jun	09:51	-35.348	45.401
Seabird survey		09:54	-35.352	45.410	20-Jun	11:04	-35.453	45.604
Towfish nutrient sample		10:50	-35.432	45.565	-	-	-	-
Seabird survey		11:05	-35.454	45.607	20-Jun	12:05	-35.544	45.775
Seabird survey		12:07	-35.547	45.780	20-Jun	13:01	-35.626	45.926
Seabird survey		13:03	-35.629	45.932	20-Jun	14:00	-35.707	46.085
Seabird survey		14:02	-35.710	46.090	20-Jun	14:46	-35.769	46.205
Seabird survey		14:49	-35.773	46.212	20-Jun	14:59	-35.786	46.239
Towfish nutrient sample		15:00	-35.788	46.241	-	-	-	-
Seabird survey		15:02	-35.791	46.246	20-Jun	15:59	-35.874	46.392
Seabird survey		16:00	-35.875	46.395	20-Jun	16:58	-35.954	46.545
Seabird survey		17:00	-35.957	46.550	20-Jun	18:00	-36.040	46.706
Towfish nutrient sample		18:00	-36.040	46.706	-	-	-	-
Seabird survey		18:01	-36.041	46.709	20-Jun	19:01	-36.124	46.866
Seabird survey		19:03	-36.127	46.871	20-Jun	19:32	-36.170	46.948
Seabird survey		19:50	-36.197	46.995	20-Jun	20:16	-36.238	47.063
Seabird survey		20:17	-36.240	47.066	20-Jun	20:59	-36.305	47.178
Cetacean survey		20:33	-36.266	47.108	20-Jun	22:13	-36.407	47.369
Seabird survey		21:00	-36.307	47.181	20-Jun	22:09	-36.403	47.365
Towfish nutrient sample		22:05	-36.398	47.355	-	-	-	-
Seabird survey	21-Jun	06:20	-36.497	47.574	21-Jun	07:29	-36.612	47.766
Towfish nutrient sample		06:43	-36.533	47.638	-	-	-	-
Cetacean survey		07:24	-36.604	47.752	21-Jun	07:35	-36.622	47.783
Seabird survey		07:30	-36.614	47.769	21-Jun	08:42	-36.726	47.973
Seabird survey		08:45	-36.731	47.982	21-Jun	10:00	-36.860	48.192
Seabird survey		10:02	-36.864	48.197	21-Jun	10:59	-36.946	48.356
Cetacean survey		10:24	-36.897	48.259	21-Jun	11:47	-37.017	48.490
Seabird survey		11:00	-36.947	48.358	21-Jun	12:00	-37.036	48.526
Towfish incubation sample		11:05	-36.954	48.373	-	-	-	-

Seabird survey		12:01	-37.038	48.529	21-Jun	12:58	-37.120	48.685
Seabird survey		13:01	-37.125	48.693	21-Jun	14:06	-37.224	48.867
Cetacean survey		13:15	-37.145	48.733	21-Jun	13:29	-37.166	48.770
Seabird survey		14:08	-37.227	48.872	21-Jun	14:59	-37.301	49.005
Seabird survey		15:02	-37.305	49.013	21-Jun	16:00	-37.385	49.164
Towfish nutrient sample		15:30	-37.344	49.086	-	-	-	-
Cetacean survey		15:31	-37.345	49.088	21-Jun	15:47	-37.366	49.130
Seabird survey		16:01	-37.386	49.166	21-Jun	17:07	-37.487	49.333
Cetacean survey		16:29	-37.428	49.237	21-Jun	16:45	-37.452	49.277
Cetacean survey		16:55	-37.468	49.302	21-Jun	17:01	-37.477	49.318
Seabird survey		17:08	-37.488	49.335	21-Jun	18:06	-37.576	49.481
Cetacean survey		17:19	-37.506	49.363	21-Jun	17:36	-37.532	49.405
Seabird survey		18:07	-37.577	49.483	21-Jun	18:50	-37.638	49.594
Towfish nutrient sample		18:54	-37.643	49.597	-	-	-	-
Towfish nutrient sample	22-Jun	00:13	-37.599	49.592	-	-	-	-
Cetacean survey		06:07	-35.985	49.674	22-Jun	11:30	-34.498	49.752
Seabird survey		06:43	-35.823	49.682	22-Jun	07:54	-35.498	49.702
Towfish nutrient sample		07:03	-35.733	49.687	-	-	-	-
Seabird survey		07:58	-35.479	49.704	22-Jun	08:45	-35.251	49.719
Seabird survey		08:48	-35.236	49.720	22-Jun	09:49	-34.939	49.742
Seabird survey		09:59	-34.911	49.745	22-Jun	11:02	-34.603	49.747
Seabird survey		11:03	-34.598	49.747	22-Jun	11:59	-34.530	49.794
Cetacean survey		11:42	-34.486	49.765	22-Jun	14:50	-34.939	50.173
Towfish nutrient sample		11:45	-34.493	49.769	-	-	-	-
Seabird survey		12:00	-34.533	49.796	22-Jun	13:00	-34.676	49.922
Towfish nutrient sample		12:15	-34.573	49.823	-	-	-	-
Towfish nutrient sample		12:45	-34.641	49.888	-	-	-	-
Seabird survey		13:02	-34.681	49.926	22-Jun	14:01	-34.820	50.060
Towfish nutrient sample		13:15	-34.711	49.955	-	-	-	-
Towfish nutrient sample		13:45	-34.782	50.023	-	-	-	-
Seabird survey		14:03	-34.825	50.064	22-Jun	14:55	-34.952	50.185
Towfish nutrient sample		14:15	-34.854	50.092	-	-	-	-
Towfish nutrient sample		14:45	-34.927	50.161	-	-	-	-
Seabird survey		15:00	-34.964	50.196	22-Jun	16:05	-35.125	50.350
Towfish nutrient sample		15:15	-35.002	50.231	-	-	-	-
Towfish nutrient sample		15:45	-35.077	50.301	-	-	-	-
Cetacean survey		16:01	-35.117	50.339	22-Jun	18:30	-35.377	50.709
Seabird survey		16:06	-35.127	50.352	22-Jun	17:00	-35.230	50.492
Towfish nutrient sample		16:15	-35.145	50.375	-	-	-	-
Towfish nutrient sample		16:45	-35.202	50.452	-	-	-	-
Seabird survey		17:01	-35.232	50.494	22-Jun	18:00	-35.332	50.638

Towfish nutrient sample		17:15	-35.258	50.530	-	-	-	-
Towfish nutrient sample		17:45	-35.309	50.602	-	-	-	-
Seabird survey		18:02	-35.335	50.643	22-Jun	19:00	-35.421	50.776
Towfish nutrient sample		18:15	-35.355	50.673	-	-	-	-
Towfish nutrient sample		18:45	-35.399	50.742	-	-	-	-
Seabird survey		19:01	-35.423	50.778	22-Jun	19:58	-35.510	50.905
Cetacean survey		19:02	-35.424	50.780	22-Jun	20:59	-35.588	51.046
Seabird survey		20:00	-35.513	50.910	22-Jun	21:00	-35.589	51.048
Seabird survey		21:02	-35.591	51.053	22-Jun	22:00	-35.654	51.197
Seabird survey		22:02	-35.656	51.202	22-Jun	22:54	-35.711	51.332
Cetacean survey	23-Jun	06:03	-36.346	52.430	23-Jun	07:06	-36.440	52.599
Seabird survey		06:10	-36.355	52.449	23-Jun	07:08	-36.444	52.604
Towfish nutrient sample		07:27	-36.436	52.615	-	-	-	-
Seabird survey		08:27	-36.433	52.617	23-Jun	08:45	-36.481	52.612
Seabird survey		08:46	-36.486	52.611	23-Jun	10:01	-36.797	52.556
Cetacean survey		10:01	-36.797	52.556	23-Jun	11:38	-37.211	52.469
Seabird survey		10:05	-36.813	52.553	23-Jun	10:57	-37.034	52.506
Seabird survey		11:00	-37.047	52.504	23-Jun	12:00	-37.308	52.449
Cetacean survey		11:43	-37.234	52.465	23-Jun	18:22	-39.025	52.061
Seabird survey		12:02	-37.317	52.447	23-Jun	12:59	-37.573	52.394
Towfish nutrient sample		13:00	-37.578	52.393	-	-	-	-
Seabird survey		13:01	-37.582	52.392	23-Jun	13:59	-37.841	52.330
Seabird survey		14:01	-37.850	52.328	23-Jun	14:59	-38.116	52.265
Seabird survey		15:00	-38.120	52.264	23-Jun	15:59	-38.393	52.205
Seabird survey		16:00	-38.398	52.204	23-Jun	17:00	-38.664	52.146
Seabird survey		17:01	-38.668	52.144	23-Jun	18:00	-38.928	52.083
Towfish nutrient sample		18:00	-38.928	52.083	-	-	-	-
Seabird survey		18:21	-39.021	52.062	23-Jun	18:22	-39.025	52.061
Seabird survey	24-Jun	06:55	-39.649	52.995	24-Jun	07:59	-39.727	53.133
Seabird survey		08:01	-39.729	53.137	24-Jun	08:02	-39.730	53.138
Towfish nutrient sample		08:07	-39.733	53.141	-	-	-	-
Seabird survey		09:00	-39.737	53.141	24-Jun	09:59	-39.754	53.028
Cetacean survey		09:17	-39.751	53.143	24-Jun	12:55	-39.811	52.537
Towfish nutrient sample		09:24	-39.749	53.124	-	-	-	-
Seabird survey		10:00	-39.754	53.025	24-Jun	11:00	-39.774	52.859
Seabird survey		11:02	-39.775	52.853	24-Jun	12:05	-39.794	52.676
Seabird survey		12:07	-39.794	52.671	24-Jun	12:56	-39.811	52.534
Towfish nutrient sample		13:00	-39.813	52.524	-	-	-	-
Seabird survey		13:01	-39.813	52.521	24-Jun	13:59	-39.829	52.366
Cetacean survey		13:09	-39.818	52.500	24-Jun	13:23	-39.820	52.462
Cetacean survey		13:29	-39.821	52.446	24-Jun	15:32	-39.866	52.122

Seabird survey		14:02	-39.830	52.359	24-Jun	14:59	-39.850	52.209
Seabird survey		15:01	-39.851	52.204	24-Jun	16:00	-39.878	52.047
Cetacean survey		16:02	-39.878	52.042	24-Jun	17:45	-39.902	51.767
Seabird survey		16:04	-39.879	52.037	24-Jun	16:55	-39.895	51.899
Seabird survey		16:58	-39.896	51.891	24-Jun	17:56	-39.905	51.740
Towfish nutrient sample		17:45	-39.902	51.767	-	-	-	-
Seabird survey	25-Jun	06:20	-39.993	50.994	25-Jun	07:31	-40.011	50.800
Towfish nutrient sample		06:33	-39.997	50.959	-	-	-	-
Cetacean survey		07:06	-40.005	50.868	25-Jun	15:55	-40.081	50.253
Seabird survey		07:33	-40.011	50.795	25-Jun	08:41	-40.029	50.611
Seabird survey		08:46	-40.031	50.597	25-Jun	09:55	-40.053	50.410
Seabird survey		09:57	-40.053	50.405	25-Jun	11:01	-40.071	50.230
Seabird survey		11:03	-40.071	50.225	25-Jun	11:58	-40.093	50.084
Towfish nutrient sample		11:30	-40.080	50.156	-	-	-	-
Seabird survey		11:59	-40.093	50.082	25-Jun	12:58	-40.107	49.932
Seabird survey		13:01	-40.108	49.924	25-Jun	13:32	-40.117	49.844
Seabird survey		13:42	-40.144	49.851	25-Jun	14:20	-40.118	49.969
Seabird survey		14:22	-40.117	49.975	25-Jun	15:00	-40.090	50.095
Seabird survey		15:05	-40.087	50.111	25-Jun	15:50	-40.073	50.247
Cetacean survey		21:19	-39.925	50.278	25-Jun	21:34	-39.916	50.280
Towfish incubation sample	26-Jun	00:30	-39.875	50.225	-	-	-	-
Seabird survey		07:08	-40.181	49.199	26-Jun	08:24	-40.206	48.987
Cetacean survey		08:04	-40.202	49.044	26-Jun	10:46	-40.254	48.606
Seabird survey		08:25	-40.206	48.984	26-Jun	09:46	-40.241	48.768
Seabird survey		09:48	-40.242	48.762	26-Jun	10:46	-40.254	48.606
Towfish nutrient sample		11:03	-40.260	48.600	-	-	-	-
Seabird survey		12:25	-40.278	48.610	26-Jun	13:13	-40.266	48.510
Cetacean survey		12:35	-40.297	48.605	26-Jun	18:53	-40.368	47.547
Towfish nutrient sample		12:37	-40.295	48.600	-	-	-	-
Seabird survey		13:14	-40.266	48.507	26-Jun	13:58	-40.274	48.384
Towfish nutrient sample		13:30	-40.268	48.464	-	-	-	-
Seabird survey		14:00	-40.275	48.379	26-Jun	15:07	-40.293	48.189
Towfish nutrient sample		14:30	-40.286	48.295	-	-	-	-
Seabird survey		15:08	-40.293	48.186	26-Jun	15:59	-40.311	48.042
Seabird survey		16:00	-40.311	48.039	26-Jun	16:59	-40.331	47.872
Towfish nutrient sample		16:30	-40.322	47.954	-	-	-	-
Seabird survey		17:00	-40.332	47.869	26-Jun	17:59	-40.349	47.698
Towfish nutrient sample		17:29	-40.340	47.786	-	-	-	-
Seabird survey		18:02	-40.351	47.688	26-Jun	18:52	-40.368	47.549
Towfish nutrient sample		18:30	-40.361	47.608	-	-	-	-
Seabird survey		21:33	-40.353	47.607	26-Jun	22:52	-40.388	47.378

Cetacean survey		21:35	-40.354	47.602	26-Jun	22:30	-40.380	47.443
Towfish nutrient sample		22:30	-40.380	47.443	-	-	-	-
Cetacean survey	27-Jun	07:08	-40.396	47.327	27-Jun	09:15	-40.426	46.960
Seabird survey		07:12	-40.396	47.315	27-Jun	08:21	-40.411	47.115
Towfish nutrient sample		08:15	-40.409	47.133	-	-	-	-
Seabird survey		08:22	-40.411	47.112	27-Jun	09:16	-40.426	46.958
Towfish nutrient sample		09:10	-40.424	46.973	-	-	-	-
Towfish nutrient sample		09:50	-40.429	46.946	-	-	-	-
Seabird survey		11:01	-40.440	46.933	27-Jun	12:02	-40.448	46.756
Cetacean survey		11:03	-40.441	46.928	27-Jun	20:14	-40.595	45.330
Towfish nutrient sample		12:00	-40.448	46.762	-	-	-	-
Seabird survey		12:05	-40.449	46.747	27-Jun	13:00	-40.464	46.591
Towfish nutrient sample		13:00	-40.464	46.591	-	-	-	-
Seabird survey		13:03	-40.465	46.583	27-Jun	13:57	-40.480	46.430
Seabird survey		14:00	-40.481	46.422	27-Jun	15:00	-40.490	46.253
Towfish nutrient sample		14:00	-40.481	46.422	-	-	-	-
Towfish nutrient sample		15:00	-40.490	46.253	-	-	-	-
Seabird survey		15:01	-40.490	46.250	27-Jun	16:02	-40.517	46.084
Towfish nutrient sample		16:00	-40.516	46.089	-	-	-	-
Seabird survey		16:03	-40.517	46.081	27-Jun	16:20	-40.522	46.032
Seabird survey		16:21	-40.522	46.029	27-Jun	16:44	-40.529	45.963
Seabird survey		16:46	-40.530	45.957	27-Jun	17:59	-40.558	45.744
Towfish nutrient sample		17:00	-40.535	45.917	-	-	-	-
Towfish nutrient sample		18:00	-40.558	45.741	-	-	-	-
Seabird survey		18:01	-40.559	45.738	27-Jun	19:10	-40.572	45.526
Towfish nutrient sample		19:00	-40.570	45.556	-	-	-	-
Seabird survey		19:11	-40.573	45.523	27-Jun	20:00	-40.589	45.374
Seabird survey		20:01	-40.589	45.370	27-Jun	20:28	-40.599	45.291
Towfish nutrient sample		20:15	-40.595	45.327	-	-	-	-
Towfish nutrient sample		23:20	-40.614	45.240	-	-	-	-
Cetacean survey	28-Jun	06:57	-40.682	44.434	28-Jun	08:47	-40.711	44.185
Seabird survey		07:09	-40.685	44.408	28-Jun	08:03	-40.701	44.284
Seabird survey		08:07	-40.702	44.275	28-Jun	08:45	-40.710	44.188
Towfish nutrient sample		09:50	-40.719	44.193	-	-	-	-
Seabird survey		10:08	-40.738	44.241	28-Jun	11:16	-40.817	44.427
Cetacean survey		10:09	-40.739	44.244	28-Jun	14:38	-41.087	45.011
Seabird survey		11:18	-40.819	44.432	28-Jun	12:13	-40.890	44.587
Seabird survey		12:14	-40.892	44.590	28-Jun	13:17	-40.976	44.774
Seabird survey		13:18	-40.978	44.777	28-Jun	13:58	-41.032	44.894
Seabird survey		14:01	-41.036	44.902	28-Jun	14:41	-41.090	45.018
Towfish nutrient sample		14:40	-41.090	45.016	-	-	-	-

Cetacean survey		15:47	-41.112	45.024	28-Jun	15:58	-41.114	45.025
Seabird survey		16:18	-41.124	45.035	28-Jun	17:08	-41.185	45.189
Cetacean survey		16:22	-41.129	45.045	28-Jun	20:48	-41.446	45.864
Seabird survey		17:09	-41.186	45.192	28-Jun	18:00	-41.245	45.354
Seabird survey		18:02	-41.248	45.361	28-Jun	19:02	-41.310	45.550
Towfish nutrient sample		18:10	-41.257	45.386	-	-	-	-
Seabird survey		19:03	-41.311	45.553	28-Jun	20:00	-41.384	45.723
Seabird survey		20:01	-41.385	45.726	28-Jun	20:48	-41.446	45.864
Towfish nutrient sample		20:40	-41.438	45.841	-	-	-	-
Cetacean survey	29-Jun	07:02	-41.890	46.868	29-Jun	08:45	-41.994	47.086
Seabird survey		07:04	-41.892	46.872	29-Jun	08:00	-41.949	46.993
Seabird survey		08:02	-41.951	46.997	29-Jun	08:43	-41.992	47.084
Seabird survey		09:52	-42.055	47.100	29-Jun	10:53	-42.316	47.110
Cetacean survey		10:04	-42.106	47.102	29-Jun	13:30	-42.964	47.140
Towfish nutrient sample		10:10	-42.132	47.103	-	-	-	-
Seabird survey		10:55	-42.325	47.110	29-Jun	11:59	-42.595	47.126
Seabird survey		12:00	-42.599	47.126	29-Jun	13:00	-42.842	47.141
Seabird survey		13:01	-42.846	47.141	29-Jun	13:59	-43.081	47.142
Seabird survey		14:01	-43.089	47.142	29-Jun	15:00	-43.326	47.153
Towfish nutrient sample		14:15	-43.144	47.145	-	-	-	-
Cetacean survey		14:34	-43.220	47.148	29-Jun	19:43	-44.493	47.207
Seabird survey		15:01	-43.330	47.153	29-Jun	15:58	-43.559	47.164
Seabird survey		16:01	-43.571	47.165	29-Jun	17:02	-43.821	47.175
Seabird survey		17:04	-43.829	47.175	29-Jun	17:59	-44.057	47.185
Seabird survey		18:01	-44.065	47.186	29-Jun	18:59	-44.309	47.197
Towfish nutrient sample		18:30	-44.187	47.192	-	-	-	-
Seabird survey		19:01	-44.317	47.198	29-Jun	19:51	-44.518	47.207
Seabird survey	30-Jun	12:47	-45.711	47.244	30-Jun	13:36	-45.728	47.241
Seabird survey		19:12	-45.766	47.228	30-Jun	20:28	-46.079	47.253
Cetacean survey		19:16	-45.782	47.229	30-Jun	20:03	-45.976	47.245
Seabird survey		20:30	-46.087	47.254	30-Jun	22:40	-46.632	47.281
Cetacean survey		21:06	-46.238	47.264	30-Jun	23:00	-46.716	47.285
Seabird survey	01-Jul	07:32	-48.936	47.400	01-Jul	08:43	-49.235	47.414
Cetacean survey		08:03	-49.066	47.406	01-Jul	09:59	-49.550	47.429
Seabird survey		08:48	-49.256	47.415	01-Jul	10:15	-49.617	47.432
Seabird survey		10:18	-49.630	47.432	01-Jul	11:24	-49.933	47.442
Cetacean survey		11:03	-49.832	47.438	01-Jul	14:00	-50.707	47.477
Seabird survey		11:27	-49.947	47.442	01-Jul	12:45	-50.332	47.462
Seabird survey		13:39	-50.601	47.472	01-Jul	14:03	-50.723	47.478
Seabird survey		14:32	-50.869	47.487	01-Jul	14:59	-51.003	47.493
Cetacean survey		15:01	-51.013	47.494	01-Jul	18:00	-51.855	47.525

Seabird survey	15:47	-51.239	47.505	01-Jul	16:26	-51.422	47.512
Seabird survey	16:27	-51.426	47.512	01-Jul	16:52	-51.542	47.515
Seabird survey	17:10	-51.626	47.518	01-Jul	18:27	-51.977	47.534
Seabird survey	18:45	-52.009	47.540	01-Jul	19:35	-52.202	47.546
Seabird survey	19:37	-52.210	47.546	01-Jul	20:16	-52.370	47.548

7. NMF-SS Ship's Systems

Mark Maltby
National Marine Facilities

7.1 Aims and purpose of data collection

Data were collected with the following broad aims:

1. To map major frontal features and nutrient regimes within the off-shelf study area and along the survey track.
2. To collect indices of environmental features likely to limit the distribution or detectability seabirds and other study organisms.
3. To estimate rates of primary production within the study area.
4. To estimate the vertical distribution and biomass of mesopelagic nekton within the study areas.
5. To collect other oceanographic data opportunistically.

7.2 Requested services

To meet the above aims, the science party requested the following services:

Scientific computing system: Position to be logged at 1 Hz throughout the cruise and the scientific computing system required throughout.

Meteorology monitoring package, WAMOS wave radar, pumped sea surface monitoring system: Metrological and wave data to be recorded using the ship's metrology package and WAMOS wave radar respectively. Surface salinity, temperature, transmissivity and fluorescence to be measured continuously by the ship's pumped sampling system. Data recording was to commence as soon as the ship had entered the English Channel (i.e. west of 001° 40' W), and continue until just prior to entering St Johns (i.e. until 052° 30' W). These data are to be analysed primarily by Igor Belkin (University of Rhode Island) and Ewan Wakefield (University of Glasgow). To avoid contamination, the sea surface monitoring system was to be shut down while fish oil etc. were being discharged during bird catching operations.

Hull-mounted ADCP system: In order to obtain current profiles, both the 75 kHz and 150 kHz ADCP units were to be operate continuously while the ship was underway in open water (i.e. between 006° and 052° W). These data are to be analysed primarily by Igor Belkin (University of Rhode Island).

Simrad EK60: Acoustic data were to be collected sing the EK60 in order to estimate the vertical distribution and biomass of mesopelagic nekton within the study area. The EK60 was to remain operational while the ship was open water (i.e. between 006° and 052° W). These data are to be analysed by Roland Proud and Andrew Brierley (University of St Andrews).

Additional instruments were run to collect data opportunistically.

7.3 Scientific Computer Systems

7.3.1 Acquisition

Network drives were setup on the on-board file server; firstly a read-only drive of the ships instruments data and a second scratch drive for the scientific party. Both were combined at the end of the cruise and copied to disks for the PSO and BODC. The Ship-fitted instruments that were logged are listed in the below file (includes BODC/Level-C notes):

Dy080_BODC_ship_fitted_information_sheet.docx Cruise Disk Location: '/Cruise_Documentation/'

Core data was logged by the Techsas 5.11 data acquisition system. The system creates NetCDF and ASCII output data files. The format of the data files is given per instrument in the "Data Description" directory:

Cruise Disk Location: ' /Cruise_Documentation/Data_Description_Documents'

Data was additionally logged into the legacy RVS Level-C format. There are ASCII dumps of all the level-C streams included on the data disk in directories:

Cruise Disk Locations: '/Ship_Fitted_Scientific_Systems/Level-C/raw_data/ascii/' '/Ship_Fitted_Scientific_Systems/Level-C/pro_data/ascii/'

7.4 Instrumentation

7.4.1 Position and attitude

GPS and attitude measurement systems were run throughout the cruise.

The **Applanix POSMV** system is the GPS system outputting the position of the ship's common reference point that is displayed around the ship on the data display system. The position fixes, attitude and gyro data are logged to the Techsas system. True Heave is logged by the Kongsberg EM122 & EM710 systems. Differential corrections are acquired by the system via the CNav 3050.

The **Seapath 330** system is the GPS system outputting the position of the ship's common reference point. The systems position fix, attitude and Real time heave data are used by the EA640, EM122, EM710 & EK60. Position fixes and attitude data are logged to the Techsas system.

The **CNav 3050** is a GPS system with differential correction service. It provides the Applanix POSMV syatem with corrected DGPS feed for auxiliary input to provide greater than 1m accuracy. The position fixes data is logged to the Techsas system.

The **Fugro Seastar** is a GPS system with differential correction service. It provides the Seapath 330 system with RTCM DGPS corrections with greater than 1m accuracy. The position fixes data is logged to the Techsas system.

The **Phins** is an inertial Navigation system which provides true-heading, attitude, speed and position. The position data is supplied from the Seapath 330 system. The data feeds from the Phins are used by the ADCP's and attitude data is logged to the Techsas system.

There was a loss of Seapath 330 GPS data due to the Techsas module crashing the period of loss was 21/06/17 08:15:02 – 21/06/2017 09:50:47.

7.4.2 Meteorology and sea surface monitoring package

The NMF Surfmet system was run throughout the cruise, excepting times for cleaning, entering and leaving port and whilst alongside. Please see the separate information sheet for details of the sensors used and weather calibrations values have been applied:

Dy080_surfmet_sensor_calibrations.docx Cruise Disk Location: '/Cruise_Documentation/'

Instrument calibration sheets are included in the directory:

Cruise Disk Location: '/Ship_Fitted_Scientific_Systems/Surfmet/SurfMet_calibration_sheets'

7.4.3 Events

The data from the starboard TIR is suspect from 11/06/17 08:14:00 – 14/06/17 16:45:33 due to a loose cable making reading intermittent, investigation and repair was delayed until conditioned permitted access to the met mast.

Cleaning events are documented in the following table:

Date	Time	Event
07/06/17	08:55:00	Non-Toxic Started – Trans open 4.7608V closed 0.0639V
15/06/17	17:58:00	Non-Toxic shutdown for cleaning
15/06/17	18:19:00	Non-Toxic Restarted – Trans open 4.7606V closed 0.0642V
21/06/17	19:35:00	Non-Toxic shutdown for cleaning
21/06/17	20:00:00	Non-Toxic Restarted – Trans open 4.754V closed 0.0641V
26/06/17	15:15:00	Non-Toxic shutdown for cleaning
26/06/17	15:25:00	Non-Toxic Restarted – Trans open 4.7537V closed 0.0641V
01/07/17	13:04:00	Non-Toxic shutdown - Trans open 4.753V closed 0.0641V

Water sample were taken twice a day for TSG salinity ties, bottle details and sample time are documented in the following table:

Date	Time	Crate/Bottle Number

07/06/17	19:00:00	TSG01/097
08/06/17	07:15:30	TSG01/098
08/06/17	19:25:00	TSG01/099
09/06/17	07:14:00	TSG01/100
09/06/17	19:01:00	TSG01/101
10/06/17	06:59:30	TSG01/102
10/06/17	19:01:00	TSG01/103
11/06/17	08:09:45	TSG01/104
11/06/17	19:59:45	TSG01/105
12/06/17	08:04:00	TSG01/106
12/06/17	19:59:3019	TSG01/107
13/06/17	08:14:50	TSG01/108
13/06/17	20:00:15	TSG01/109
14/06/17	09:08:00	TSG01/110
14/06/17	21:24:00	TSG01/111
15/06/17	09:06:00	TSG01/112
15/06/17	19:59:00	TSG01/113
16/06/17	08:48:30	TSG01/114
16/06/17	20:00:00	TSG01/115
17/06/17	09:06:15	TSG01/116
17/06/17	19:57:20	TSG01/117
18/06/17	09:08:30	TSG01/118
18/06/17	20:01:00	TSG01/119
19/06/17	08:51:00	TSG01/120
19/06/17	20:06:00	TSG02/049
20/06/17	08:56:30	TSG02/050
20/06/17	20:00:30	TSG02/051
21/06/17	09:10:00	TSG02/052
21/06/17	20:02:00	TSG02/053
22/06/17	09:10:30	TSG02/054
22/06/17	20:04:30	TSG02/055
23/06/17	09:38:30	TSG02/056
23/06/17	20:00:20	TSG02/057
24/06/17	09:06:45	TSG02/058
24/06/17	19:58:30	TSG02/059
25/06/17	09:06:00	TSG02/060
25/06/17	20:01:35	TSG02/061
26/06/17	10:21:40	TSG02/062
26/06/17	20:54:20	TSG02/063
27/06/17	10:11:50	TSG02/064
27/06/17	20:58:45	TSG02/065
28/06/17	10:04:30	TSG02/066
28/06/17	20:57:00	TSG02/067
29/06/17	10:08:30	TSG02/068
29/06/17	21:01:30	TSG02/069
30/06/17	10:31:00	TSG02/070

7.4.4 Ocean Waves WaMoS II

The Wamos wave radar was run throughout the cruise. The system is currently calibrated against forecast data so may not be absolutely accurate.

Cruise Disk Location: ‘/Ship_Fitted_Scientific_Systems/WaMos’

7.4.5 Kongsberg EA640 10kHz single beam

The EA640 single-beam echo-sounder was run throughout the cruise. The 10kHz transducer was used to avoid interference with the other acoustic systems.

It was used with a constant sound velocity of 1500m/s throughout the water column to allow it to be corrected for sound velocity in post processing. Kongsberg RAW files and History BMP files are logged and depths were logged to the Techsas system:

Cruise Disk Location: ‘/Ship_Fitted_Scientific_Systems/Acoustics/EA640/’

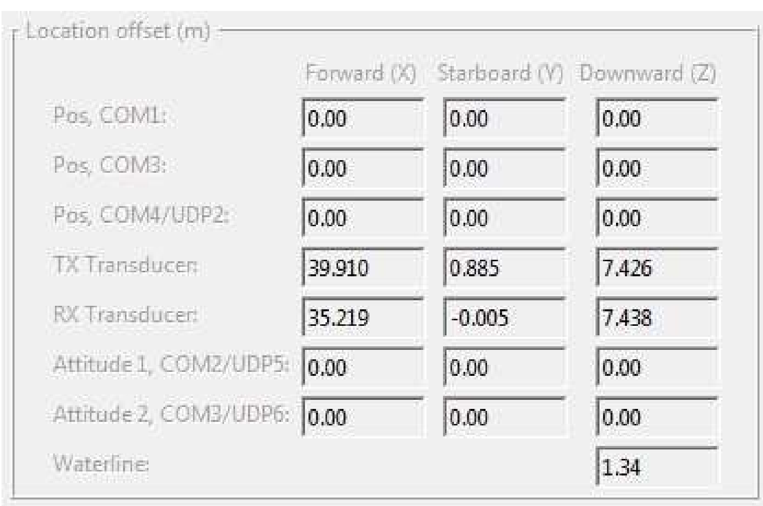
7.4.6 Kongsberg EM122 deep water multi beam

The EM122 multibeam echo-sounder was run throughout the cruise triggered via K-sync to avoid interference with the other acoustic systems.

The position and attitude data is supplied from the Seapath 300 due to its superior real-time heave. True Heave from the Applanix POSMV was also logged and could be used in reprocessing.

Cruise Disk Location: ‘/Ship_Fitted_Scientific_Systems/Acoustics/EM122/’

The following figures shows the system installation configuration. The values are from the ships Parker survey report.


Location offset (m)

	Forward (X)	Starboard (Y)	Downward (Z)
Pos, COM1:	0.00	0.00	0.00
Pos, COM3:	0.00	0.00	0.00
Pos, COM4/UDP2:	0.00	0.00	0.00
TX Transducer:	39.910	0.885	7.426
RX Transducer:	35.219	-0.005	7.438
Attitude 1, COM2/UDP5:	0.00	0.00	0.00
Attitude 2, COM3/UDP6:	0.00	0.00	0.00
Waterline:			1.34


Offset angles (deg.)

	Roll	Pitch	Heading
TX Transducer:	0.07	0.15	0.05
RX Transducer:	0.05	0.37	359.98
Attitude 1, COM2/UDP5:	0.05	0.00	-0.65
Attitude 2, COM3/UDP6:	0.00	0.00	0.00
Stand-alone Heading:			0.00

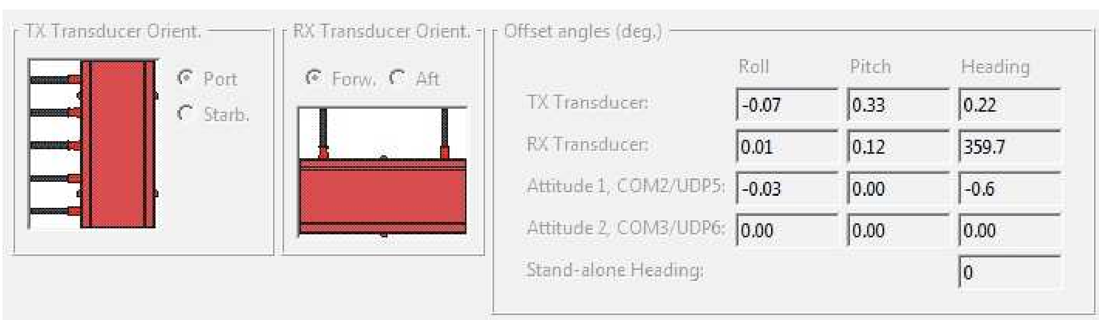
7.4.7 Kongsberg EM710 shallow water multi beam (70-100kHz)

The EM710 multibeam echo-sounder was run on departure and arrival when depths allowed triggered via K-sync to avoid interference with the other acoustic systems.

Cruise Disk Location: '/Ship_Fitted_Scientific_Systems/Acoustics/EM710/'

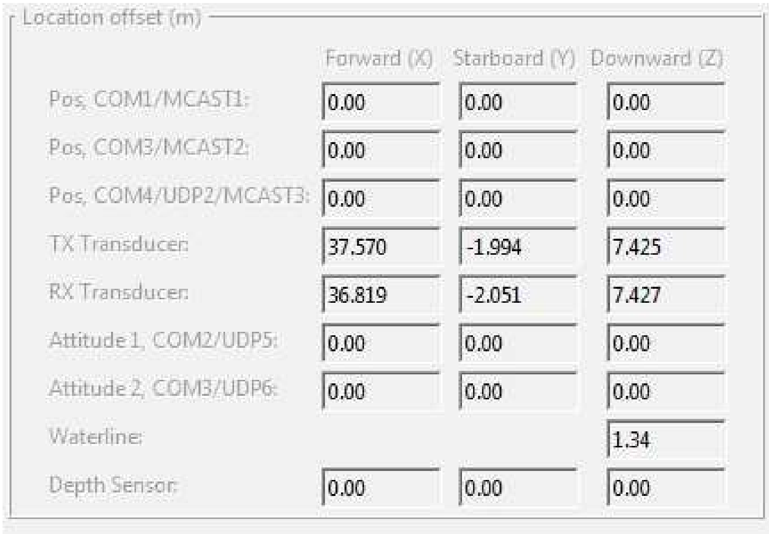
The position and attitude data is supplied from the Seapath 300 due to its superior real-time heave. True Heave from the Applanix POSMV was also logged and could be used in reprocessing.

The following figures shows the system installation configuration. The values are from the ships Parker survey report.



Offset angles (deg.)

	Roll	Pitch	Heading
TX Transducer:	-0.07	0.33	0.22
RX Transducer:	0.01	0.12	359.7
Attitude 1, COM2/UDP5:	-0.03	0.00	-0.6
Attitude 2, COM3/UDP6:	0.00	0.00	0.00
Stand-alone Heading:			0



Location offset (m)

	Forward (X)	Starboard (Y)	Downward (Z)
Pos, COM1/MCAST1:	0.00	0.00	0.00
Pos, COM3/MCAST2:	0.00	0.00	0.00
Pos, COM4/UDP2/MCAST3:	0.00	0.00	0.00
TX Transducer:	37.570	-1.994	7.425
RX Transducer:	36.819	-2.051	7.427
Attitude 1, COM2/UDP5:	0.00	0.00	0.00
Attitude 2, COM3/UDP6:	0.00	0.00	0.00
Waterline:			1.34
Depth Sensor:	0.00	0.00	0.00

7.4.8 **Sound velocity profiler**

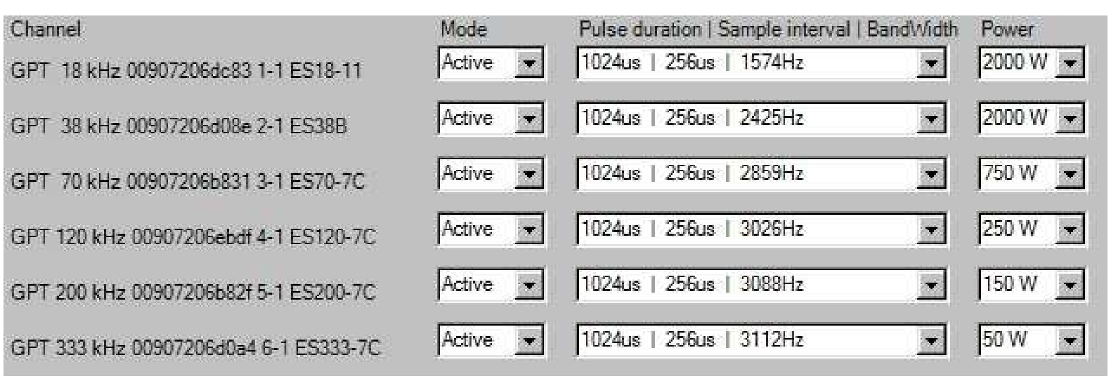
Sound velocity profiles were taken with the MIDAS Valeport SVP SN:22356. The profiles were taken during CDT casts and were only to a depth of 500m, the rest of the extended profile is computed. The profiles were applied to both the EM122 & EM710 systems.

Date/Time	Profile	Location
13/06/17 08:48	Dy080_station1_sorted_extended_thinned.asvp	43 48.50 N 029 002.57 W
17/06/17 10:04	Dy080_station8_sorted_extended_thinned.asvp	53 08.21 N 032 56.67 W
26/06/17 11:52	Dy080_station23_sorted_extended_thinned.asvp	48 36.02 N 040 15.60 W

Cruise Disk Location: '/Ship_Fitted_Scientific_Systems/Acoustics/Sound_Velocity_Profiles/'

7.4.9 **Simrad EK60 fish finder**

The Simrad EK60 Fish Finder was configured as per the request of the science party as below.



Channel	Mode	Pulse duration | Sample interval | BandWidth	Power
GPT 18 kHz 00907206dc83 1-1 ES18-11	Active	1024us | 256us | 1574Hz	2000 W
GPT 38 kHz 00907206d08e 2-1 ES38B	Active	1024us | 256us | 2425Hz	2000 W
GPT 70 kHz 00907206b831 3-1 ES70-7C	Active	1024us | 256us | 2859Hz	750 W
GPT 120 kHz 00907206ebdf 4-1 ES120-7C	Active	1024us | 256us | 3026Hz	250 W
GPT 200 kHz 00907206b82f 5-1 ES200-7C	Active	1024us | 256us | 3088Hz	150 W
GPT 333 kHz 00907206d0a4 6-1 ES333-7C	Active	1024us | 256us | 3112Hz	50 W

The record range was set to 1500m, a max file size of 25Mb, constant sound velocity of 1500m/s and a max bottom detection of 1500m. It had been requested for a ping interval of 2 seconds to be used but for interference free data K-sync was used to synchronize the system with the other acoustic systems. This meant that 2 second interval wasn't achieved but the best quality data was achieved.

At the time of cruise DY080, the EK60 had not been calibrated for some years and calibration was not practicable during DY080. However, the instrument was calibrated by Sophie Fielding (British Antarctic Survey) on the 27 and 28 November, 2017 in Stromness Harbour, South Georgia during cruise DY086. Calibrations files (18, 38, 120, 200 and 333 kHz) can be obtained from the BODC or Sophie Fielding to allow retrospective calibration of data collected using the EK60 during DY080.

There were gaps in the data due to the ER60 Software crashing the following table documents the periods of no data.

Data Collection Stopped	Data Collection Restarted
10/06/17 23:23:52	11/06/17 08:07:00
16/06/17 01:49:00	16/06/17 08:42:00
21/06/17 03:15:00	21/06/17 09:06:00
26/06/17 03:44:00	26/06/17 10:19:00

Cruise Disk Location: '/Ship_Fitted_Scientific_Systems/Acoustics/EK60/'

7.4.10 **75kHz and 150kHz hull-mounted ADCP**

The ADCP's were setup with a standard setup as below, the control files are saved along with the data.

	75kHz	150kHz
Number of Bins	100	96
Bin Size	8m	8m
Blanking	8m	4m
Transducer Alignment	-45.5342 degrees	-45.1128 degrees

The systems were trigger by K-sync to synchronise with the other acoustic systems and prevent interference. On departure and arrival to port bottom tracking was run to allow for transducer alignment check to be performed in post processing.

Cruise Disk Location: '/Ship_Fitted_Scientific_Systems/Acoustics/OS75kHz/'

'/Ship_Fitted_Scientific_Systems/Acoustics/OS75kHz/'

8. NMF-SS CTD

Candice Cameron
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8.1 Aims and purpose of data collection

The main purpose of collecting CTD data was to characterise water masses in order to map major frontal features and nutrient regimes within the off-shelf study area and along the survey track.

8.2 Introduction and Overview

The science party requested that temperature, salinity, dissolved oxygen, florescence, transmissivity, PAR and light scatter profiles be obtained to a depth of 500 m using the ship's CTD. On lines 2-7, casts were to be made twice per day (i.e. spaced approximately every 75 nm assuming a cruising speed of 10 kts). In addition, casts using the rosette to obtain water samples for nutrient analysis, as well as the CTD, were to be carried out at the northern and southern extremities of lines 2-6. Required bottle stops, and the number of bottles to fire at each depth were: 500m x2, 400m x2, 300m x2, 200m x2, 150m x2, 100m x2, 80m x3, 60m x 3, 40m x3, 20m x3.

All CTD casts were undertaken with the stainless steel CTD frame and used 10l Niskin water samplers throughout. The CTD package was left the same as the previous expedition – DY078 – bar the removal of the LADCPs as this had not been requested in the SME. This was confirmed with the PSO during an initial science meeting on board (05/06/17) and in order to reduce risk of loss of units as well as wear and tear on the cables the units have been removed from the CTD frame with only the workhorse remaining to add weight to the frame. The Sensor Information Sheet has been updated to reflect this.

A Sea-Bird 35 Temperature sensor was installed on the 9Plus underwater unit with the sensor tip mounted as close as possible to the Sea-Bird 3P temperature sensor also installed on the 9Plus. A cable connected the Sea-Bird 35 to both the 9Plus and also to the Sea-Bird 32 Carousel. With this arrangement it is possible for the Sea-Bird 35 to trigger sampling once a bottle fire command has been detected, and to also download the data at the end of the cast using the Sea-Bird 11 Plus CTD Deck Unit and Sea-Bird Seaterm software.

Housed on the vane were the Sea-Bird 43 Oxygen and the secondary Sea-Bird 3P temperature and 4C conductivity sensors.

For each deployment the crew directed all deck operations and drove the winch, lines were attached to the frame to steady the package whilst it was either lifted off the deck overboard, or lifted on deck inboard. The technician assisted in this process. Once in the water, the crew lowered the package to an initial depth of 10m, allowing the Sea-Bird 5T pumps to prime and start operating, once this had occurred for most casts, and where weather allowed, the package was raised to near the surface then lowered to a depth given by the technician in the lab for this expedition this was a constant of 500m.

Upon completion of the cast the package was landed on deck, moved into the hanger and stowed in the CTD deck plate for the scientists to commence sampling. Due to the configuration of the lifting hoist and slow operating speed, this typically added a 5 minute delay to the scientists before they were able to start their sampling.

Between stations sensors were flushed with MilliQ and the whole CTD rinsed with fresh water to prevent salt crystals forming in the sensors, associated tubing and carousal.

8.3 List of Sensors Used

Listed below (Table 8.1) are details of all of the sensors and instruments as used on the CTD system for the duration of the expedition. Fortunately, all sensors worked as expected and there were no failures.

Table 8.1 Sensors used during CTD casts.

Instrument / Sensor	Model	Serial No	Chan nel	Casts Used
Primary CTD deck unit	SBE 11plus	11p-0676	N/A	All casts
CTD Underwater Unit	SBE 9plus	09p-0943	N/A	All casts
Stainless steel 24-way frame	NOCS	SBE CTD1	N/A	All casts
Primary Temperature Sensor	SBE 3P	3p-2674	F0	All casts
Primary Conductivity Sensor	SBE 4C	4c-2571	F1	All casts
Digiquartz Pressure sensor	Paroscientific	110557	F2	All casts
Secondary Temperature Sensor	SBE 3P	3p-4383	F3	All casts
Secondary Conductivity Sensor	SBE 4C	4c-2580	F4	All casts
Primary Pump	SBE 5T	05-3085	N/A	All casts
Secondary Pump	SBE 5T	05-7371	N/A	All casts
24-way Carousel	SBE 32	32-0423	N/A	All casts
Dissolved Oxygen Sensor	SBE 43	43-1624	V0	All casts
Dissolved Oxygen Sensor	SBE 43	43-2575	V1	All casts
Altimeter	Benthos 916T	59494	V2	All casts
Light Scattering Sensor	WETLabs BBRTD	BBRTD-169	V3	All casts
PAR Up-looking DWIRR	Biospherical QCP Cosine PAR	70510	V4	All casts
PAR Down-looking UWIRR	Biospherical QCP Cosine PAR	70520	V5	All casts
Fluorometer	CTG Aquatracka MKIII	88-2615-126	V6	All casts
Transmissometer	WET Labs C-Star	1602TR	V7	All casts
10L Water Samplers	OTE	1-24	N/A	All casts
Deep Ocean Standards Thermometer	SBE 35	0048	N/A	All Casts

8.4 CTD Processing

Immediately after each cast the raw data was backed up to the network drive, to reduce the risk of data loss and to make the data available to the scientific party.

Basic Sea-Bird processing of the raw data then took place using Sea-Bird Data Processing software. The full “Recommended steps for basic processing of SBE-911 CTD data (Version 1.0, October 2010)” was followed for all casts and is outlined below.

All casts were processed as per BODC/NMF "recommended steps for basic processing of SBE-911 CTD data" except where stated. (Data Conversion, Bottle Summary, Sea Plot, Wild Edit (pressure), Filter, AlignCTD, CellTM, Loop Edit, Derive, Bin Average, Strip)

Cast	Station Number	Max depth	Processing
1	Dawn	500m	
2	Dawn	500m	No bottle summary (none fired)
3	Dusk	500m	
4	Dawn	500m	No bottle summary (none fired)
5	Dusk	500m	
6	Dawn	500m	No bottle summary (none fired)
7	Dusk	500m	
8	Dawn	500m	
9	Dusk	500m	
10	Dawn	500m	No bottle summary (none fired)
11	Dusk	500m	
12	Dawn	500m	No bottle summary (none fired)
13	Dusk	500m	
14	Dusk	500m	
15	Dawn	500m	No bottle summary (none fired)
16	Dusk	500m	
17	Dawn	500m	
18	Dusk	500m	
19	Dawn	500m	
20	Dusk	500m	
21	Dawn	500m	No bottle summary (none fired)
22	Dusk	500m	
23	100mi N of front	500m	
24	Centre of front	500m	
25	100mi S of front	500m	
26	Dawn	500m	
27	Dusk	500m	No bottle summary (none fired)
28	Dawn	500m	

8.5 Software Used

Sea-Bird SeaTerm 1.59

Sea-Bird Seasave 7.26.2.13

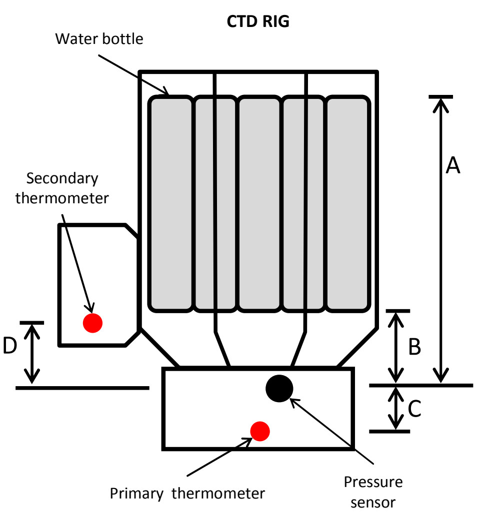
RD Instruments BBTalk 3.06

RD Instruments WinADCP 1.13

TOTAL WIRE: 26000 m

HAUL / VEER: 26.00 km

8.6 CTD Package Geometry



ID	Vertical distance from pressure sensor (m)
A	1.5
B	0.3 s/s system (with 10L samplers)
C**	0.07
D	0.00

**NOTE: C & D may be minimal.

8.7 Configuration

Listed below are the contents of the configuration file as used for all casts completed on the expedition, as saved in the Sea-Bird configuration file DY078_SS.xmlcon.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  <!-- 2 == SBE 17plus SEARAM -->
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9. Seawater nutrient and trace element and phytoplankton pigment concentrations; community structure and physiological status

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9.1 Regular sampling from trace-metal-clean towed-fish

At regular intervals (Table 9.1), surface (~2-3 m depth) seawater was sampled from a custom-built towed-fish via acid washed 1cm diameter tubing with suction provided by a Teflon bellows pump powered by filtered compressed air from the ship supply. Water was pumped directly into the RRS Discovery purpose-built clean air laboratory. Positive air pressure was maintained via a continuous inward airflow, with dust particles in this airflow removed by a HEPA filter.

106 discrete sampling sites were sampled for dissolved macronutrient (nitrate/phosphate/silicate) concentrations, trace element concentrations, phytoplankton pigment composition, phytoplankton cell counts, chlorophyll-a concentrations, and active fluorescence physiological measurements (Figure 9.1). Further details for each of these are outlined below. Sample collection for this suite of measurements ranged between ~1-6 hours of steaming time with a preference for sampling just before (~10-15 minutes) a CTD station.

Table 9.1 Dates, times and locations of sampling from trace-metal-clean towed-fish.

Date	Time	Lon(°)	Lat(°)
07/06/2017	12:26:00	-5.821	49.503
07/06/2017	17:40:00	-6.789	49.245
07/06/2017	22:42:00	-7.930	49.005
08/06/2017	05:18:00	-9.102	48.707
08/06/2017	15:18:00	-10.925	48.233
08/06/2017	20:16:00	-11.661	47.941
09/06/2017	05:40:00	-13.106	47.054
09/06/2017	11:13:00	-14.003	46.576
09/06/2017	17:11:00	-14.517	46.165
09/06/2017	23:07:00	-15.075	45.656
10/06/2017	05:20:00	-15.734	45.027
10/06/2017	11:08:00	-16.405	44.717
10/06/2017	17:15:00	-17.391	44.620
10/06/2017	23:05:00	-18.333	44.544
11/06/2017	06:23:00	-19.755	44.449
11/06/2017	12:07:00	-20.892	44.369
11/06/2017	18:15:00	-22.211	44.289
12/06/2017	00:13:00	-23.487	44.187
12/06/2017	06:14:00	-24.839	44.099
12/06/2017	12:15:00	-26.153	44.011
12/06/2017	18:28:00	-27.388	43.924

12/06/2017	22:12:00	-28.186	43.864
13/06/2017	04:50:00	-29.003	43.810
13/06/2017	05:45:00	-29.043	43.808
13/06/2017	12:00:00	-29.308	44.489
13/06/2017	18:37:00	-29.645	45.361
13/06/2017	23:53:00	-29.967	45.791
14/06/2017	06:58:00	-30.332	45.885
14/06/2017	13:00:00	-30.194	46.725
15/06/2017	07:00:00	-30.682	47.934
15/06/2017	13:13:00	-31.064	48.863
15/06/2017	23:02:00	-31.358	49.592
16/06/2017	06:38:00	-31.815	50.623
16/06/2017	11:58:00	-32.205	51.509
16/06/2017	17:08:00	-32.481	52.123
17/06/2017	04:12:00	-32.945	53.137
17/06/2017	04:12:00	-32.945	53.137
17/06/2017	07:43:00	-33.006	52.769
17/06/2017	13:00:00	-33.149	51.921
18/06/2017	07:05:00	-33.594	49.195
18/06/2017	12:15:00	-33.736	48.244
19/06/2017	06:49:00	-34.027	46.246
19/06/2017	11:55:00	-34.180	45.282
19/06/2017	16:33:00	-34.300	44.453
19/06/2017	21:13:00	-34.412	43.638
19/06/2017	21:43:00	-34.419	43.604
20/06/2017	01:10:00	-34.583	43.921
20/06/2017	06:15:00	-35.037	44.781
20/06/2017	10:50:00	-35.432	45.565
20/06/2017	15:00:00	-35.788	46.241
20/06/2017	18:00:00	-36.040	46.706
20/06/2017	22:05:00	-36.398	47.355
21/06/2017	06:43:00	-36.533	47.638
21/06/2017	15:30:00	-37.344	49.086
21/06/2017	18:54:00	-37.643	49.597
22/06/2017	00:13:00	-37.599	49.592
22/06/2017	07:03:00	-35.733	49.687
22/06/2017	11:45:00	-34.493	49.769
22/06/2017	12:15:00	-34.573	49.823
22/06/2017	12:45:00	-34.641	49.888
22/06/2017	13:15:00	-34.711	49.955
22/06/2017	13:45:00	-34.782	50.023
22/06/2017	14:15:00	-34.854	50.092
22/06/2017	14:45:00	-34.927	50.161

22/06/2017	15:15:00	-35.002	50.231
22/06/2017	15:45:00	-35.077	50.301
22/06/2017	16:15:00	-35.145	50.375
22/06/2017	16:45:00	-35.202	50.452
22/06/2017	17:15:00	-35.258	50.530
22/06/2017	17:45:00	-35.309	50.602
22/06/2017	18:15:00	-35.355	50.673
22/06/2017	18:45:00	-35.399	50.742
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23/06/2017	13:00:00	-37.578	52.393
23/06/2017	18:00:00	-38.928	52.083
24/06/2017	09:24:00	-39.749	53.124
24/06/2017	08:07:00	-39.733	53.141
24/06/2017	13:00:00	-39.813	52.524
24/06/2017	17:45:00	-39.902	51.767
25/06/2017	06:33:00	-39.997	50.959
25/06/2017	11:30:00	-40.080	50.156
26/06/2017	11:03:00	-40.260	48.600
26/06/2017	12:37:00	-40.295	48.600
26/06/2017	13:30:00	-40.268	48.464
26/06/2017	14:30:00	-40.286	48.295
26/06/2017	16:30:00	-40.322	47.954
26/06/2017	17:29:00	-40.340	47.786
26/06/2017	18:30:00	-40.361	47.608
26/06/2017	22:30:00	-40.380	47.443
27/06/2017	08:15:00	-40.409	47.133
27/06/2017	09:10:00	-40.424	46.973
27/06/2017	09:50:00	-40.429	46.946
27/06/2017	12:00:00	-40.448	46.762
27/06/2017	13:00:00	-40.464	46.591
27/06/2017	14:00:00	-40.481	46.422
27/06/2017	15:00:00	-40.490	46.253
27/06/2017	16:00:00	-40.516	46.089
27/06/2017	17:00:00	-40.535	45.917
27/06/2017	18:00:00	-40.558	45.741
27/06/2017	19:00:00	-40.570	45.556
27/06/2017	20:15:00	-40.595	45.327
27/06/2017	23:20:00	-40.614	45.240
28/06/2017	09:50:00	-40.719	44.193
28/06/2017	14:40:00	-41.090	45.016
28/06/2017	18:10:00	-41.257	45.386
28/06/2017	20:40:00	-41.438	45.841
29/06/2017	10:10:00	-42.132	47.103

29/06/2017	14:15:00	-43.144	47.145
29/06/2017	18:30:00	-44.187	47.192

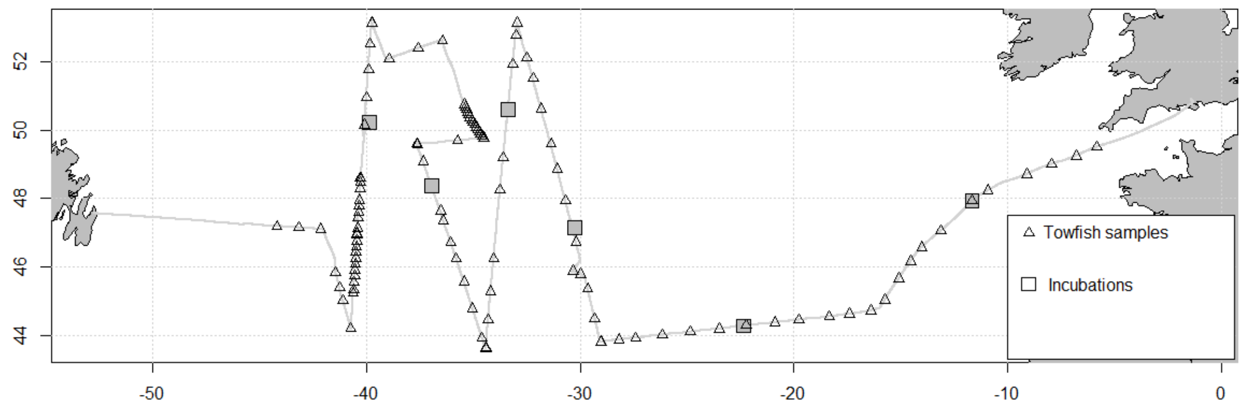

Figure 9.1. Samples from the towed fish and incubation experiments

9.1.1 Trace elements

Samples were collected in acid washed 125mL LDPE sample bottles for dissolved (0.2 µm filter capsule) and total (no filtration) trace metal concentrations (metals: Fe, Zn, Mn, Mg, Cu, Co, Cd, Al). Samples were acidified with 140 µL concentrated (10M) Fisher Optima grade hydrochloric acid, in batches and under a laminar flow hood, within a few days of collection. These samples will be measured on return to GEOMAR via pre-concentration on a SeaFAST system (Thermo scientific) and subsequent analysis on an Element 2 ICP-MS following the method of Milne et al. (2010).

9.1.2 Major nutrients

Samples were collected for dissolved nitrate, phosphate, and silicate concentration analysis (50mL) Samples were frozen immediately in a -20 °C freezer. These samples will be analysed on return to GEOMAR using a Seal Quattro autoanalyser.

9.1.3 Phytoplankton measurements

At each sampling sites the following phytoplankton measurements were made:

- **Chlorophyll-a concentrations:** 100 mL samples were filtered onto Machery Nagel GFF filter papers and extracted for 12-24 hours in 10 mL 90% HPLC-grade acetone in a -20 °C freezer in the dark before measurement on a Turner Designs trilogy fluorometer following the method of Welschmeyer (1994).
- **High Performance Liquid Chromatography (HPLC):** 1-4L seawater was filtered onto Machery Nagel GFF filter papers and placed directly into a -80 °C freezer. These will be analysed on return to GEOMAR following the method of e.g. Gibb et al. (2000).
- **Analytical flow cytometry:** 1.87mL of seawater was mixed with 0.125mL 16% paraformaldehyde yielding a final paraformaldehyde concentration of 1%. Mixing was carried out using vortex, after which samples were left for 10 minutes at room temperature in the dark before transfer to a -80 °C freezer. Samples will be analysed on a FACSort flow cytometer (Beckton-Dickinson, UK) following the method of e.g. Davey et al. (2008), with the intention of analysing for nanophytoplankton, picophytoplankton, *Synechococcus*, *Prochlorococcus* and total bacterial cell counts.

- **Fast Repetition Rate fluorometry (FRRf):** A FASTOcean fluorometer (Sensor ID: 14-9740-003) with integrated FASTact laboratory system (both Chelsea Technologies LTD., UK) was used to measure in vitro variable fluorescence of phytoplankton samples after a 30 minute dark acclimation period (with temperature maintained by submersion in continuously flowing water from the ships underway system). Fluorescence light curves were also ran following a protocol of progressively increasing light intensities between 20 and 2000 µmol photons m^{-2} s^{-1} (as described in Browning et al., (2014) Blank filtrates (0.2 µm filtrates) were measured for virtually all samples. All FRRf data will be blank-corrected and fluorescence parameters recalculated upon return to GEOMAR.
-

9.2 Depth profiles from CTD casts

Seawater was collected from 7 CTD casts for biogeochemical characterisation of the upper 500m water column (CTD numbers 001, 008, 013, 019, 023, 024, and 025; Table 9.2). Sampling depths were always 20m, 40m, 60m, 80m, 100m, 150m, 200m, 400m, and 500m. Samples were collected for dissolved inorganic macronutrients (nitrate/phosphate/silicate), dissolved organic nutrients (nitrate, phosphate) for all depths, and biological measurements (chlorophyll-a, FRRf, phytoplankton diagnostic pigments, flow cytometry cell counts, POC, biogenic silica) from the upper 6 depths (i.e., until 150m).

Table 9.2 Dates and times of CTD casts during which seawater samples for nutrient analysis were obtained.

CTD #	Date	Time
1	13/06/17	05:45:00
8	17/06/17	04:12:00
13	19/06/17	21:43:00
19	24/06/17	08:07:00
23	26/06/17	11:03:00
24	27/06/17	09:50:00
25	27/06/17	23:20:00

9.3 Incubation experiments

Six 48-hour duration on-deck incubation experiments were carried out in 1-2L trace-metal-clean Nalgene polycarbonate bottles (Figure 9.1). Seawater was collected in a 60L acid washed carboy, generally at dusk/night time, using the trace-metal-clean towed-fish described previously (Table 9.3). Filling times for the 60L carboy were approximately ~1 hour. Seawater was siphoned from the 60L carboy into the polycarbonate incubation bottles. Bottled seawater was spiked with the following combinations of nutrients/trace metals: N, Fe, N+Fe, N+Fe+Co, N+Fe+vitamin B12, N+Fe+Zn, N+Fe+Mn, N+Fe+P, N+Fe+Si. Initial conditions were sampled directly from the 60L carboy. Triplicate control bottles (2 L) with no nutrients added were also collected and incubated alongside all nutrient treated bottles. Treated bottles were spiked to the following nutrient/trace metal concentrations: N: 1 µM nitrate and 1 µM ammonium; P: 0.2 µM phosphate; Fe: 2 nM; Zn: 2 nM; Co: 2 nM; vitamin B12: 100 pM; Mn: 2 nM;

Silicate: 2 µM. In addition, for one experiment, guano collected from a caught seabird was added to triplicate bottles. Part of this guano sample was retained for further analysis (see below).

Bottles were placed in on-deck incubators connected to the ships underway flow-through system to continuously maintain temperatures at that of sea surface waters. Incubators were screened with Blue Lagoon screening (Lee Filters), which maintained irradiance at ~30% of that of the surface. After 48 hours incubation, experiments were taken down and measurements made for: Chlorophyll-a concentrations (1 replicate per treatment bottle), FRRf, analytical flow cytometry, a time course analysis of alkaline phosphatase activity using MUF-P (Sigma) as the organic phosphate substrate (selection of treatments only), particulate organic carbon (pooled treatments), biogenic silica (pooled treatments), dissolved trace metal and nutrient concentrations (selection of treatments only).

Table 9.3 Dates, times and locations at which seawater was collected for incubation experiments.

Date	Time	Lon(°)	Lat(°)
08/06/2017	20:16	-11.661	47.941
11/06/2017	18:56	-22.361	44.278
15/06/2017	00:17	-30.263	47.157
17/06/2017	20:35	-33.369	50.606
21/06/2017	11:05	-36.954	48.373
26/06/2017	00:30	-39.875	50.225

9.4 Seabird guano/feather collection for analysis of trace metal/nutrient content

Samples of guano and malting feathers were collected from caught seabirds for future analysis of trace element and nutrient content/release. Guano samples were collected from plastic seabird holding pens in 1.5 mL acid-washed plastic vials using acid-washed plastic spatulas and frozen immediately at -20 °C. Moulting body feathers were collected in sample bags and stored at room temperature. Samples will be analysed for nutrients and trace elements released in a Milli-Q leach (guano and feathers), and for bulk nutrient content following total acid digestion (method to be determined). Nutrient concentrations will be analysed using a Seal Quatrro autoanalyser, and trace element concentrations via ICP-MS, with quantification via standard additions made using a multi-element spike solution.

10. Zooplankton sampling, 200-µm-mesh net hauls

Vladimir Laptihovsky
CEFAS

10.1 Aims and purpose of data collection

The main aim of this activity was to determine the species composition and minimum individual species densities (biomass) of the zooplankton community in the layer above thermocline in the off-shelf study area, and in particular to detect the occurrence juvenile cephalopod stages.

10.2 Methods

A total of 17 planktonic stations were carried out. A planktonic net WP2 (mesh size 200µ), fitted with a flowmeter to record the volume of water filtered, was deployed every night or whenever possible straight after a CTD station. During each cast, 250 m (or 150 m at station 17) of cable was released and the angle between the cable and sea surface was measured to estimate maximum depth of the net haul. This depth was compared with the actual position of thermocline layer obtained during the CTD deployment. At all stations this maximum depth was > 200 m and was situated well below the thermocline layer if the latter was present. On recovery, the net was washed down and the end bag thoroughly rinsed with sea water before preserving the samples in 4% formaldehyde for species identification onshore.

10.3 Preliminary results

A total of 17 hauls were made (Table 10.1). Catches consisted mostly of planktonic crustaceans (copepods, hyperiids), chaetognaths and some pelagic gastropods. They included some species (*Themisto*, *Clio*, euphausiids) also found in seabird diet samples obtained during the cruise. Gelatinous mesozooplankton occurred irregularly and in small numbers.

10.4 Planned analysis

Sample analysis and full planktonic species identification will be carried out in 2018 financial year by Vladimir Laptihovsky using the Plankton Image Analyser (PIA). The PIA is a real-time high speed colour line scan-based imaging instrument. The system is made of a 25 mm brass tube flow cell that has two quartz optical windows halfway along its length. The flow cell at the windows is square with the same cross sectional area as the 25mm tube. A Basler 2048-70kc camera, sampling at 70K lines per second, images the water running through the flow cell. The flow rate is monitored by a Bell electro-magnetic flow meter and set to 34L/min. colour images are captured using an EPIX E4 frame store. The RGB composite images are constructed by joining consecutive lines together, thresholding and extracting a region of interest ROI, or vignette that is saved to hard drive as a TIF file. Each TIF image is time-stamped and named in the Zooscan convention of date+imageID.tif. Raw images are stored to maximise dynamic range of the captured particles. These are converted to JPG format through a process of scaling and conversion from 12bit to 8bit resolution, for viewing and for subsequent processing.

Table 10.1 Dates, times and locations of zooplankton hauls.

Station	Date	Time		Lon(°)	Lat(°)	Flow meter			Max. depth (m)
		From	To			From	To	Diff	
PLK1	14/06/2017	23:14	23:33	-30.221	47.152	411451	420615	9164	234.9
PLK2	15/06/2017	22:10	22:26	-31.337	49.611	-	-	-	250.0
PLK3	16/06/2017	21:15	21:28	-32.494	52.221	795167	805414	10247	250.0
PLK4	17/06/2017	23:25	23:43	-33.420	50.232	805409	814373	8964	216.5
PLK5	18/06/2017	23:15	23:28	-33.919	47.034	814377	823694	9317	250.0
PLK6	19/06/2017	22:30	22:46	-34.418	43.604	823697	833678	9981	241.5
PLK7	20/06/2017	23:04	23:19	-36.409	46.373	833677	843762	10085	249.0
PLK8	21/06/2017	23:23	23:44	-37.610	49.602	843768	852293	8525	226.6
PLK9	23/06/2017	23:40	00:09	-39.053	52.067	852302	862673	10371	250.0
PLK10	24/06/2017	00:10	00:40	-39.053	52.067	862673	872249	9576	250.0
PLK11	25/06/2017	00:00	00:20	-39.956	51.785	872249	881302	9053	249.0
PLK12	25/06/2017	23:20	23:38	-39.869	50.273	881306	891863	10557	191.5
PLK13	26/06/2017	11:50	10:39	-40.260	48.600	891864	902105	10241	246.2
PLK14	27/06/2017	10:20	09:08	-40.428	46.946	902116	910778	8662	250.0
PLK15	28/06/2017	00:15	00:35	-40.614	45.240	910792	919366	8574	249.0
PLK16	28/06/2017	23:20	22:38	-41.728	45.917	919368	928866	9498	241.5
PLK17	29/06/2017	23:45	22:59	-44.546	47.196	928875	934035	5160	149.4

11. Seabird survey

Holly Hogan & Ewan Wakefield
Environment Canada & University of Glasgow

11.1 Aims and purpose of data collection

Comparatively few surveys have been carried out of seabirds in the deep north west Atlantic (Boertmann 2011, Bennison and Jessopp 2015) but tracking data suggest that this area is an important hotspot for many species (see section 3.1). However, little is known about the abundance of these species not how they partition habitats. The aims of the visual survey component of DY080 were therefore to estimate the distribution, abundance and behaviour of seabirds in the off-shelf study area, as well as on transit to and from the ports of embarkation and disembarkation, and to determine the comparative habitat use of large shearwaters, fulmars and other species. In addition, marine mammals, fish, turtles, etc. surface, which are visible at the, and floating rubbish, were recorded.

11.2 Methods

The majority of data were recorded using standard line transect and distance sampling methods while the ship was underway but data were also collected using point sampling methods while the ship was stationary.

11.2.1 Underway visual line transect survey

Seabirds and other animals visible at or near the surface (i.e. cetaceans, tunas, sharks, flying fish, turtles, gelatinous animals, etc.), as well as refuse and other matter that could indicate the location of fine-scale fronts (*Sargassum*, etc.) were surveyed using standard line and distance sampling methods (Tasker et al. 1984, Webb and Durinck 1992, Camphuysen et al. 2004), as described in detail min the Eastern Canada Seabirds At Sea (ECSAS) protocol (Gjerdrum et al. 2012). In brief, birds were recorded in distance bands A-D running perpendicular to one side of the track line at 0-50, 50-100, 100-200 and 200-300 m. Those in flight were also flagged as being 'in transect' if they were within a 300 m square box during 'snapshots', which occurred every 300 m. Behaviour was recorded following Camphuysen and Garthe (2004). In addition, the range and bearing to marine mammals was noted at their first sighting.

Observations were made from the bridge, with an eye height of approximately 17.5 m above sea level. Observers were located at either the extreme port or starboard side of the bridge, the side being changed regularly to take advantage of best observing conditions as dictated by glare, spray, etc. Birds, etc. were detected by naked eye and identified using 10 x 40 or 8 x 40 binoculars. A second person recorded observations. In addition, distant birds and other hard to identify biota were photographed whenever possible by a second observer using a digital camera with a 400 mm image-stabilised lens in order to aid identification. Observations were undertaken whenever the ship was under way and conditions were suitable (i.e. daylight and sea state low enough to allow safe working and reliable detection and identification of birds). Three observers, Holy Hogan, Simon Pinder and Ewan Wakefield, had extensive experience of identifying and recording seabirds at sea. The remainder were trained in these methods during the cruise and acted as primary observers once they were deemed to have reached a level of competence equivalent to that required of European Seabird at Sea observers.

Initially, data were entered directly into a laptop computer supplied by the Canadian Wildlife Service using a voice to text facility. However, the laptop used to operate this system fell onto a hard surface and was made inoperable ~11:00 on the 7th of June. Data were therefore recorded on paper forms from this time, until 10:55 on the 8th of June, when a replacement data entry system was devised on a second laptop, and this was used for all subsequent data entry. Following the cruise, all data were exported to the ECSAS database.

11.2.2 Stationary visual point transect survey

In order to detect the presence elusive species as well as to monitor attraction of commoner species to chum, point transect surveys were carried out from the rear of the monkey island (eye height ~20 m) by a single observer during bird catching sessions. Methods were adapted from those described by Gjerdrum et al. (2012). Recording began 30 minutes before the first release of chum form the back deck, while the vessel was stationary. Every 10 minutes the total number of birds in three distance bands running radially from the observer at 0 – 100, 100 – 300 and >300 m over a 180° arc centred aft were recorded. The number foraging was then recorded, followed by the number in flight. The presence of rare birds outwith these conditions was also recorded as they were sighted.

11.3 Preliminary results

11.3.1 Underway observations

Observation conditions were not ideal in the first week, characterized by strong winds and two to three meter swells. The ship's speed was reduced during this time and arrival at the study area took longer than expected, arriving at ~5:00 on June 13th. From this date forward, the seas were moderate and viewing conditions were relatively good; there was only one day of fog between June 13th and the 20th. However from the afternoon of the 20th until the end of the trip fog was persistent and impeded visibility moderately to severely on most days. Figure 11.1 shows the distributions of survey effort, which was spread reasonably well throughout the survey area. Uncorrected sighting rates for each species are shown in Appendix 17.1.

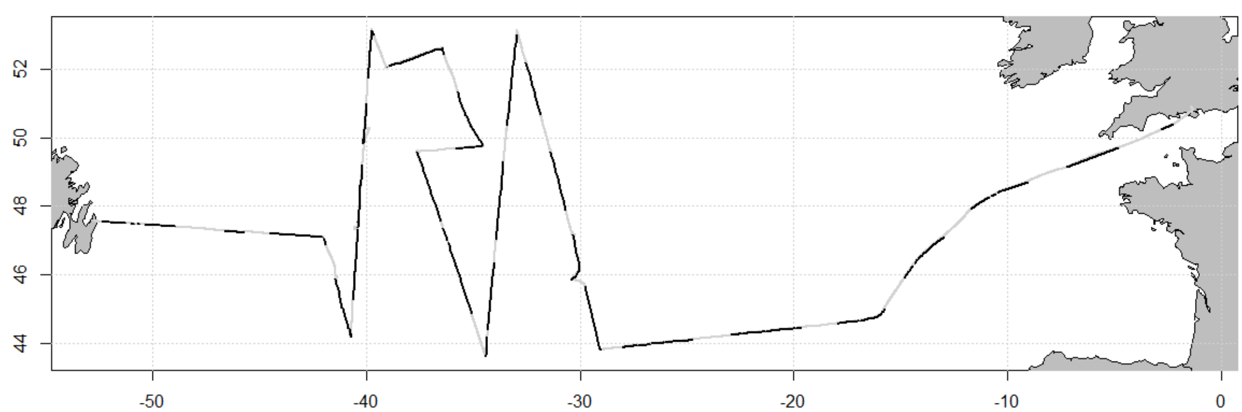

Figure 11.1 Visual seabird survey effort (black) overlaid on the track (grey).

Subjectively, it appeared that there were trends in species distributions both east-west and north south. Procellariiformes were the dominant group seen throughout the trip (Table 11.1), with the possible exception of the shelf west of the Flemish Cap, where alcids appeared in large numbers. European

Storm-Petrel was not seen past the European continental shelf. There appeared to be a change in composition of the three numerically dominant species with water mass: Cory's Shearwaters dominated in warm water, replaced by Great Shearwater in cooler waters, and Northern Fulmars in the coldest and most northerly waters (Figure 11.2). Statistical analysis by Ewan Wakefield will shed light on these apparent trends.

Table 11.1 Raw, uncorrected counts of seabirds, other organisms and trash recorded by seabird observers during underway survey.

Group	Name		Total	
			Overall	In MPA
Birds	Fulmar	*Fulmarus glacialis*	2045	666
	Dark petrel sp.		2	1
	Cory's Shearwater	*Calonectris borealis*	1076	251
	Great Shearwater	*Ardenna gravis*	4353	2665
	Sooty Shearwater	*Ardenna grisea*	181	123
	Small shearwater sp.	*Puffinus sp.*	2	0
	Manx Shearwater	*Puffinus puffinus*	69	9
	Bulwer's Petrel	*Bulweira bulwerii*	1	1
	Storm ptrel sp.	*Hydrobatidae/Oceanitidae sp.*	24	17
	Wilson's Petrel	*Oceanites oceanicus*	11	3
	European Storm Petrel	*Hydrobates pelagicus*	15	0
	Band-rumped Storm Petrel	*Oceanodroma castro*	2	0
	Leach's Petrel	*Oceanodroma leucorhoa*	295	190
	Northern Gannet	*Morus bassanus*	103	1
	Skua sp.	*Stercorarius sp.*	4	3
	Small skua sp.	*Stercorarius sp.*	8	7
	Pomarine Skua	*Stercorarius pomarinus*	4	1
	Arctic Skua	*Stercorarius parasiticus*	5	3
	Long-tailed Skua	*Stercorarius longicaudus*	4	3
	Large skua sp.	*Catharacta sp.*	12	11
	South Polar Skua	*Catharacta maccormicki*	7	6
	Auk sp.	*Alcidae sp.*	5	0
	Puffin	*Fratercula arctica*	104	0
	Guillemot/Razorbill/Brunnichs	*Uria/Alca sp.*	17	0
	Razorbill	*Alca torda*	3	0
	Guillemot	*Uria aalge*	480	1
	Brunnich's Guillemot	*Uria lomvia*	2	0
	Common/Arctic tern		11	2
	Common Tern	*Sterna hirundo*	1	1
	Arctic Tern	*Sterna paradisaea*	24	10
	Kittiwake	*Rissa tridactyla*	7	0
	Large Gull sp.		1	0
	Lesser Black-backed Gull	*Larus fuscus*	3	0

	Herring Gull	*Larus argentatus*	2	0
	American Herring Gull	*Larus smithsonianus*	4	0
	Great Black-backed Gull	*Larus marinus*	2	1
Cetaceans	Cetacean sp.		59	55
	Large cetacean sp.		24	7
	Baleen whale sp.		26	2
	Minke whale	*Balaenoptera acutorostrata*	3	0
	Sei whale	*Balaenoptera borealis*	1	0
	Fin whale	*Balaenoptera physalus*	10	4
	Sperm whale	*Physeter macrocephalus*	3	2
	Common dolphin	*Delphinus delphis*	290	125
	Long-finned pilot whale	*Globicephala melas*	34	21
	Dolphin sp.		3	3
	Risso's dolphin	*Grampus griseus*	10	10
	Striped dolphin	*Stenella coeruleoalba*	55	55
Pinnipeds	Seal sp.		1	0
	Harp seal	*Pagophilus groenlandicus*	1	0
Turtles	Loggerhead turtle	*Caretta caretta*	2	1
Fish	Fish sp.		3	2
	Sunfish	*Mola mola*	13	8
	Flying fish sp.	*Exocoetida sp.*	10	10
Other	Gelatinous sp.		2	0
	Portuguese man o' war	*Physalia physalis*	56	8
	Float barnacle	*Dosima fascicularis*	9	0
	Sargassum weed	*Sargassum sp.*	9	4
	Trash		101	40

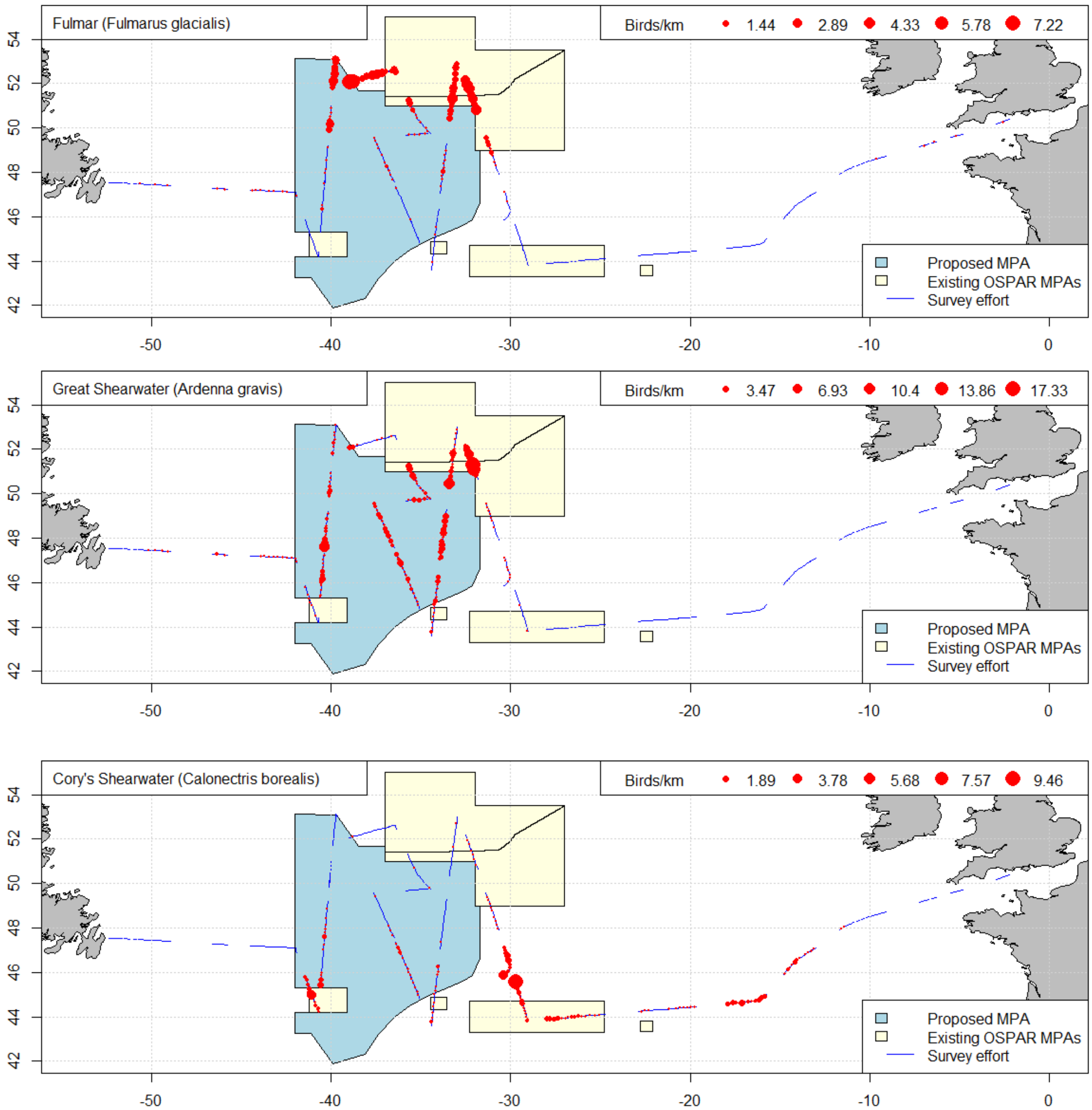

Figure 11.2 Relative, uncorrected, abundance of the three commonest species observed, relative to proposed and existing MPAs.

11.3.2 **Stationary observations**

Stationary observations were made during 14 catching sessions. These data have not been analysed or summarised yet but will be worked up by Ewan Wakefield.

12. Seabird capture and sampling

Ewan Wakefield
University of Glasgow

12.1 Aims and purpose of data collection

In the past, it has been very difficult to determine the diet of pelagic seabirds in remote, oceanic waters. Indeed, there is a general paucity of information on the diet of pelagic seabirds in oceanic waters. What data there come almost exclusively from birds by-caught in fisheries or from lethal sampling by shooting (Brown et al. 1981, Jackson 1988, Shiomi and Ogi 1992, Petry et al. 2008). The latter practice is increasingly regarded as unethical. The aims of seabird capture and sampling during DY080 were firstly therefore, to refine non-lethal methods of sampling seabirds at sea. Secondly, they were to estimate the diet, stable isotope and contaminant loading, faecal nutrient and moult status of seabirds within the study areas, with particular focus on the cephalopod component of seabird diet.

12.2 Methods

The intention was to capture seabirds on lines 2-7, in both the offshore and inshore study areas. In order to capture seabirds we generally hove to in the afternoon (or night for mist-netting), as weather and sea conditions allowed, in some cases back-tracking to aggregations of seabirds noted earlier in the day. Attempts were then made to capture birds using one of the following techniques.

12.2.1 **Cast net, from the back deck**

Birds were attracted to the ship using chum, a mixture of fresh water (40%), fish oil (20%) and ground fish meal (40%) frozen in 10 litre blocks at -80°C. Blocks of chum will be trailed ~5 m from the stern on a light line. This resulted in a thin slick forming downwind. As birds were attracted to the slick, small pieces of horse mackerel were thrown in the water to attract them close under the stern. They were then captured with a hand-thrown cast net (diameter 5 m, mesh size 30 mm), as described by Bugoni et al. (2008) from a height of 4 m above sea level.

12.2.2 **Hoop net, from the Fast Rescue Boat**

The freeboard of the back deck of the *Discovery* is relatively high, making it difficult to deploy a cast net effectively. Hence, it was indented that birds would also be caught from the ship's Fast Rescue Boat (FRB). In the event, sea conditions during the cruise sufficiently quiescent to launch the FRB on only two occasions. On one of these difficulties with the mooring lines, followed by thickening fog meant the FRB could not be boarded by scientists. Therefore the FRB was used only once for bird catching. On this occasion, a chum block of the type described above was deployed, tethered to a free floating buoy, rather than to the ship. The FRB was launched and the chum block and associated slick tracked. Birds attracted to the chum block were then lured closer to the FRB using pieces of horse mackerel. Attempts were then made to capture them using a hoop net (handle length 3 – 5 m, net diameter 0.5 m, mesh size 20 mm) (Adams et al. 2012, Hatch et al. 2016).

12.2.3 **Mist nets**

On two occasions, the sea state and wind speed was sufficiently low to allow the experimental use of mist nets, to target storm petrels. At dusk, while the ship was hove to, a mist net, 2.6 m high and 12 m long, was set on bamboo poles. On the 18th of June it was set up on the port side of the foredeck. On the 20th of June it was set up on the starboard side of the back deck. As far as practicable, the ship's external lighting was turned off. Calls of various storm petrels species (*Hydrobates pelagicus, Oceanodroma leucorhoa,* the *O. castro* complex*, O. monorhis, Oceanites oceanicus, Pelagodroma marina*) were then played for ~3 hours using a 200 watt loud speaker set up behind the mist net. On both occasions, a hand-held spotlight was used in an attempt to guide birds into the net. On the 18th, one bird was attracted sufficiently close to this light to capture it by hand.

12.2.4 Incidental capture

It is common for some species of seabird, especially storm petrels, to alight on ships at night, either on purpose or more commonly accidentally. On several occasions, usually on misty nights during CTD operations, Leach's petrels *O. leucorhoa* found on the ship's decks were caught by hand. It is suspected that they were either attracted to or disorientated by the flood lights above the DTD hanger.

12.2.5 Seabird processing

Once captured using one of the methods described above, birds were transferred in cotton bags to plastic cages (large spp.; L 475, W 236, H 240 mm) in the main hanger or cardboard boxes (L/W/H 300 mm), lined with paper towels, in the wet lab (Leach's petrels), where they were housed temporarily. Cages and boxes were secured to prevent unnecessary motion. In order to reduce distress to the birds and to allow their plumage to dry, these areas were kept quiet, dry and warm.

Birds were processed either to obtain morphometrics, feathers, blood, stomach contents and faeces. Some great shearwaters were temporarily equipped with a GPS tag (see section 13). To reduce stress, stomach samples were not obtained from these birds. Faeces were collected from the cage floors or paper towel linings of boxes using clean plastic scoops. Cages were cleaned thoroughly and paper towels renewed in boxes between birds to reduce the chances of cross contamination of faecal samples. Faecal samples for molecular analysis were stored in absolute ethanol at -80° C in screw-top plastic tubes. Those intended for nutrient analysis and incubation experiments were treated as described in section 9.

Diet samples were obtained by gastric lavage (Wilson 1984, Neves et al. 2006). Birds were be restrained by hand and a plastic catheter was fed slowly down the oesophagus until it reached the base of the stomach (Wilson 1984). A manual enema pump was then be used to pump seawater, at room temperature, into the stomach until it flowed back around the sides of the catheter. The bird was then be inverted over a bucket with the beak held open until regurgitation occurred. When regurgitation appeared complete the neck was massaged gently to remove any items remaining in the oesophagus. Stomach contents were sorted to remove cephalopod remains and to identify any hard parts. Samples were then stored frozen in plastic bags or tubes at -80° C in 70% ethanol.

For larger species, a small amount of blood (<1 ml, i.e. in accordance with ASPA guidelines, < 5 % of total blood volume) was collected either by (1) puncturing the a digital vein using a 25 g needle and drawing the blood up using a capillary tube or (2) for smaller species by, drawing the blood from the ulnar vein in the same manner (Clark et al. 2009). Two drops of each blood sample was stored in absolute ethanol for molecular sex determination and the remainder was air-dried and stored for stable isotope analysis.

Small (<0.5 mm) sections of primary or tail feathers were removed by cutting. If the bird was in primary or tail moult, the section was removed from the base of the youngest actively growing feathers. Otherwise they were taken from the base of primaries 1 and 5. In addition, three breast feathers were removed. All feather samples were stored dry, in paper envelopes.

Moult scores were recorded following Bugoni et al. (2015) and Redfern and Clark (2001). Standard morphometrics, including mass, were measured following Redfern and Clark (2001). In addition, the right wings of great shearwaters and fulmars was photographed against a graduated board to determine wing area and the total wing length and the body girth were measured using a tailor's tape (Pennycuick 1989).

Before release, birds' plumage was checked to ensure it was fully dry. Leach's petrels were generally released the morning after capture, while other species were released the same day. In both cases, birds were released into the air from the starboard side deck after an average of 1.7 h (range 0.5-2.9 h) for great shearwaters and fulmars and 8.2 h (range 1.8-11.4 h) for Leach's petrels.

12.3 Preliminary results

12.3.1 Capture success

In total, 45 birds were captured and sampled (Table 12.1), all of which were released unharmed and apparently in good condition after processing. At total of 19 birds captured were Leach's petrels, caught incidentally (13) or using playback and/or mist nets (6) in the off-shelf study area. The tape lure was very effective at attracting Leach's petrels to the vicinity of the vessel, many of which could be heard calling in response. It was felt that the effectiveness of the mist net was impaired when mounted on the foredeck due to its considerable height above the surface of the sea. Our experience suggests that the combination of a tape lure and powerful spotlight could be an effective means of capturing storm petrels from ships but considerable care would be needed to do this in a manner that reduced the chances of bird colliding accidently with the ship's superstructure.

A total of 26 birds were caught from the back deck, using a hand-thrown cast net. This method was not as effective as when employed from smaller fishing vessels off Brazil (Bugoni et al. 2008), probably for the following reasons: (1) The back deck on the *Discovery* is approximately 4 m above water level, allowing birds considerable time to see the net being deployed and therefore to escape (it was 2 m in the Bugoni et al. study). (2) The bulwarks and guard rail around the *Discovery's* back deck is around 1.3 m, making it difficult to launch the net effectively. This difficulty was further exacerbated when the net was deployed on the port and starboard quarters, where the net caught frequently on bollards, cleats, etc. (3) In all but very quiescent conditions, backwash from waves hitting the stern prevented birds from approaching the ship closely. (4) Birds were encountered in relatively low densities. Despite these difficulties, 26 birds were caught using the cast net. The majority (14) were great shearwaters. Indeed, contrary to prior expectations, these were markedly easier to catch than fulmars (12 of which were caught, in four parts of the off-shelf study area). The latter were attracted by chum in large numbers (flocks of >50 birds) but were wary of approaching the vessel very closely, especially if there was any swell. One great shearwater was caught in the off-shelf study area. The remainder (13) were all caught at the end of the cruise on the Flemish Cap, in the on-shelf study area, where the density of birds was greater. Here it was remarkably easy to catch great shearwaters using the cast net, with two birds sometimes being retrieved in a single cast. Many more great shearwaters could have been caught in this area if time had remained to process them. Other species were attracted to the chum slick, especially south polar and long-tailed skuas but these remained well beyond the range of the cast net.

For the majority of the cruise the sea state was too high to launch the FRC. Moreover, on a number of days when the swell was low enough to launch the boat its use was precluded by fog reducing visibility to unsafe levels. Hence, the FRC was only deployed once for bird catching, on the 18th of June. On that occasion, densities of birds were extremely low so it is difficult to comment on the effectiveness of the technique. A single great shearwater and a flock of four were encountered, both of which could be approached more easily than those encountered by EW in inshore waters of the Gulf of Maine in 2016, using similar techniques (described by Hatch et al. (2016)). These birds readily took bait and one was almost caught to a hoop net. Our experience suggests that hoop-netting from an FRC could be an effective method of capturing petrels in oceanic areas that are more usually quiescent (e.g. at lower latitudes), with higher densities of petrels.

Table 12.1. Summary of bird captures and sampling

Species	Day (June)	Time	Lon	Lat	Method[1]	Holding time (h)	GPS Tag	Sample			
								Feather	Blood	Stomach	Feces
Fulmar	22	21:09	-35.599	51.070	CN	1.8	0	1	1	1	1
	23	19:19	-39.035	52.063	CN	1.9	0	1	1	1	1
	23	19:26	-39.037	52.062	CN	1.3	0	1	1	1	1
	23	22:00	-39.060	52.047	CN	1.4	0	1	1	1	1
	23	22:41	-39.063	52.044	CN	1.2	0	1	1	1	1
	23	22:41	-39.063	52.044	CN	1.5	0	1	1	1	1
	24	21:30	-39.944	51.776	CN	1.3	0	1	1	1	1
	25	16:55	-40.068	50.242	CN	1.3	0	1	1	1	0
	25	16:55	-40.068	50.242	CN	2.4	0	1	1	1	1
	25	19:15	-39.993	50.262	CN	1.0	0	1	1	1	1
	25	19:55	-39.973	50.267	CN	1.7	0	1	1	1	0
	25	22:00	-39.900	50.282	CN	0.5	0	1	1	1	1
Great shearwater	14	19:35	-30.258	47.153	CN	1.5	0	1	1	0	1
	30	13:05	-45.718	47.244	CN	1.0	1	1	1	0	0
	30	13:55	-45.731	47.240	CN	1.3	1	1	1	0	1
	30	15:00	-45.737	47.239	CN	1.6	1	1	1	0	0
	30	15:02	-45.737	47.239	CN	1.2	1	1	1	0	0
	30	15:20	-45.738	47.239	CN	1.8	0	1	1	0	1
	30	15:30	-45.738	47.239	CN	2.2	1	1	1	0	1
	30	15:45	-45.739	47.240	CN	2.5	1	1	1	0	1
	30	16:45	-45.739	47.234	CN	2.1	1	1	1	0	1
	30	16:53	-45.740	47.233	CN	2.5	1	1	1	0	0
	30	16:53	-45.740	47.233	CN	2.9	1	1	1	0	1
	30	17:47	-45.743	47.229	CN	2.2	0	1	1	0	1
	30	18:30	-45.745	47.227	CN	1.8	1	1	1	0	1
	30	18:32	-45.745	47.227	CN	2.0	0	1	1	0	1
Leach's Petrel	14	21:00	-30.223	47.154	IN	9.0	0	1	1	1	0
	17	23:40	-33.417	50.227	IN	6.6	0	0	0	0	0
	18	04:40	-33.548	49.443	IN	1.7	0	0	0	0	0
	19	00:10	-33.919	47.031	MN/PB	5.8	0	1	1	1	0
	18	23:00	-33.919	47.033	IN	7.0	0	1	1	1	1
	19	00:00	-33.919	47.031	SL/PB	6.0	0	0	1	1	0
	20	22:25	-36.409	47.372	HD/PB	11.1	0	1	1	1	1

20	22:30	-36.409	47.373	HD/PB	11.0	0	1	1	1	0
20	22:35	-36.409	47.372	HD/PB	11.4	0	1	1	1	0
20	23:05	-36.409	47.374	HD/PB	11.2	0	1	1	1	0
21	04:50	-36.483	47.525	IN	5.3	0	1	1	1	0
21	05:18	-36.492	47.549	IN	5.2	0	1	1	1	0
21	04:59	-36.486	47.533	IN	5.8	0	1	1	1	0
21	05:24	-36.492	47.551	IN	5.6	0	1	1	1	0
27	23:30	-40.614	45.240	IN	11.0	0	1	1	1	1
27	23:30	-40.614	45.240	IN	11.1	0	1	1	1	1
27	23:30	-40.614	45.240	IN	11.3	0	1	1	1	1
28	00:50	-40.626	45.212	IN	10.1	0	1	1	1	0
28	00:50	-40.626	45.212	IN	10.2	0	1	1	1	0
					Total	10	42	43	29	25

[1]CN = cast net, from the back deck; IN = incidental capture at night, generally in the vicinity of the CTD hangar; MN = mist net, foredeck; SL = hand-held spotlight; HD = capture by hand; PB = playback of storm petrel calls.

12.3.2 Samples obtained and further analysis

Morphometrics, blood, feather and faeces samples were obtained from the majority of birds captured (Table 12.1). Samples will be used for stable isotope analysis (University of Glasgow and University of Manitoba), genetic sex determination (University of Glasgow), genetic diet studies (University of Glasgow) and nutrient analysis (GEOMAR). Stomach contents were obtained by gastric lavage from the majority of birds, the exception being that in order to reduce stress; samples were not obtained from the ten great shearwaters fitted with satellite tags. Stomach contents of Leach's petrels were generally too digested to be readily identifiable but many contained considerable numbers of particles of plastic. These samples will be analysed further using genetic techniques at the University of Glasgow. Stomach contents of fulmars were dominated by Hyperiid amphipods, squid (especially *Gonatus* spp.) and fish. Samples will be analysed further at the University of Glasgow and CEFAS.

13. Seabird GPS tracking

Paloma Calabria Carvalho
University of Manitoba

13.1 Purpose of the data collection

Understanding the distribution and abundance of seabirds in the high seas can elucidate patterns and processes of marine ecosystems in regions of the ocean that are difficult to study. Surveys from vessels offer one method to record bird numbers in the ocean; however, these efforts are often limited in spatial and temporal coverage since vessels often briefly transit through areas of high marine productivity. Alternatively, deployments of tags on marine birds offer the opportunity to track individuals for weeks or months, following their movements independent of vessel schedules or routes. Monitoring the movements and behaviour of seabirds at sea can also be useful for delineating important regions where Marine Protected Areas may be established to enhance the conservation of marine biodiversity.

13.2 Aims

Shearwaters were tracked to quantify their movements, behaviour, and habitat use on the Grand Banks (GB) and along the Charlie Gibbs Fracture Zone (CGFZ). Specific aims were to 1) compare movement rates and habitat use between birds foraging on the continental shelf (GB) vs. those using deep water habitats, 2) assess the relative importance of static (e.g. bathymetric) vs. dynamic (e.g. currents and sea surface temperatures) habitat features, and 3) investigate the connectivity and timing of birds moving between the CGFZ and the coastal areas of Newfoundland.

13.3 Methods

Ten great shearwaters were captured as described in section 12. Satellite-linked GPS devices (PinPoint Argos-120, Lotek; 30×16×14 mm [LxWxH] plus 17cm antenna; 11 g) were deployed attached to the bird feathers either on the tail (n=4) or on the dorsal contour feathers (n=6) using Tesa tape and cable ties (4 inches). Prior to deployment, the tags were attached with epoxy to a plastic base (40x16x1.5 mm) which extended the length of the device to allow for additional attachment points with tape and cable ties (total weight with attachment material ~13 g). Manufacturer software (Lotek; Pin Point Host v. 2.11.2.9) was used to charge and program the tags immediately prior to deployment. This model is capable to collect up to 100 GPS fixes. The schedule for the device was set to collect 2 GPS fixes/day (10:00 and 22:00 GMT) and transmit these data through the Argos satellite system after every 3 GPS fixes. This configuration was estimated to provide approximately 60 days of data per tag.

All tags were deployed on June 30th, 2017 in the Flemish Cap (Table 13.1). This resulted in a total of 459 GPS locations and 363 bird-tracking days (average 45.9 locations and 36.3 days per bird). Tag attachment position (dorsal vs. tail) showed equal average tracking duration for both methods (~36 days) but tail mounted tags recorded fewer GPS fixes than did dorsal mounted tags, mean of 27.5 vs. 58.2 locations per bird.

Table 13.1 Summary of data collected from 10 GPS tags deployed on great shearwaters at 47.236° N, 45.738° W.

Tag ID	Bird mass (g)	Tag/body mass (%)	Attachment position	No. fixes	Days tracked	Start/End dates
170134	675	1.63	Tail	23	34	Jun 30 – Aug 3
170135	815	1.35	Tail	20	24	Jun 30 – Jul 24
170136	770	1.43	Dorsal	62	38	Jun 30 – Aug 7
170137	860	1.28	Tail	42	38	Jun 30 – Aug 7
170138	730	1.51	Dorsal	27	16	Jun 30 – Jul 16
170139	815	1.35	Dorsal	57	32	Jun 30 – Aug 1
170140	760	1.45	Dorsal	53	38	Jun 30 – Aug 7
170141	810	1.35	Dorsal	89	45	Jun 30 – Aug 14
170142	760	1.45	Dorsal	61	47	Jun 30 – Aug 16
170143	770	1.43	Tail	25	51	Jun 30 – Aug 20
Average	777	1.42	All	45.9	36.3	
			Dorsal	58.2	36.0	
			Tail	27.5	36.8	
			Total	459	363	

13.4 Preliminary results

Data were downloaded via the Argos website (https://argos-system.clsamerica.com) as a text file (.txt) and was converted using the software Lotek Argos-GPS Data Processor V3.15 to an ".csv" file which contains the tag ID, date, time (GMT) and coordinates. Data will be further analyzed using GIS software.

The GPS devices transmitted for about a month on average (36 days), which was less than expected (60 days) based on the tag configurations. The shorter duration might be due to attachment method, as GPS devices could have fallen before the end of the life cycle of the device. In addition, attachment position on the bird may have influenced the duration and number of GPS fixes collected by the devices.

Preliminary results suggest distinct foraging strategies between different habitat types (Figure 13.1). While birds remained on the Grand Banks, daily travel distances were shorter and habitat use appears to be concentrated along the continental slope where the shelf transitions to deeper water. Once birds left the continental shelf, individuals dispersed widely showing greater daily travel distances presumably searching for prey that is more patchy and ephemeral in deep water areas. Contrary to predictions, no individuals travelled to coastal regions of Newfoundland during the capelin spawning period.

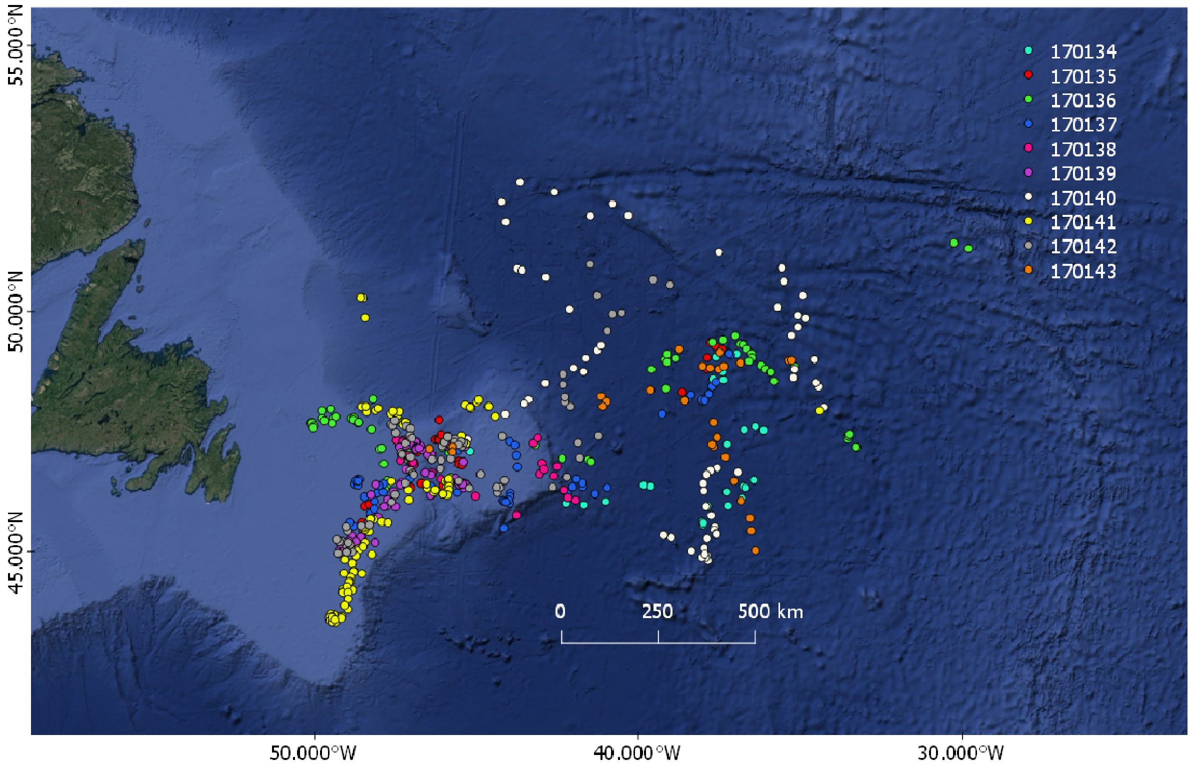

Figure 13.1 GPS locations from 10 Great Shearwaters tracked from the Flemish Cap (47° N, 45° W) between 30 June and 20 August, 2017.

13.5 Estimated total data returns

Total data returns include 459 GPS locations (typically accurate to within 15 m) from 10 birds. Data processing is complete and raw tracking data will be archived with the BirdLife International Seabird Tracking Database (http://www.seabirdtracking.org/).

14. Cetacean survey

Claire Lacey
Sea Mammal Research Unit

14.1 Aims

To estimate the distribution and abundance of cetaceans in the off-shelf study area, centred on the sub-polar front, south of the Charlie Gibbs Fracture Zone (CGFZ), and on transit to and from the ports of embarkation and disembarkation.

14.2 Visual Survey

A visual survey of cetaceans was made using distance sampling methods while the vessel was underway during daylight hours, as weather and sea conditions permitted.

14.2.1 **Platform set-up**

The RRS Discovery is a very stable vessel, and provides an excellent platform from which to conduct visual surveys for cetaceans.

The observer platform was established on the monkey island, directly above the bridge (Figure 14.1). The observers utilised a box which was already in-situ and provided good shelter against the wind. The eye height from the monkey island was approximately 20m, affording a good view, and a distance to horizon of approximately 16km. Due to the shape of the vessel and the location of the observer platform in the very centre of the ship, there was a “blind bubble” estimated to be 5-10m surrounding the ship in which cetaceans would not be visible to observers located on the platform.

Angle boards were mounted on the front of the observer box, and sightings buttons located in the centre of the desk. Distances to animals were estimated using range-finder sticks, which were created for each observer prior to the start of the survey.

The data recorder was located behind the observer box, at the top of the stairwell leading to the bridge deck directly below. This location was indoors, providing good shelter from the wind and rain, whilst also being close enough that the data recorder could take photographs of animals to help confirm species identification when necessary. Communication between the data recorder and the observers was carried out via two-way radio.

Figure 14.1 Observation platform setup on the monkey island of the RRS *Discovery*

14.3 Survey effort

There were four cetacean observers on this cruise – Claire Lacey (SMRU), Nadya Ramirez-Martinez (SMRU), Guilherme Bortolotto De Oliviera (SMRU) and Marguerite Tarzia (Birdlife International). Survey effort was carried out by two cetacean observers at a time, with a third acting as data recorder and the fourth observer off watch. Observers rotated every hour.

Survey activity commenced on 07/06/2017 and continued until 01/07/2017. A total of 3704.39 km and 269h 44m (Table 1) of survey effort was achieved across all transects (Figure 14.2, Table 14.2). A summary of watch hours is included in Appendix 17.2.

Table 14.1 Summary of duration of survey hours conducted per day.

Date	HH:MM:SS of survey completed
07/06/2017	03:49:50
08/06/2017	14:53:36
09/06/2017	04:14:53
10/06/2017	15:17:55
11/06/2017	15:06:52
12/06/2017	14:36:04
14/06/2017	08:04:04
16/06/2017	10:37:35
17/06/2017	15:06:52
18/06/2017	14:27:09
19/06/2017	14:06:43

20/06/2017	15:10:57
21/06/2017	10:11:40
22/06/2017	14:51:33
23/06/2017	12:19:35
24/06/2017	08:27:36
25/06/2017	14:28:28
26/06/2017	14:25:48
27/06/2017	13:06:16
28/06/2017	13:50:35
29/06/2017	12:40:25
30/06/2017	03:43:08
01/06/2017	09:56:56
Total	269:44:40

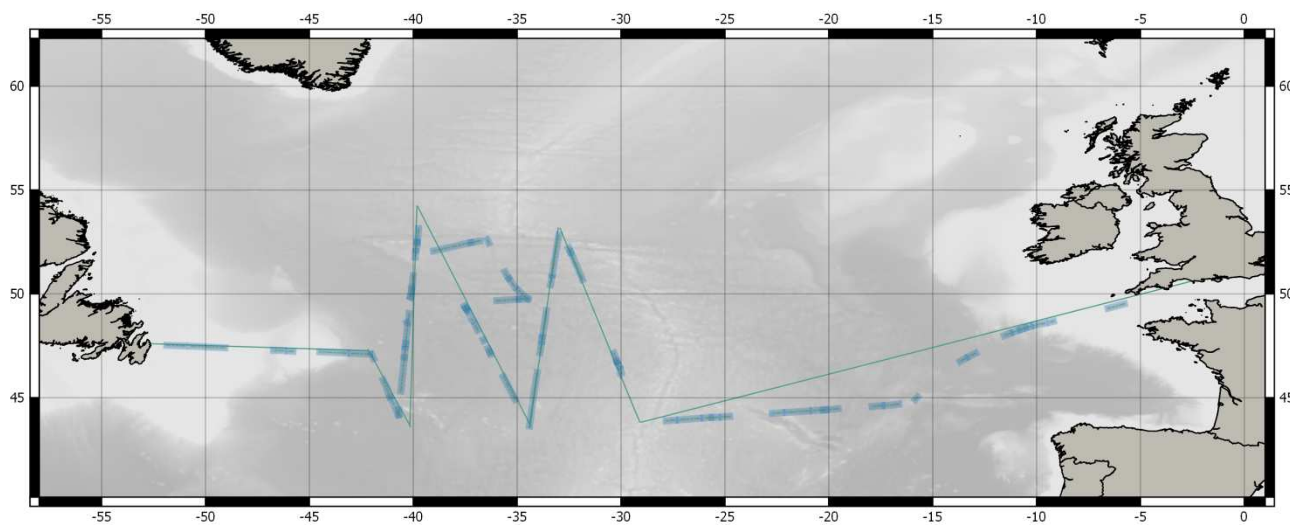

Figure 14.2 Total effort achieved on all survey transects.

Table 14.1 Summary of effort achieved across transects.

Transect name	Designed transect length (km)	Effort achieved	Proportion planned track line covered
1	2213.91	743.19	0.34
2	1074.15	257.79	0.24
3	1071.65	739.76	0.69
4	1238.61	212.19	0.17
5	1177.21	678.34	0.58
6	441.57	213.67	0.48
7	796.79	400.44	0.50
Opportunistic (survey effort conducted when not following predetermined track lines).		459.00	N/A
Total	8013.88	3704.39	0.40

Weather conditions on this survey were relatively poor for collecting marine mammal data. Prior to the start of the survey, conditions in which data would be collected were defined as:

- Vessel underway (speed >6knts)
- Daylight
- Sea state <5
- Visibility >500m

To begin with, this was adhered to however, it soon became apparent that this would likely result in highly reduced data collection. As a result, it was decided that data collection would continue into sea states 5 and 6. The long periods of thick fog also necessitated the collection of data in periods of low visibility; the minimum 500m visibility was discounted and instead data collection continued reduced visibility and the amount of clear water was estimated and recorded. The amount of survey effort conducted in different sea states is shown in Figure 14.3 & Table 14.3.

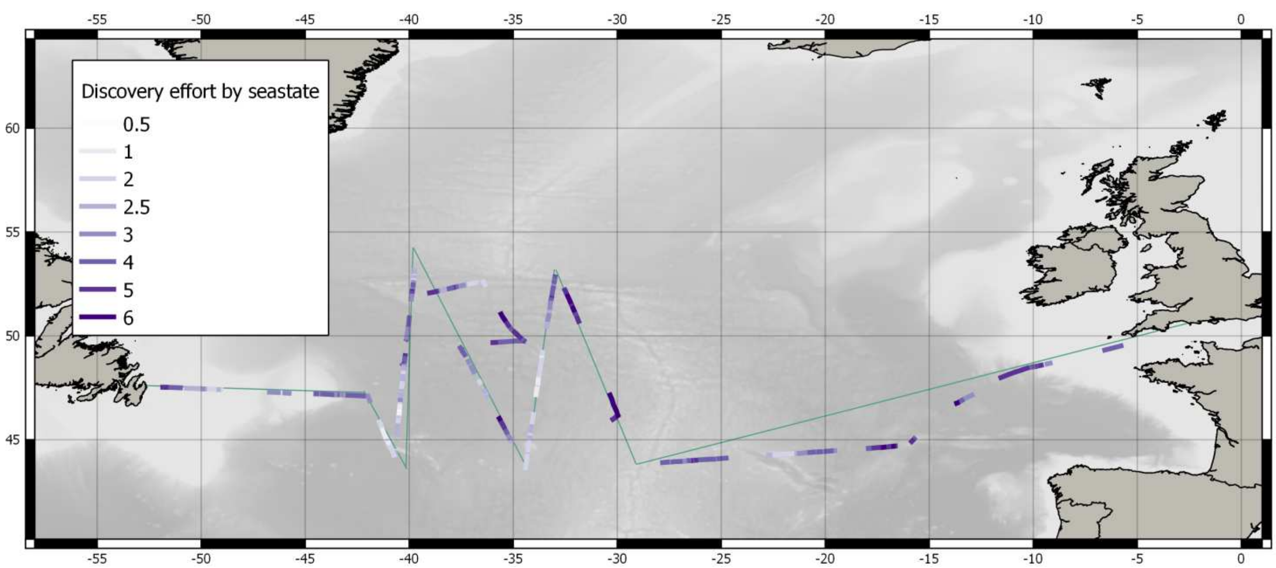

Figure 14.3 Survey effort categorised by Beaufort sea state category

Table 14.2 Summary of percentage survey effort by Beaufort Sea state category. Percentages have been rounded.

Sea state	Effort (%)
≤ 1	5.4
2	20.3
2.5	13.2
3	14.9
4	26.1
5	13.8
6	6.3

In order to take account of visibility as well as sea state, survey conditions were categorised as either Good, Moderate, Poor and Very Poor based on a combination of sea state, visibility and sightability – a subjective assessment made by the observers in real time of the chances of sighting dolphins based on the current weather conditions (Appendix 17.3). The amount of survey effort conducted in different overall conditions is shown in Figure 14.4 & Table 14.4.

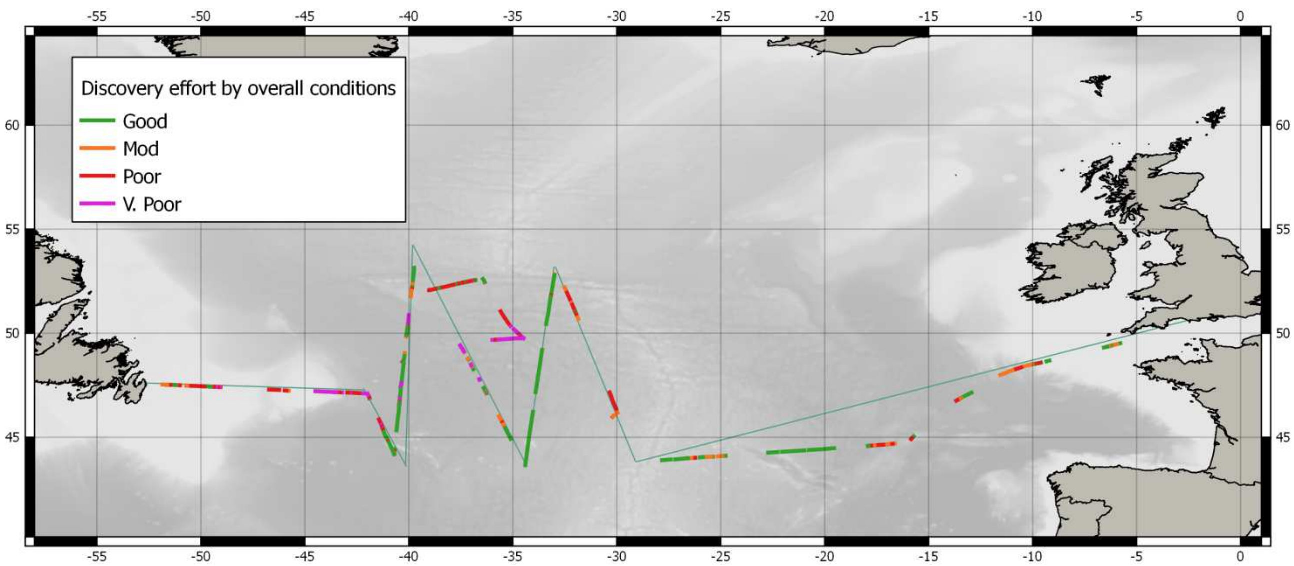

Figure 14.4 Survey effort categorised by overall conditions, taking account of sea state, visibility and sightability.

Table 14.3 Summary of percentage survey effort by overall conditions category

Conditions	Effort (%)
Good	53.6
Moderate	12.1
Poor	22.7
Very Poor	11.7

14.4 Sightings

A total of 250 marine mammal sightings were made whilst on line-transect survey effort, representing 12 species (Table 14.5). The most frequently sighted species was the fin whale, with 39 individual sightings of 70 individuals. Common dolphins and humpback whales were also frequently seen (34 and 37 sightings respectively). There were large numbers of unidentified sightings of both dolphins and large whales. Identification was very difficult in moderate and poor sighting conditions and when groups were seen far away. Photographs were taken and used to confirm species identification wherever possible.

Table 14.4 Marine mammal species seen during line-transect survey across all transects

Species	Number of sightings	Total number of animals
Baleen whales		
Blue whale	5	7
Fin whale	39	70
Sei whale	7	10
Humpback whale	37	40
Minke whale	8	8
Blue, fin or sei whale	46	51
Humpback whale or sperm whale	3	3
Unidentified "large" whale	21	22
Unidentified "medium" whale	2	2
Deep divers		
Sperm whale	7	8
Pilot whale	7	159
Delphinids		
Bottlenose dolphin	1	1
Common dolphin	34	391
Risso's dolphin	1	10
Striped dolphin	3	157
White-sided dolphin	3	28
Patterned dolphin	6	26
Unidentified dolphin	20	109
Grand Total	250	1102

14.4.1 Baleen whales

Blue whales

Five sightings of blue whales were made during the survey, totalling seven individual animals. Three of the sightings were made towards the northern apex of transects 2 and 3 (Figure 14.5).

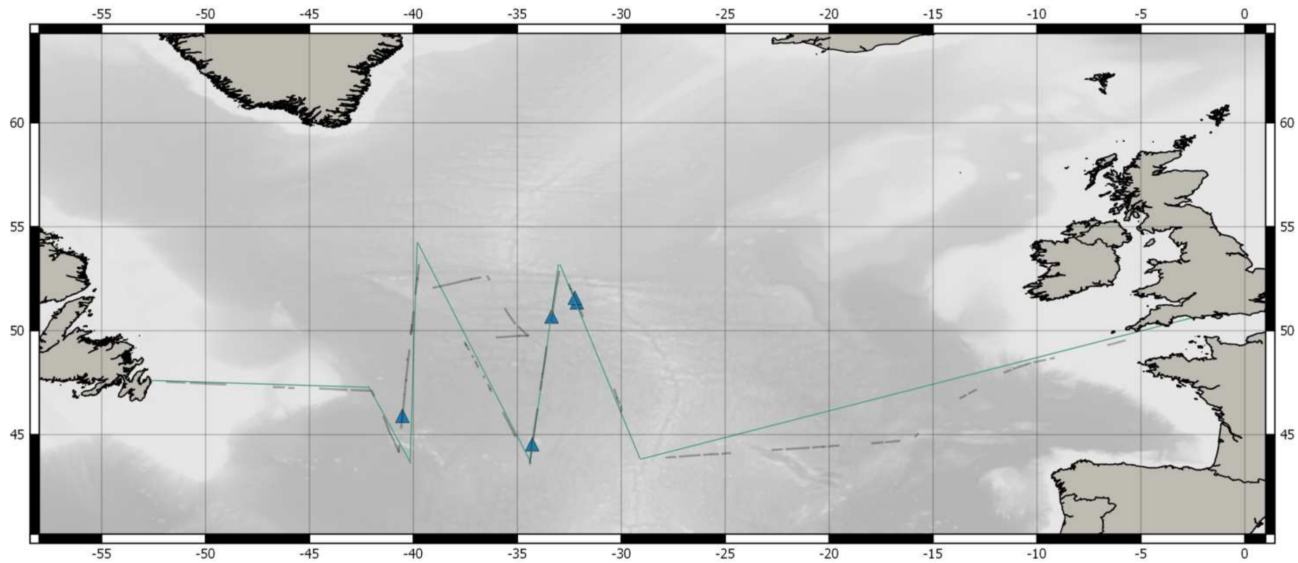

Figure 14.5 Blue whale sightings made during survey effort across all weather conditions

Fin whales

Fin whales were the most commonly sighted species, with a total of 39 individual sightings, comprising an estimated 70 individuals. Sightings were made on all transects (Figure 14.6).

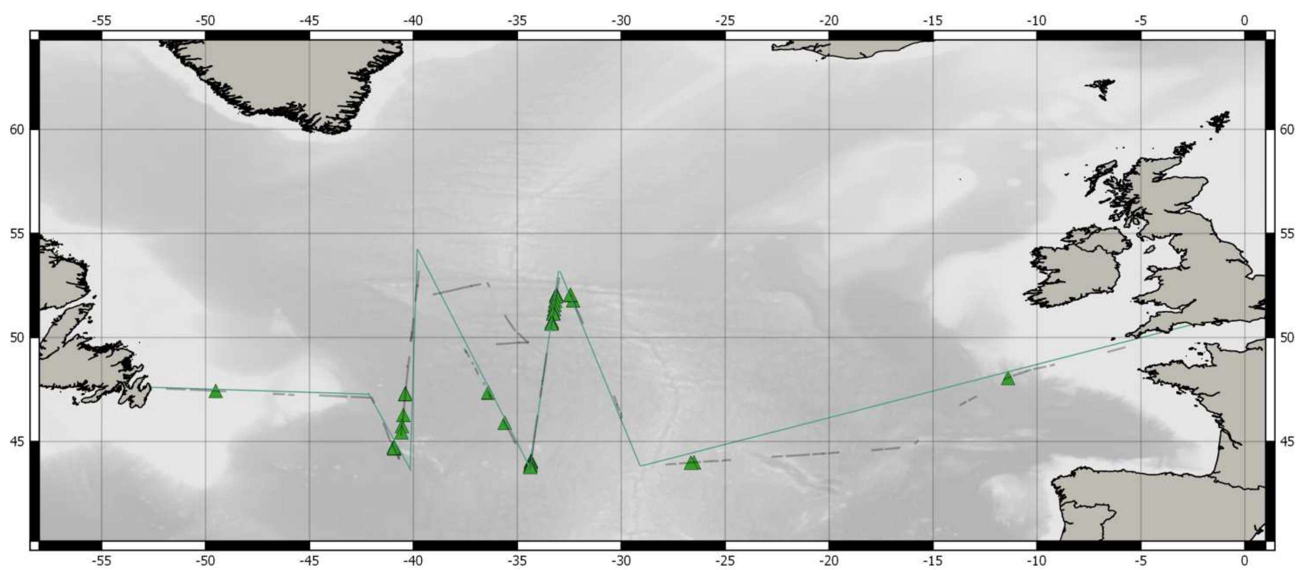

Figure 14.6 Fin whale sightings made during survey effort across all weather conditions

Sei whales

Sei whales were seen on seven occasions, totalling 10 individuals (Figure 14.7). This species can be hard to differentiate from fin whales under sub-optimal survey conditions or if the animal is seen far away.

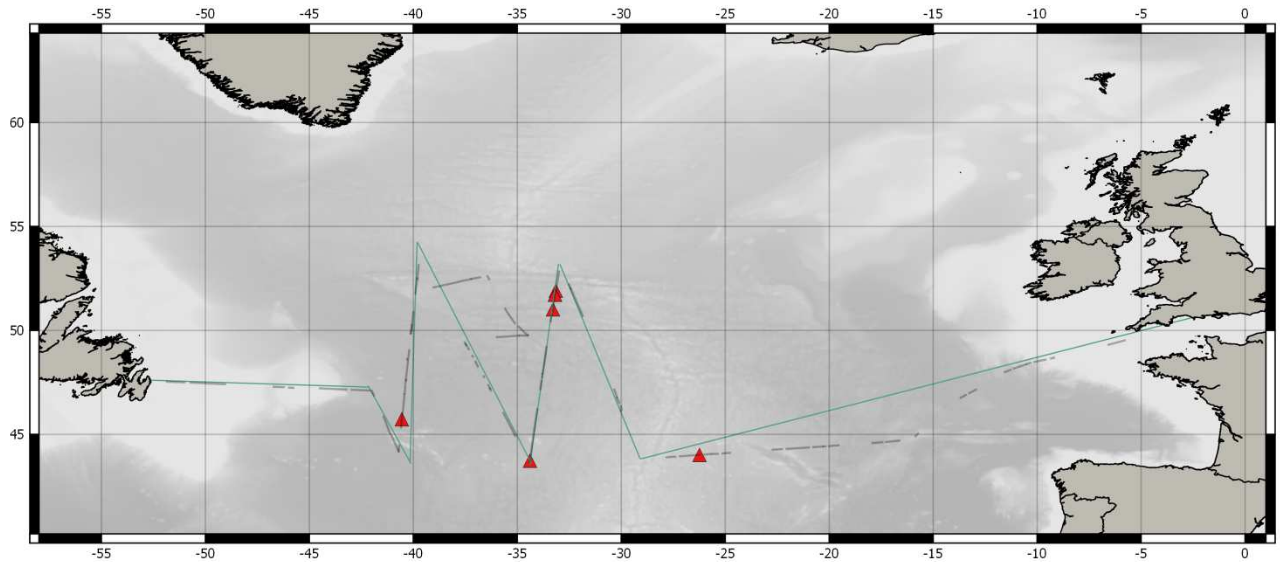

Figure 14.7 Sei whale sightings made during survey effort across all weather conditions

Humpback whales

Humpback whales were also commonly sighted, with a total of 37 individual sightings, comprising an estimated 40 individuals. Sightings were made primarily at the northern end of transect three and the western end of transect 1 (Figure 14.8).

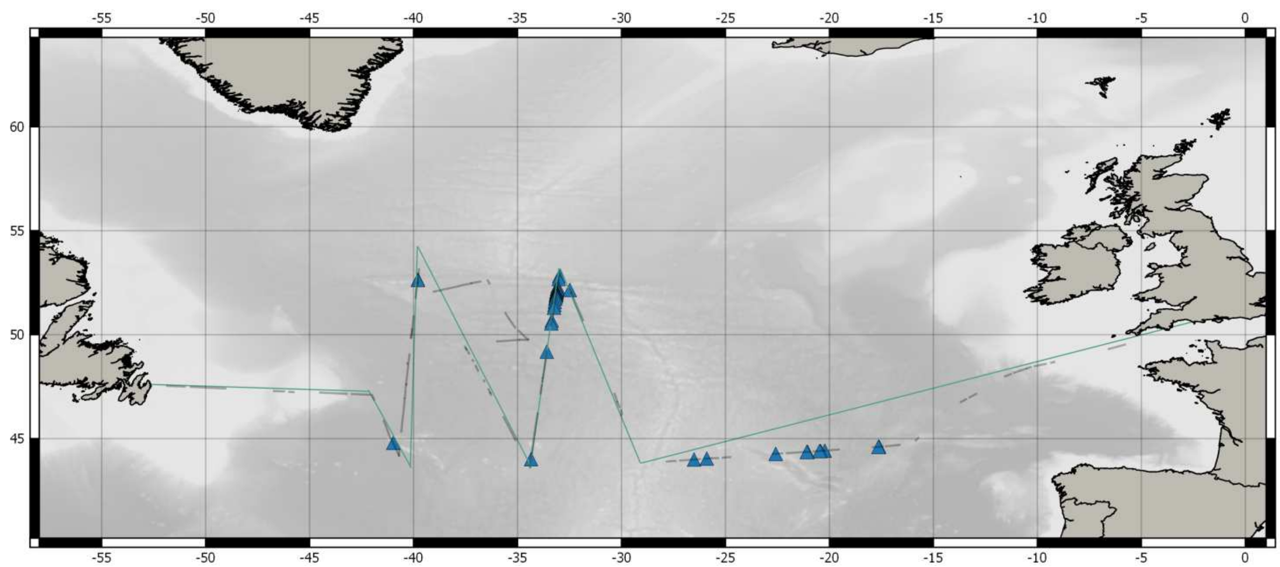

Figure 14.8 Humpback whale sightings made during survey effort across all weather conditions

Minke whales

Minke whales were seen eight times, all sightings of single individuals (Figure 14.9). With the exception of one sightings, all of the minke whales recorded were seen on transect 7, in the shallower waters on the approach to St Johns.

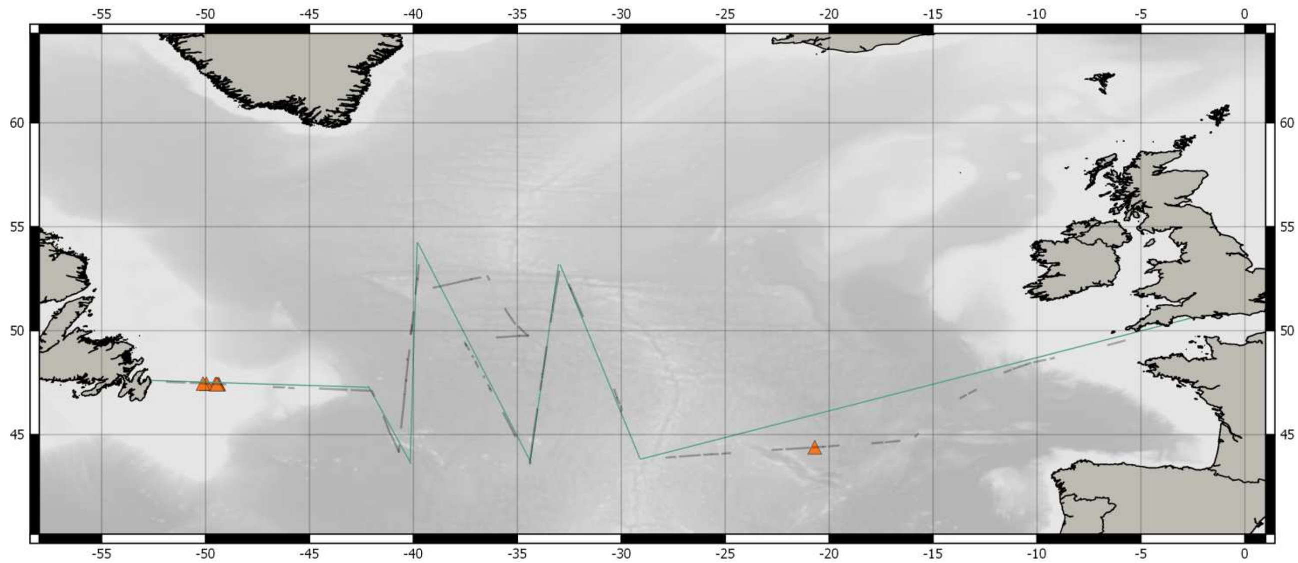

Figure 14.9 Minke whale sightings made during survey effort across all weather conditions

Unidentified whales

There were 72 sightings of 78 individual whales for which it was not possible to ascertain species (Figure 14.10). These sightings were recorded into one of four categories depending on the information available in the field. The categories used are shown in Table 6.

Table 14.5. Categories used to classify unidentified whale sightings

Category	Definition
Blue / fin / sei whale	Large columnar blow. Observer is confident this is a large rorqual whale, but hasn't seen enough to identify which species it is. Confident this isn't a humpback whale or a sperm whale. Body may be seen, but without a good look at the dorsal fin.
Humpback or sperm whale	Smaller, bushier blow or angled blow. Observer is confident this isn't a large rorqual whale, but hasn't seen enough to identify which species it is.
Unidentified large whale	Blow seen, but not possible to tell whether this was a large blow (indicative of large rorqual) or not.
Unidentified medium whale	Glimpse of body seen, little blow information, and no large blow seen. Animal doesn't appear to be large enough to class as a "large" whale. Likely a minke whale, beaked whale or northern bottlenose whale.

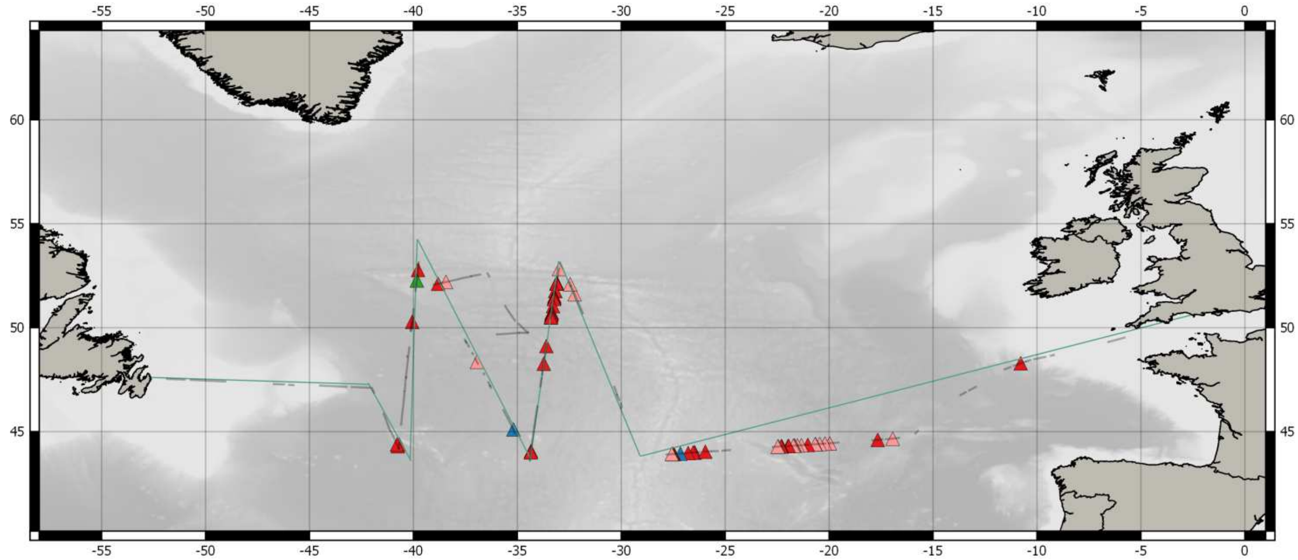

Figure 14.10 Locations of unidentified “Large” whale (pink triangle), unidentified “Medium” whale (blue triangles), blue, fin or sei whale sightings (red triangles), and humpback or sperm whale sightings (green triangle) sightings across all survey transects and in all weather conditions.

14.4.2 **Deep divers**

Sperm whales

Sperm whales were seen on seven occasions (Figure 14.11), primarily as single individuals, but on one occasion as a group of two totalling 8 individuals.

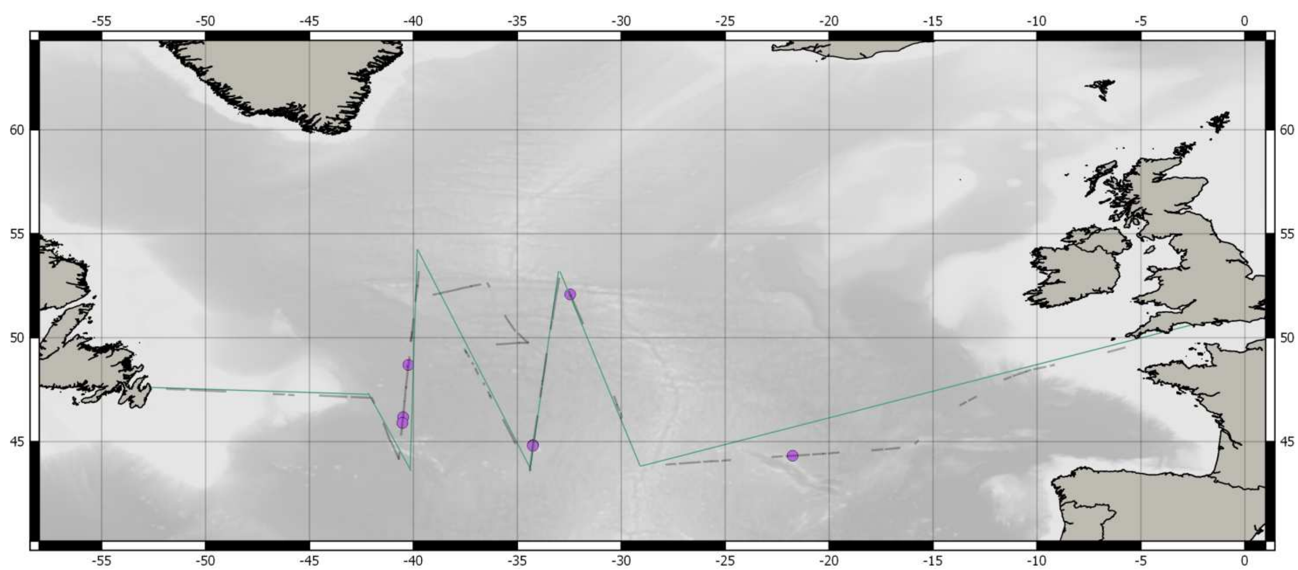

Figure 14.11 Sperm whale sightings made during survey effort across all weather conditions

Pilot whales

There are two species of pilot whale found regularly within the North Atlantic – the long-finned pilot whale (*Globicephala melas*), and the short-finned pilot whale (*G. macrorhynchus*). These two species are separated by morphological differences which are very difficult to distinguish at sea. In general, the study area is inhabited by long-finned pilot whales, with short-finned pilot whales being found primarily to the south of the study area. However, as there is some geographical overlap between the two species, the sightings made on this survey will be classified simply as pilot whales (*Globicephala sp.*).

Sightings of pilot whales during the line-transect survey were made primarily on transect five, although they were also seen once on transect two (Figure 14.12). A total of seven sightings were made of a total of 159 individuals.

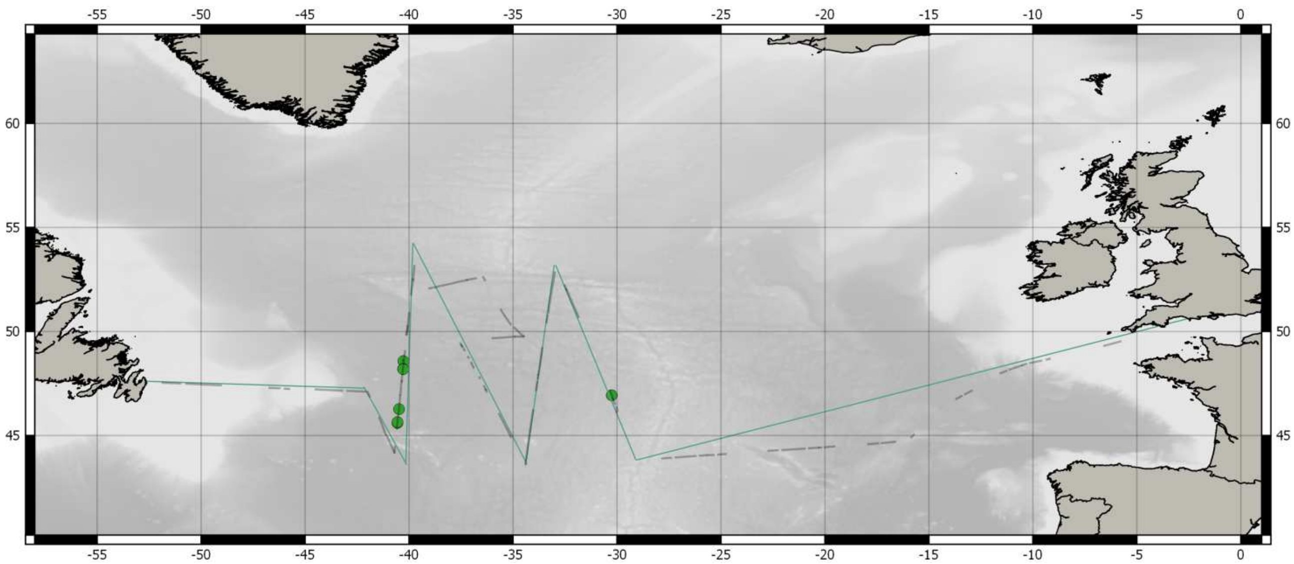

Figure 14.12 Pilot whale sightings made during survey effort across all weather conditions

14.4.3 **Delphinids**

Bottlenose dolphin

Bottlenose dolphins were only seen once during the survey. The sighting was made on transect 1 at the edge of the UK continental shelf (Figure 14.13).

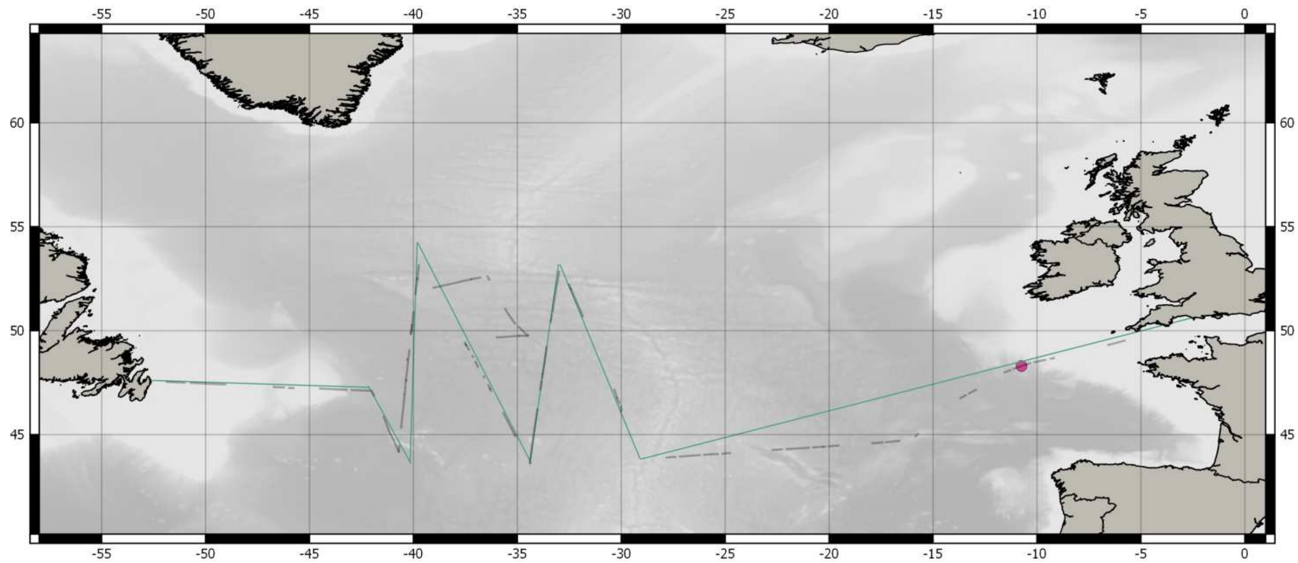

Figure 14.13 Bottlenose dolphin sighting made during survey effort across all weather conditions

Common dolphins

Common dolphins were the most frequently sighted delphinid species, with 34 sightings of 391 individuals. They were seen on all transects except transect 6, and always towards the southern end of the transect lines (Figure 14.14).

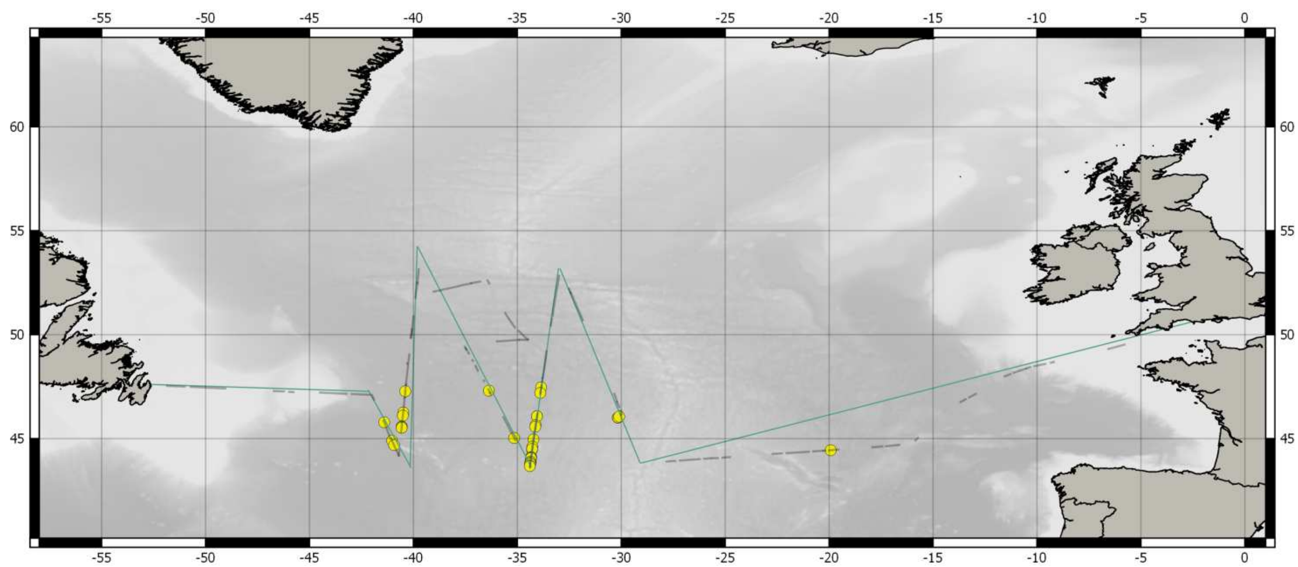

Figure 14.14 Common dolphin sightings made during survey effort across all weather conditions

Risso's dolphins

A single Risso's dolphin sighting was made on transect 5 (Figure 14.15). The best estimate of group size for this sighting was 10 individuals.

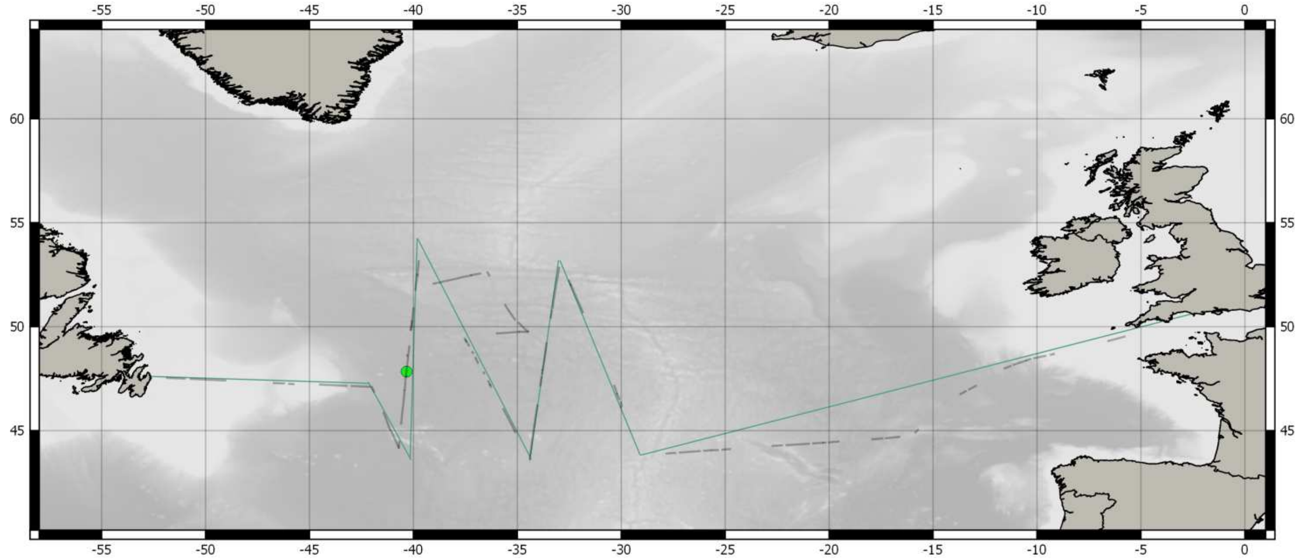

Figure 14.15 Risso's dolphin sighting made during survey effort across all weather conditions

Striped dolphins

Striped dolphins were seen on three occasions, totalling 157 individuals. Sightings were made towards the south-west part of the survey design, on transects 4 and 6 (Figure 14.16).

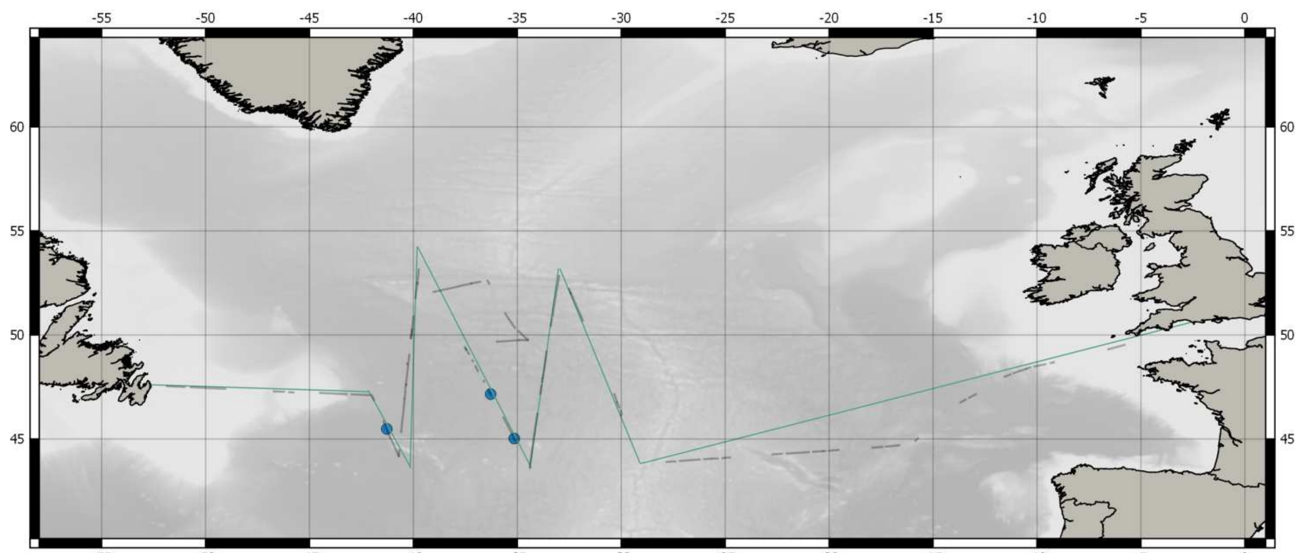

Figure 14.16 Striped dolphin sightings made during survey effort across all weather conditions

Atlantic white-sided dolphins

Atlantic white-sided dolphins were seen on two occasions, both on transect 5 (Figure 14.17). 28 individuals were recorded across the two sightings.

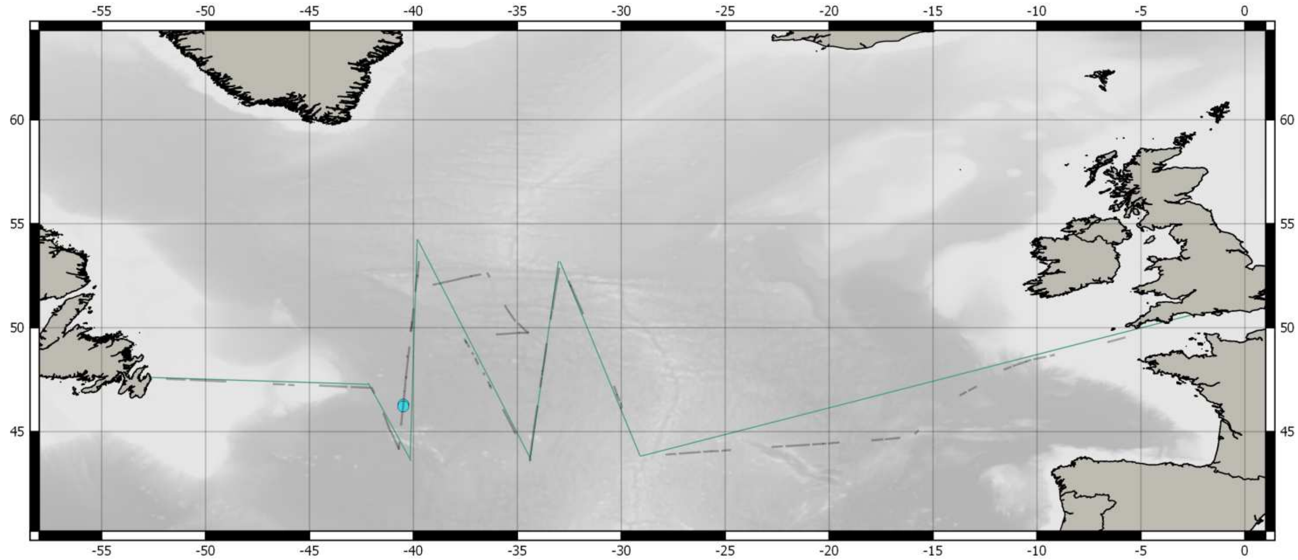

Figure 14.17 White-sided dolphin sightings made during survey effort across all weather conditions

Unidentified dolphins

There were 26 sightings of 135 individual whales for which it was not possible to ascertain species (Figure 14.18). These sightings were recorded into one of two categories depending on the information available in the field. The categories used are shown in Table 14.7.

Table 14.6. Categories used to classify unidentified dolphin sightings

Category	Definition
Patterned dolphin	Dolphin species with colouration – such as striped, common, white-beaked or white-sided dolphins. Observer is confident this isn't a "grey" dolphin – e.g. bottlenose, Risso's, Spinner.
Unidentified dolphin	No species information available at all – could be either a "grey" species or a "patterned" species.

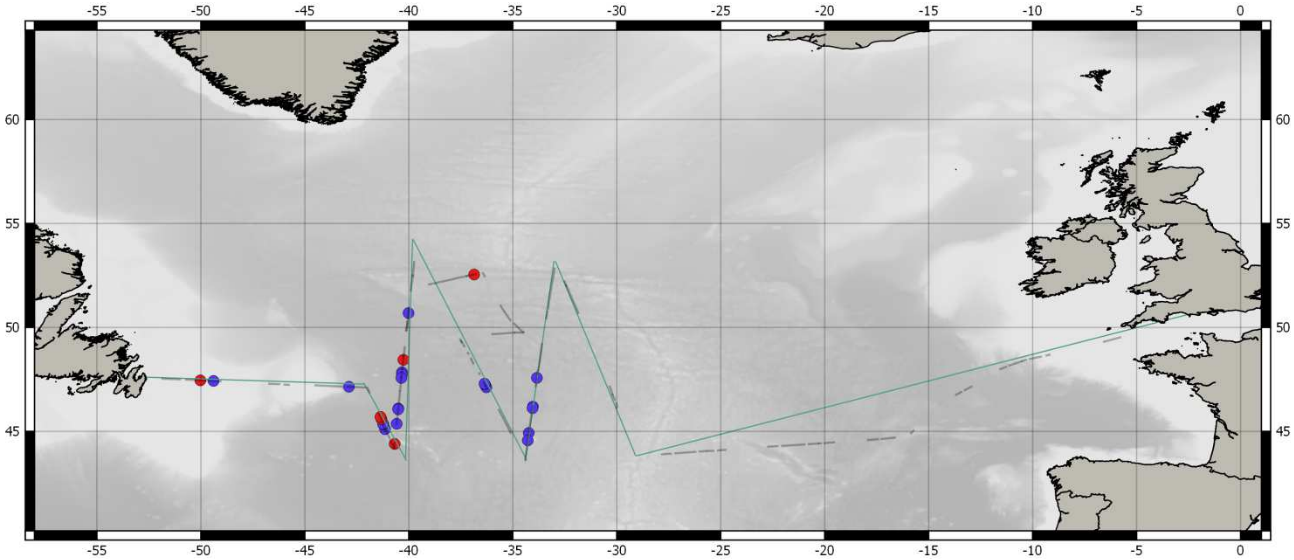

Figure 14.18 Patterned dolphin (red dots) and unidentified dolphin (blue dots) sightings made during survey effort across all weather conditions.

14.5 Point transect survey

At times when the vessel was stationary so that bird catching operations could be carried out, the marine mammal observers undertook point transect observations instead. The locations of these surveys are shown in Figure 19. Surveys were undertaken by one observer, who scanned the 180 degree arc ahead of the vessel. Sightings were reported to a data recorder in the same way as for visual surveys. Point transects were undertaken on 8 different days. A total of 19h 16m point transect data collection were conducted. Daily totals are shown in Table 14.8. Start and end times of watches on each day are shown in Appendix 17.4.

Table 14.7 Summary of point transect effort

Date	Effort (HH:MM:SS)
15/06/2017	02:03:30
16/06/2017	02:02:07
24/06/2017	01:58:16
25/06/2017	01:45:27
26/07/2017	00:57:53
27/06/2017	01:39:55
28/06/2017	01:47:38
30/06/2017	07:01:36
Total	19:16:22

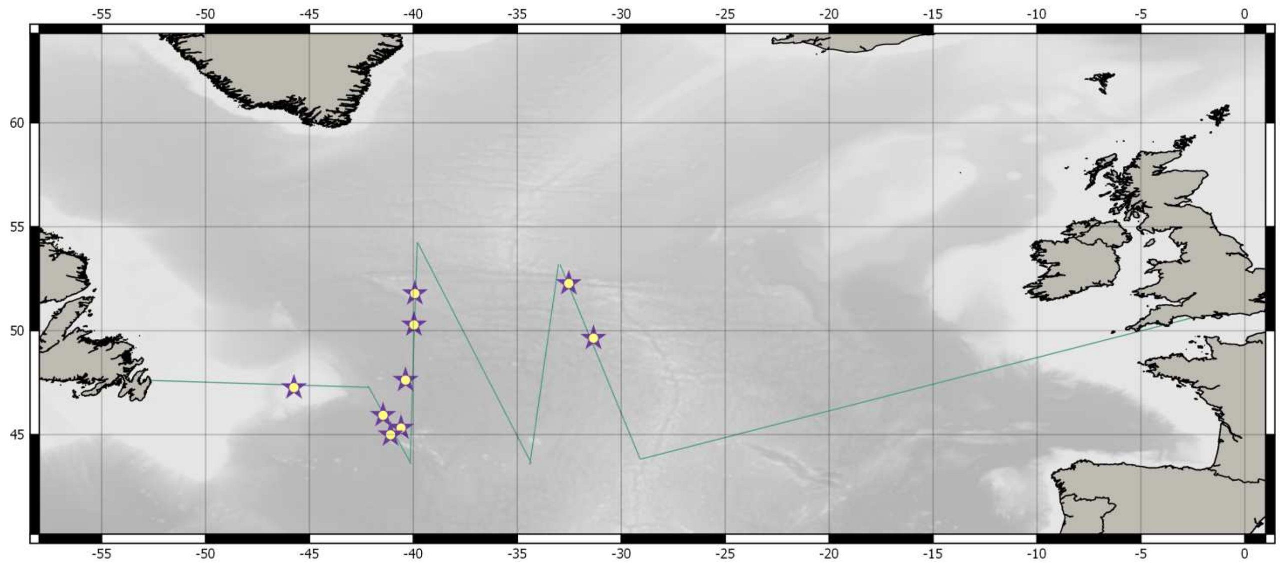

Figure 19 Locations of point transect samples conducted by the marine mammal team during periods when the vessel was stationary.

A total of four marine mammal sightings were made whilst on point transect effort; one sighting of an unknown whale, two sightings of pilot whales, both at the same location, totalling 28 animals and one sighting of 30 unidentified dolphins. The locations of these sightings are shown in Figure 14.20.

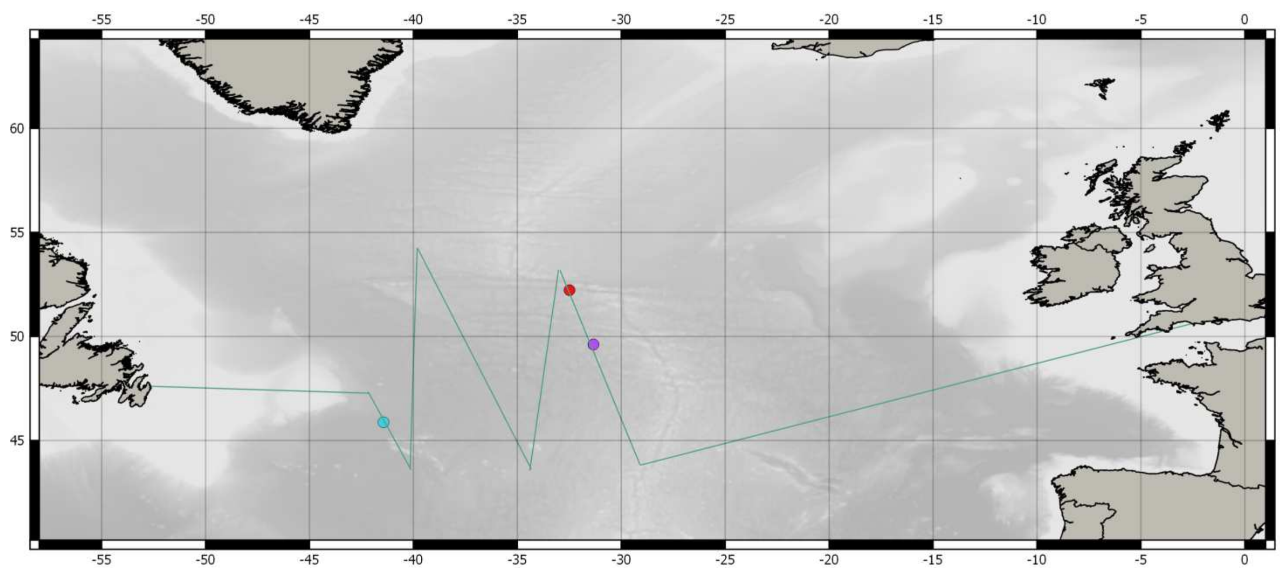

Figure 14.20 Locations of pilot whale (purple dot), unidentified large whale (red dot) and unidentified dolphin (turquoise dot) sightings seen during point transect surveys by the marine mammal team.

In addition to the point transect sampling, it had been hoped that some video tracking of whales would also be possible. This methodology involves using a calibrated video camera mounted on top of some binoculars to accurately track the position of an animal as it moves around the vessel. For this to work successfully, the following things are required:

- Dry weather
- Clear horizon
- Low enough sea state than animal cues can be seen on the video
- Animals in the area

Unfortunately, this set of conditions did not arise on any one occasion and no tracks were possible.

14.6 Acoustic survey

At all times when the vessel was underway and that it was safe to do so, a three element hydrophone array was towed 200m behind the vessel. This array is used for the passive detection of marine mammal vocalisations. The array had three hydrophone elements, with a flat response of 1kHz and above, which is suitable for the detection of odontocete species. Samples were made at a rate of 500 kHz and recorded to hard drive. In excess of 4TB recordings totalling over 361 hours were gathered during the course of the survey. Analysis has yet to take place. A full breakdown of acoustic effort is shown in Appendix 17.5

14.7 Future Analysis

As a minimum, the following analysis is planned for the data collected on the DY080 cruise.

- Line transect survey data will be analysed by Nadya Ramirez Martinez as part of her PhD thesis. This will include producing abundance estimates for the species for which sufficient sightings were made, as well as habitat modelling across the region.
- Acoustic files will be analysed to look for the presence of beaked whales, sperm whales and harbour porpoises within the data. Should there be sufficient data, acoustically-derived abundance estimates will be calculated for these species.
- Marine mammal data collected by the bird survey team and marine mammal data collected by the marine mammal survey team will be compared, and detection rates analysed to see if there are ways in which these methodologies could be improved with respect to one another.
- Opportunities for collaborative work with other partners who collected data on the cruise will also be sought and pursued where possible.

15. Acknowledgements

This cruise was funded primarily by the Natural Environment Research Council via Independent Research Fellowship NE/M017990/1, awarded to Ewan Wakefield. In addition, Tom Browning acknowledges funding from a Marie Skłodowska-Curie Postdoctoral European Fellowship (OceanLiNES; project ID 658035) and supporting financial aid from the European Commission (OCEAN-CERTAIN; project ID 603773). The cetacean survey was undertaken in collaboration with Gisli Vikingsson (Marine and Freshwater Research Institute, Reykjavik, Iceland) and was part-funded by the Marine and Freshwater Research Institute. Paulo Catry acknowledges financial support from Fundação para a Ciência e a Tecnologia (FCT Portugal), provided through the strategic project UID/MAR/04292/2013 granted to MARE. Paloma Carvalho acknowledges funding provided to her doctoral supervisor, Gail Davoren, by Natural Sciences and Engineering Research Council of Canada Discovery (6290-2014) and the University of Manitoba Faculty of Science Fieldwork Support Program.

We would also like to thank the NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS) for supplying data used to plan the cruise; Dagmar Kieke, for generously sharing CTD data collected during cruise MSM-64, which crossed our study area immediately before DY080; and Rob Ronconi, Carina Gjerdrum and Gail Davoren for help in planning and implementing the cruise and for subsequent data analysis.

Finally, we are very grateful to Captain Antonio Gatti, Matt Tiahlo, Dan Comben and the officers and crew of the *Discovery* for making the cruise a success.

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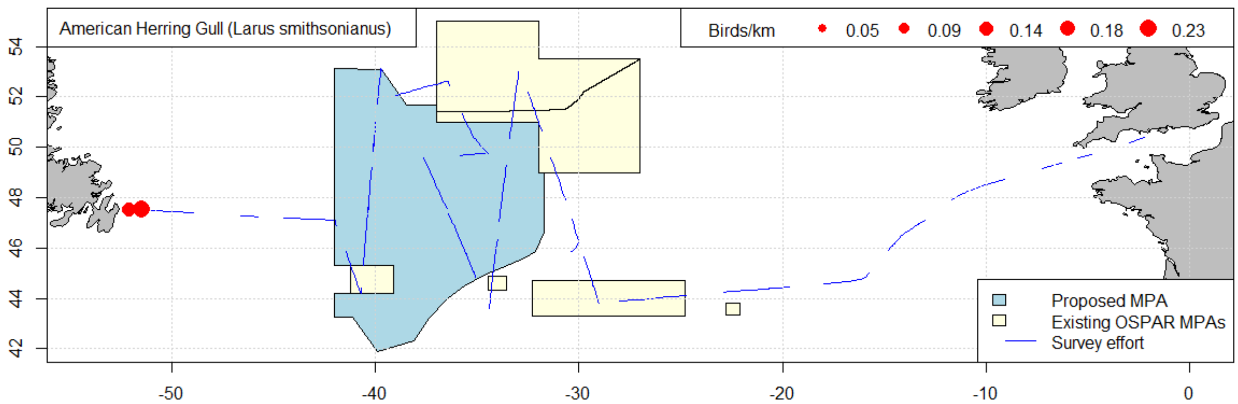
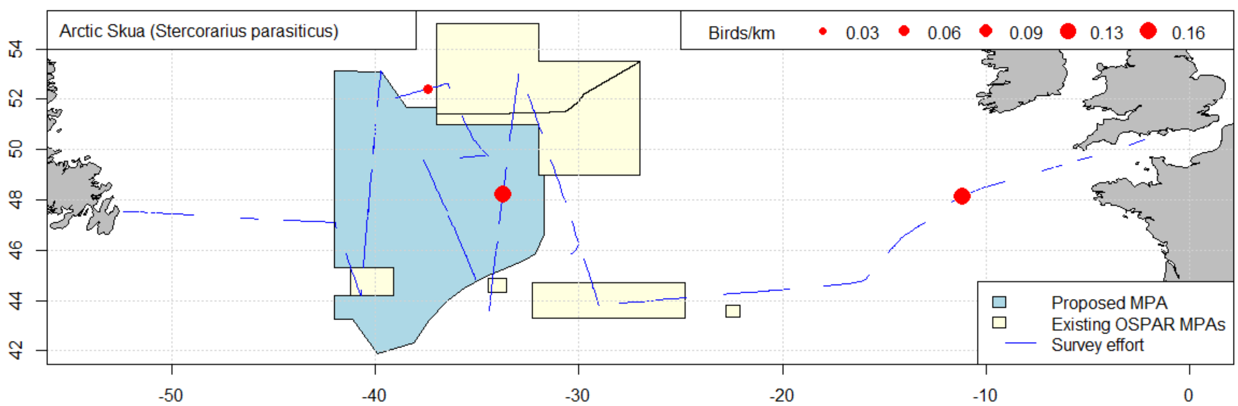
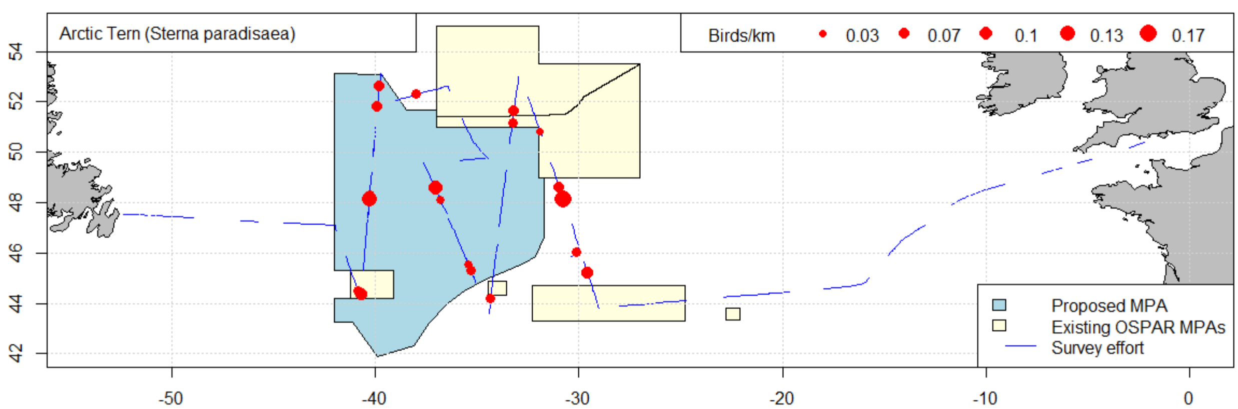
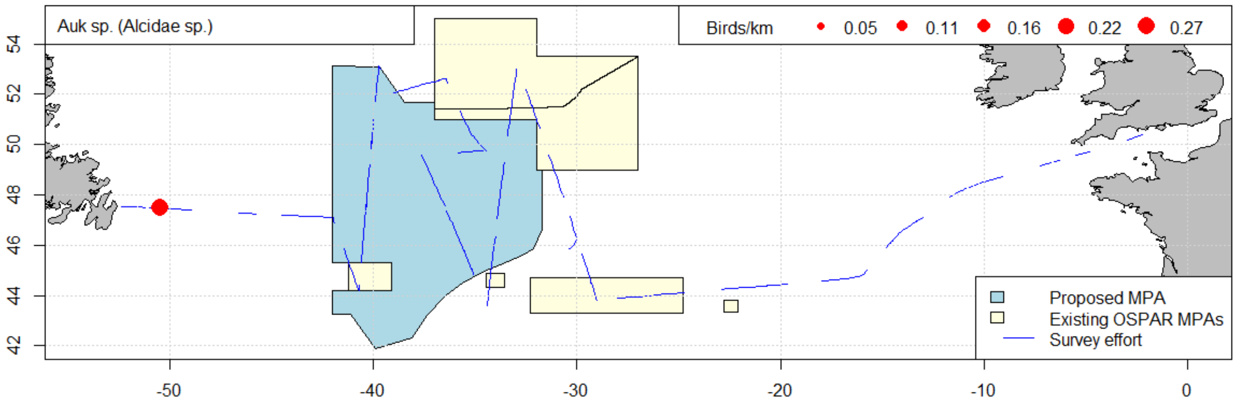
17. Appendices

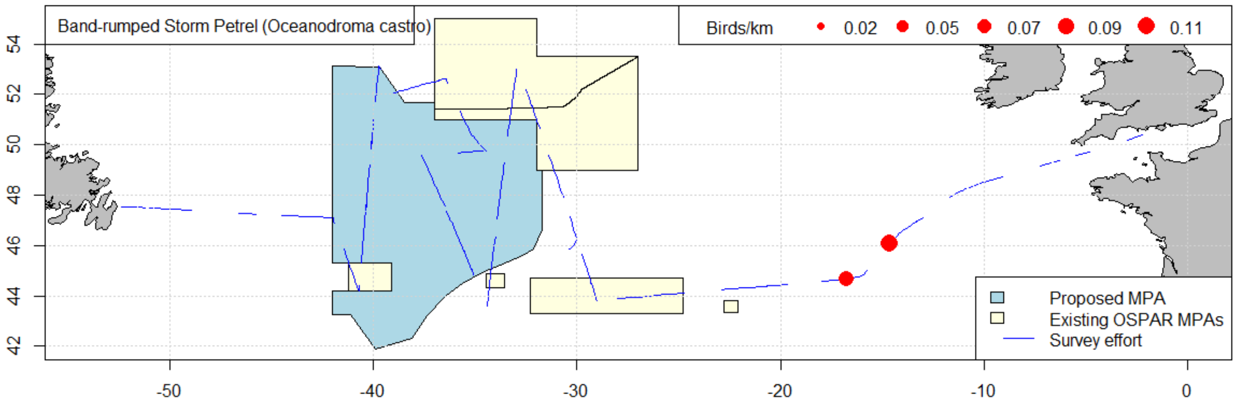
17.1 Appendix: Uncorrected sighting rates of birds, etc., recorded by seabird observers during underway survey

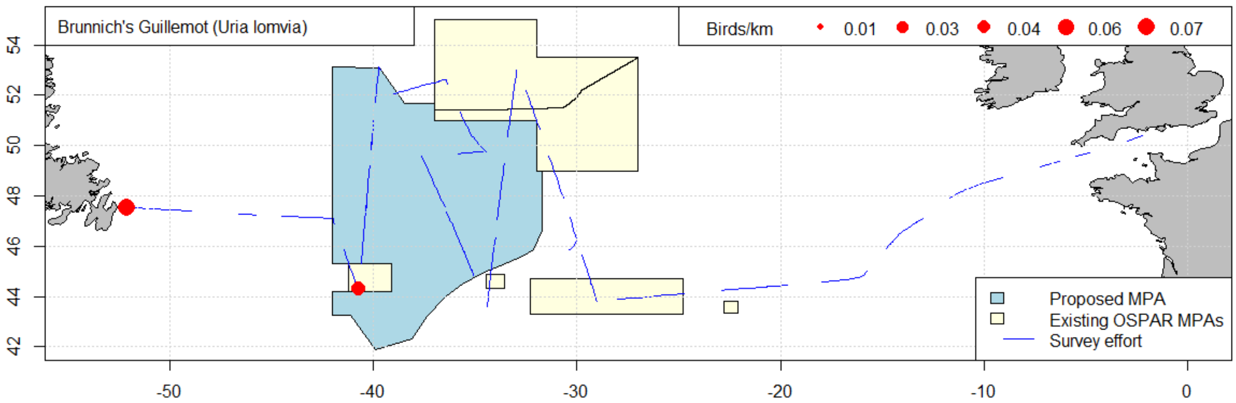







Auk sp. (Alcidae sp.)
Birds/km 0.05 0.11 0.16 0.22 0.27
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0


Band-rumped Storm Petrel (Oceanodroma castro)
Birds/km 0.02 0.05 0.07 0.09 0.11
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0


Brunnich's Guillemot (Uria lomvia)
Birds/km 0.01 0.03 0.04 0.06 0.07
Proposed MPA
Existing OSPAR MPAs
Survey effort
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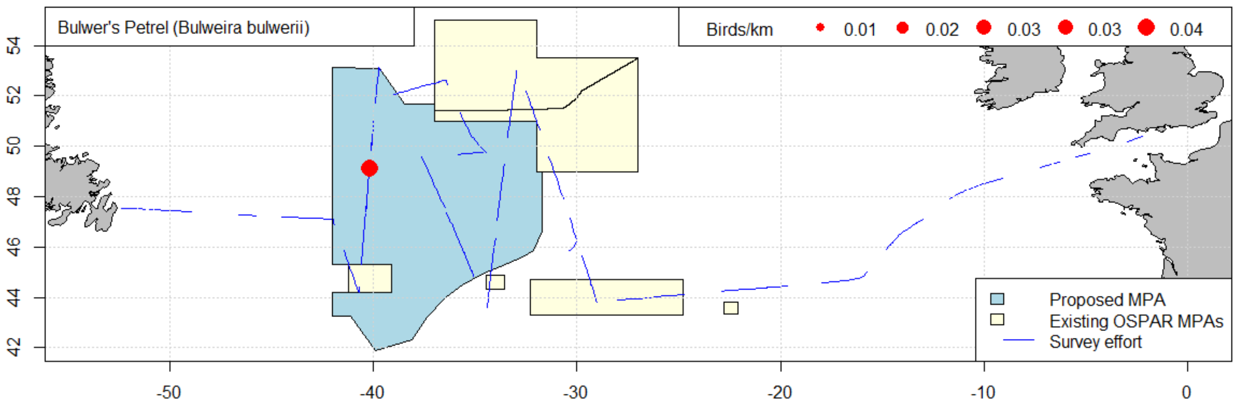
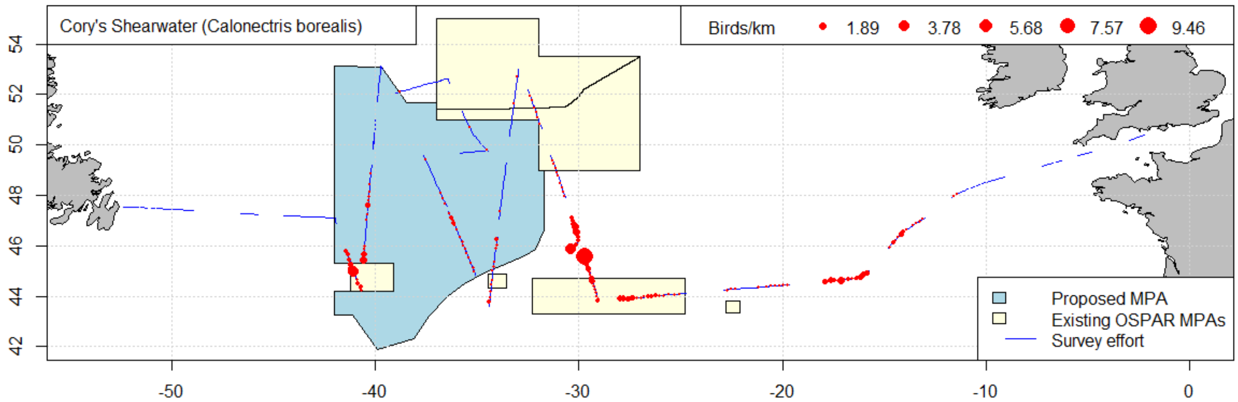
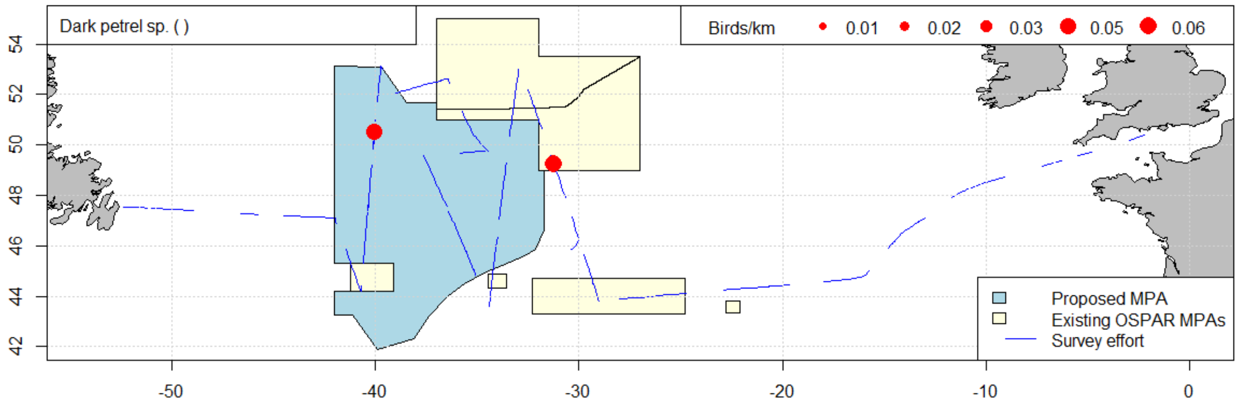
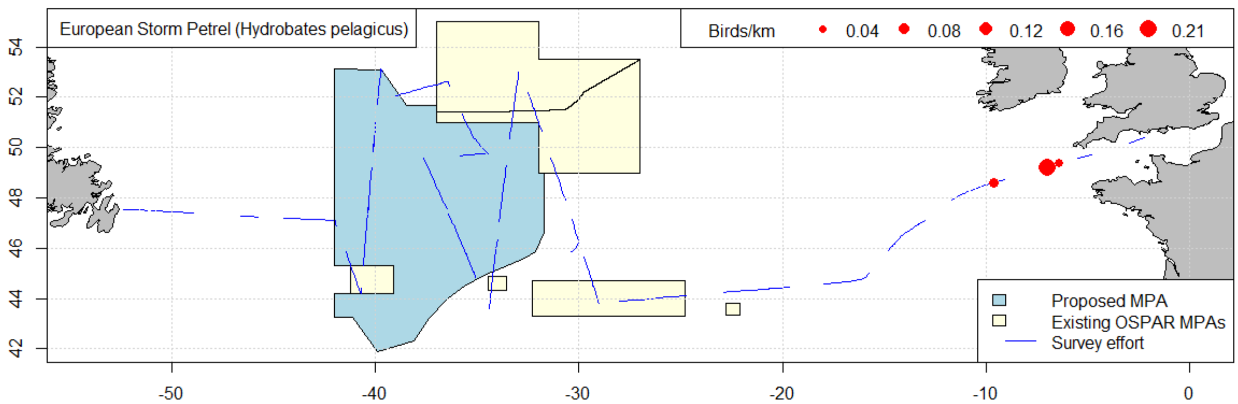
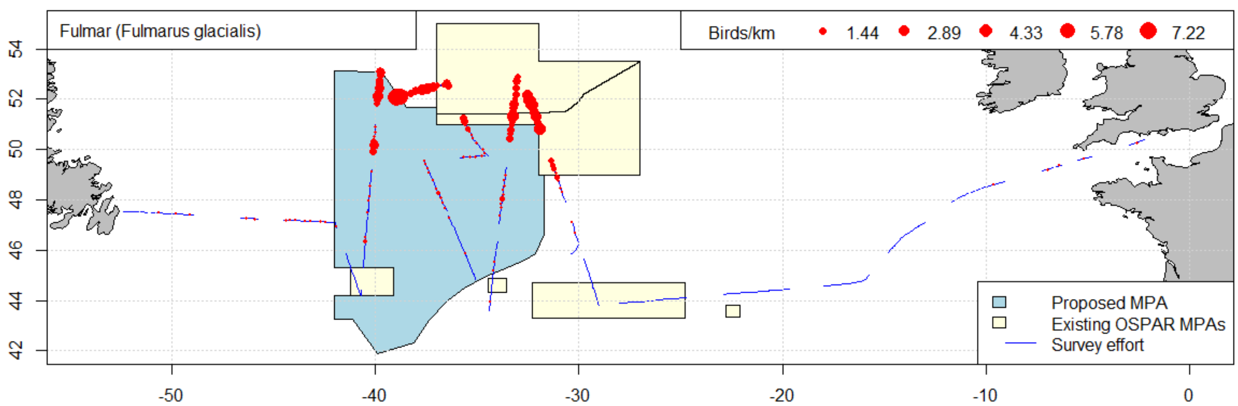
-50 -40 -30 -20 -10 0

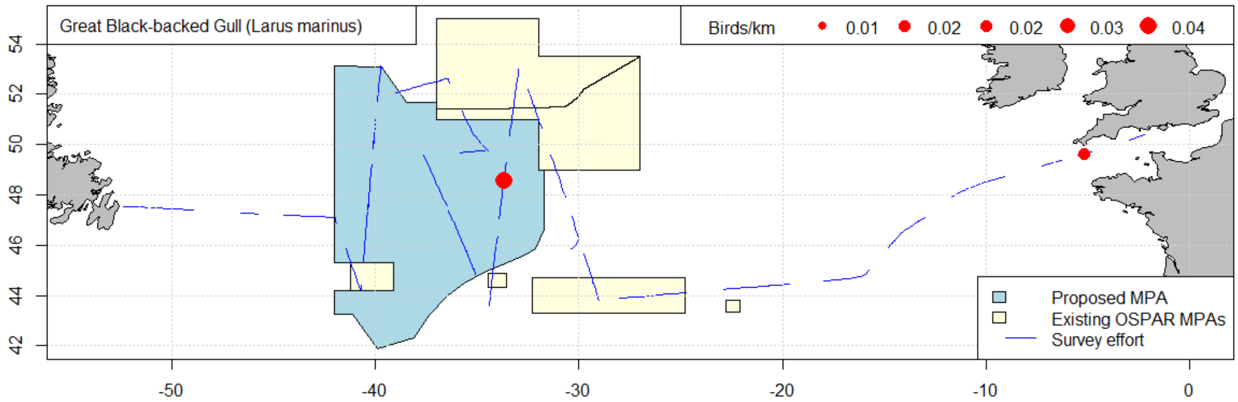

Bulwer's Petrel (Bulweira bulwerii)
Birds/km 0.01 0.02 0.03 0.03 0.04
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

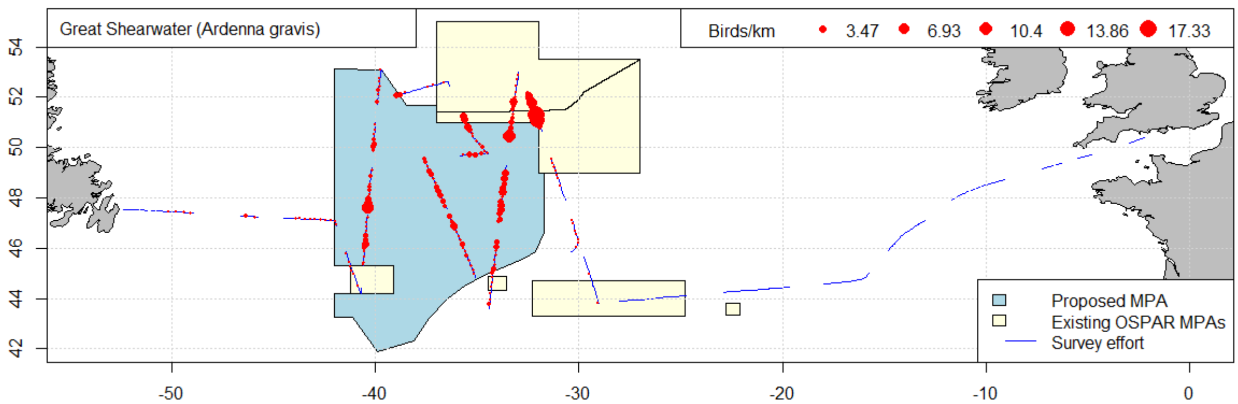

Cory's Shearwater (Calonectris borealis)
Birds/km 1.89 3.78 5.68 7.57 9.46
Proposed MPA
Existing OSPAR MPAs
Survey effort

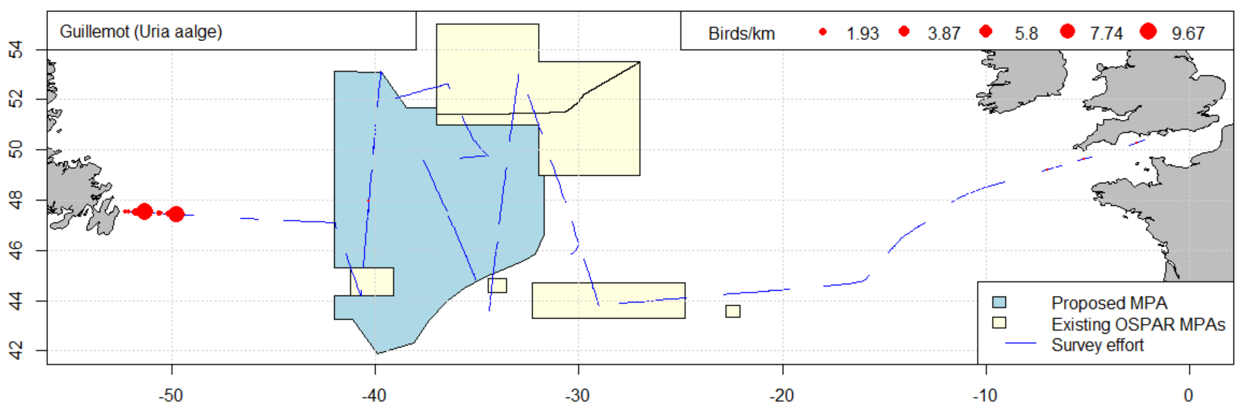

Dark petrel sp. ( )
Birds/km 0.01 0.02 0.03 0.05 0.06
Proposed MPA
Existing OSPAR MPAs
Survey effort

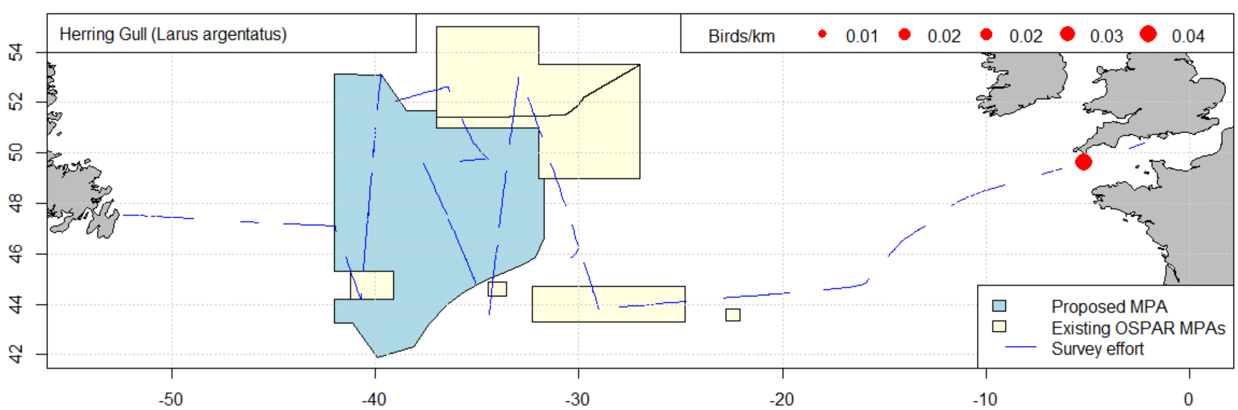

European Storm Petrel (Hydrobates pelagicus)
Birds/km 0.04 0.08 0.12 0.16 0.21
Proposed MPA
Existing OSPAR MPAs
Survey effort

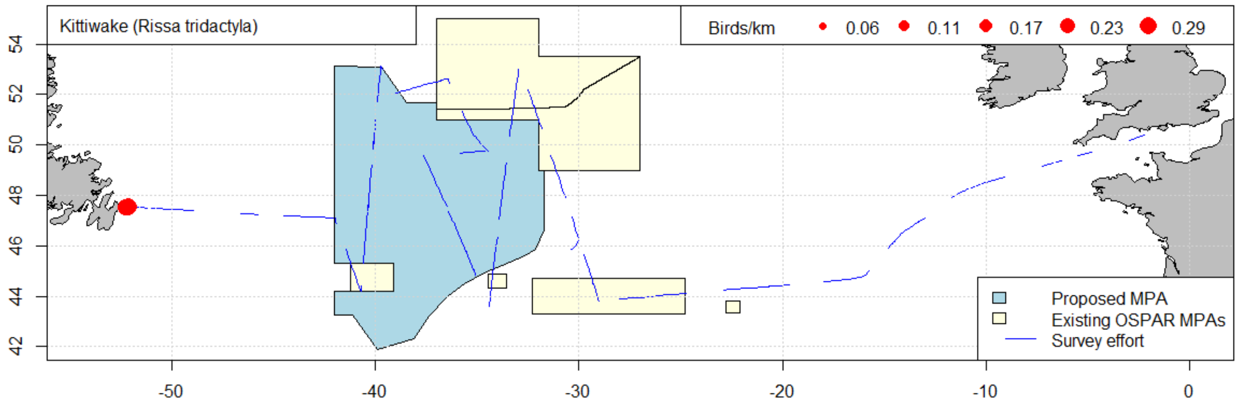

Fulmar (Fulmarus glacialis)
Birds/km 1.44 2.89 4.33 5.78 7.22
Proposed MPA
Existing OSPAR MPAs
Survey effort

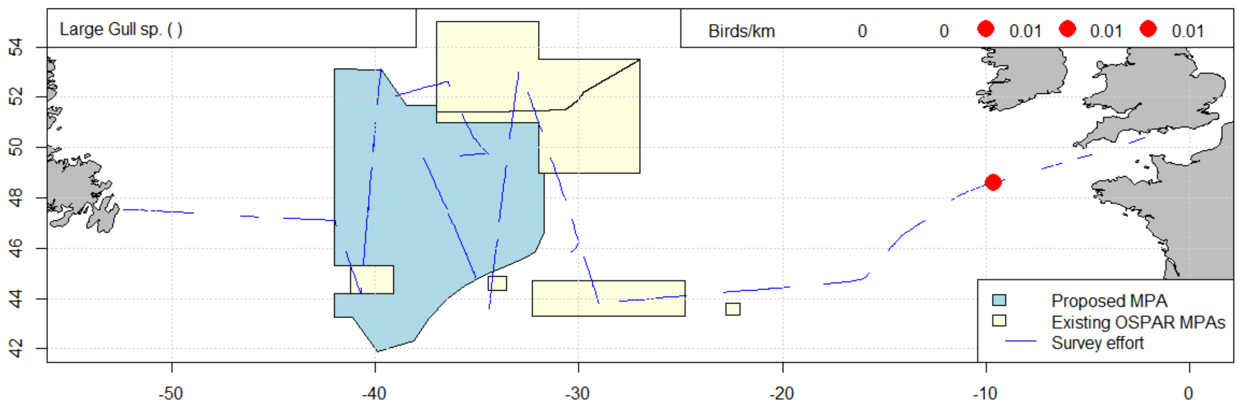

Great Black-backed Gull (Larus marinus)
Birds/km 0.01 0.02 0.02 0.03 0.04
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

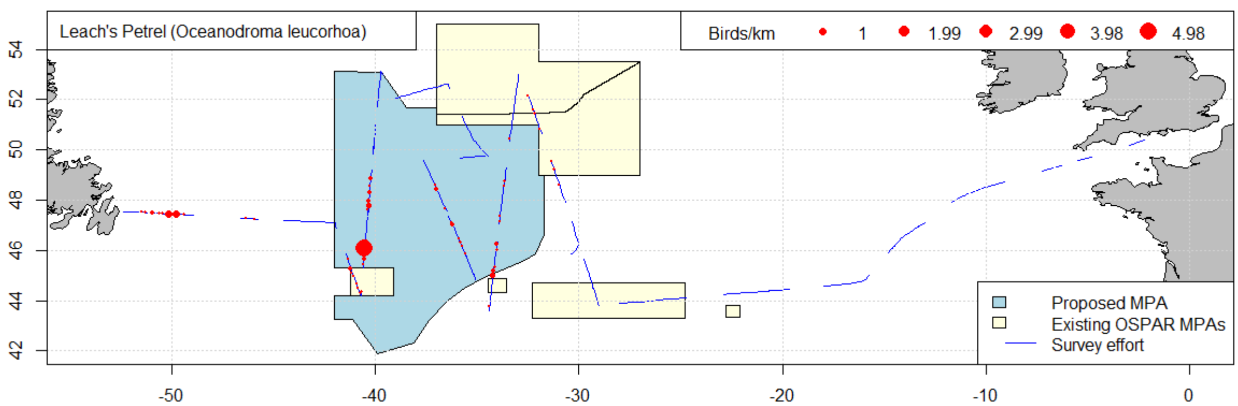

Great Shearwater (Ardenna gravis)
Birds/km 3.47 6.93 10.4 13.86 17.33
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

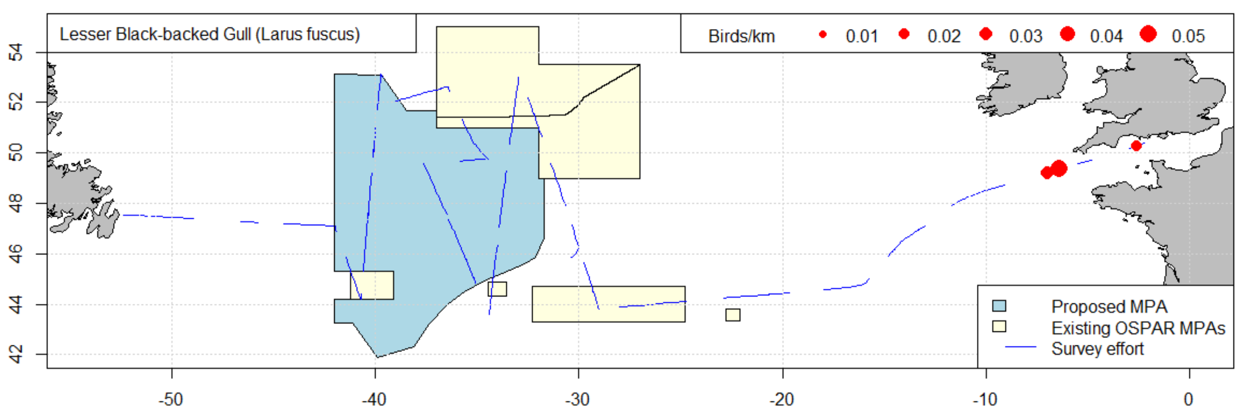

Guillemot (Uria aalge)
Birds/km 1.93 3.87 5.8 7.74 9.67
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

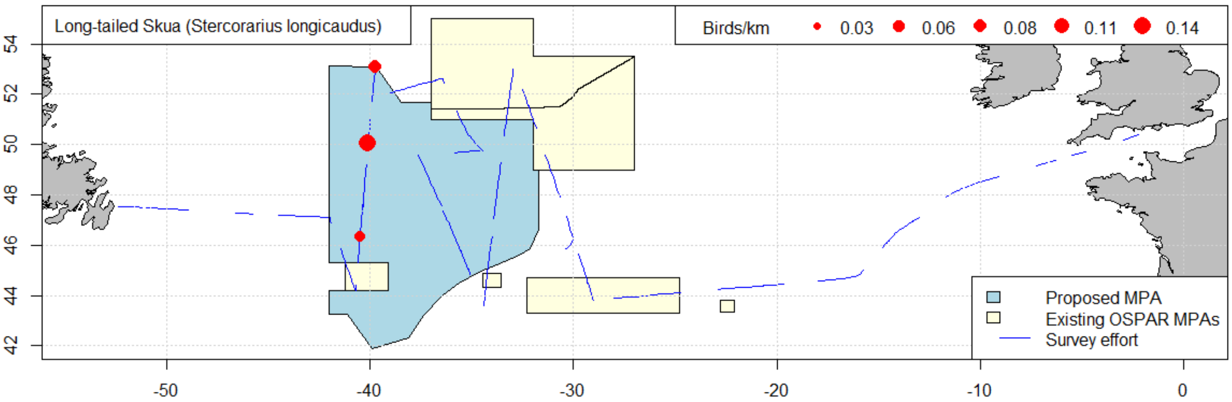

Herring Gull (Larus argentatus)
Birds/km 0.01 0.02 0.02 0.03 0.04
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

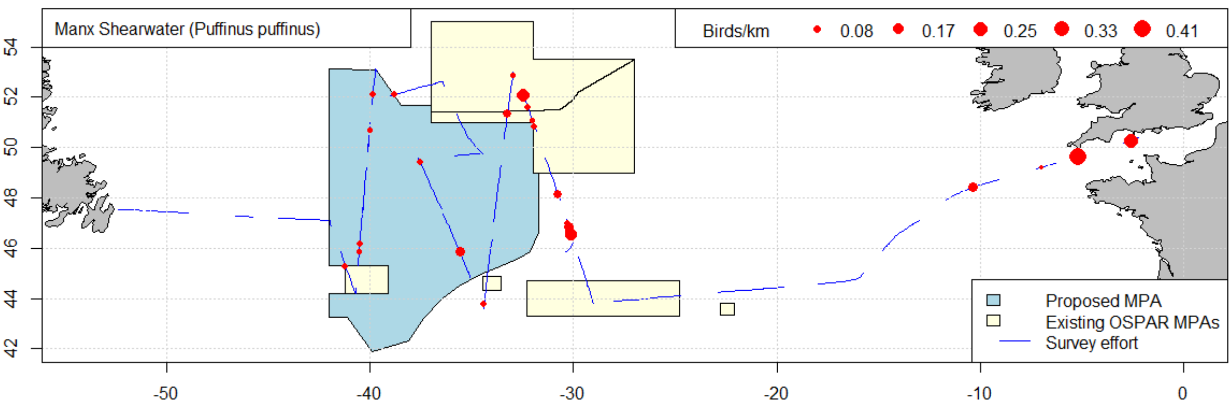

Kittiwake (Rissa tridactyla)
Birds/km
0.06
0.11
0.17
0.23
0.29
Proposed MPA
Existing OSPAR MPAs
Survey effort
54
52
50
48
46
44
42
-50
-40
-30
-20
-10
0

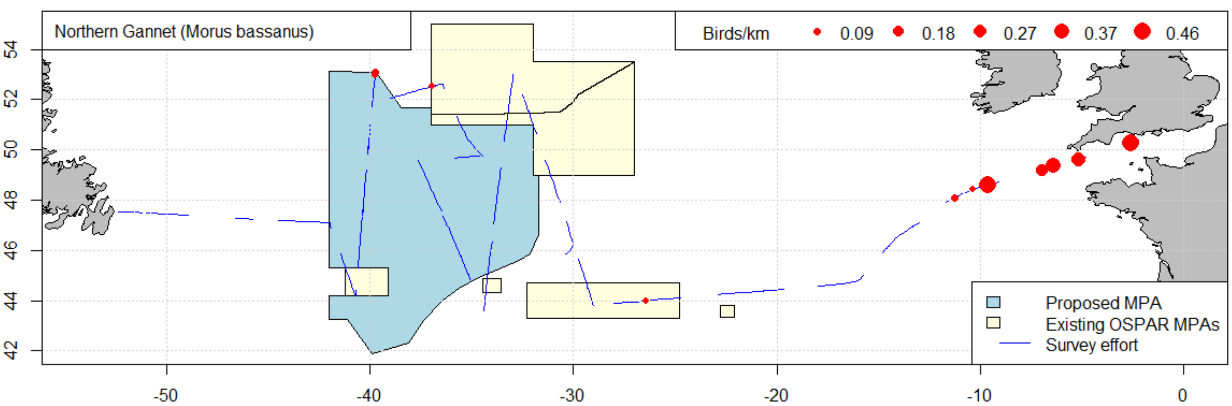

Large Gull sp. ( )
Birds/km
0
0
0.01
0.01
0.01
Proposed MPA
Existing OSPAR MPAs
Survey effort
54
52
50
48
46
44
42
-50
-40
-30
-20
-10
0

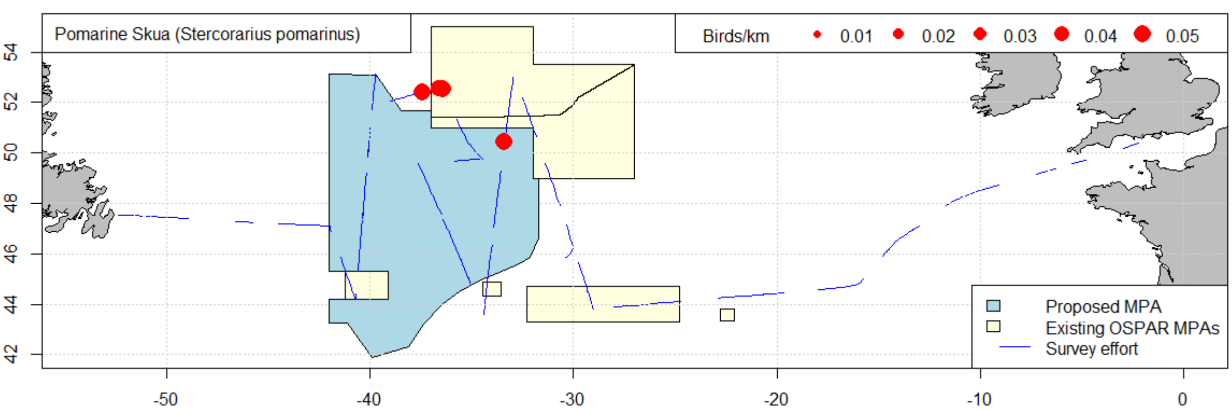

Leach's Petrel (Oceanodroma leucorhoa)
Birds/km
1
1.99
2.99
3.98
4.98
Proposed MPA
Existing OSPAR MPAs
Survey effort
54
52
50
48
46
44
42
-50
-40
-30
-20
-10
0

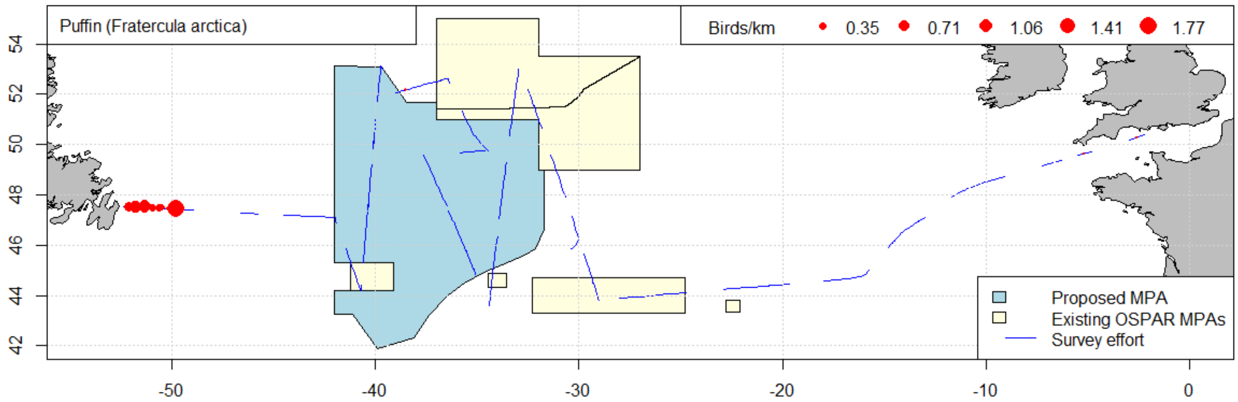

Lesser Black-backed Gull (Larus fuscus)
Birds/km
0.01
0.02
0.03
0.04
0.05
Proposed MPA
Existing OSPAR MPAs
Survey effort
54
52
50
48
46
44
42
-50
-40
-30
-20
-10
0

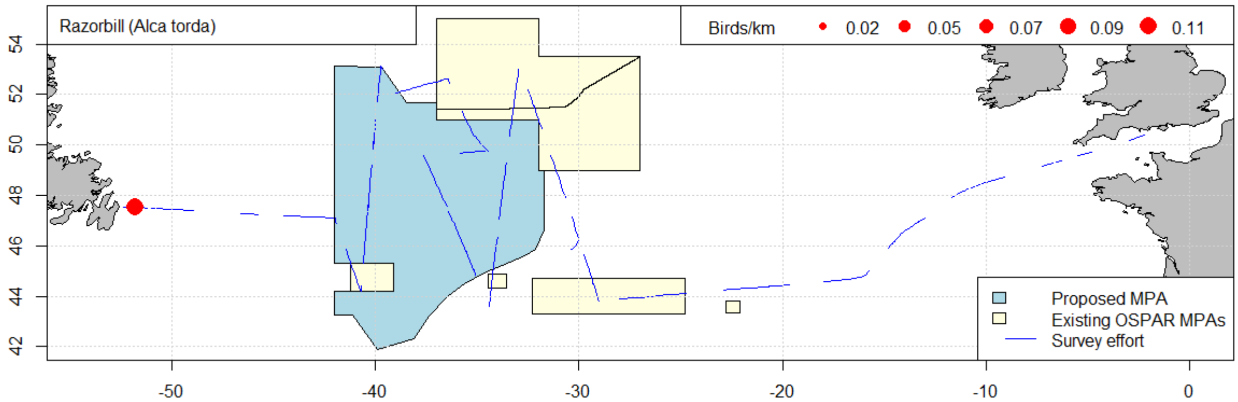

Long-tailed Skua (Stercorarius longicaudus)
Birds/km 0.03 0.06 0.08 0.11 0.14
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

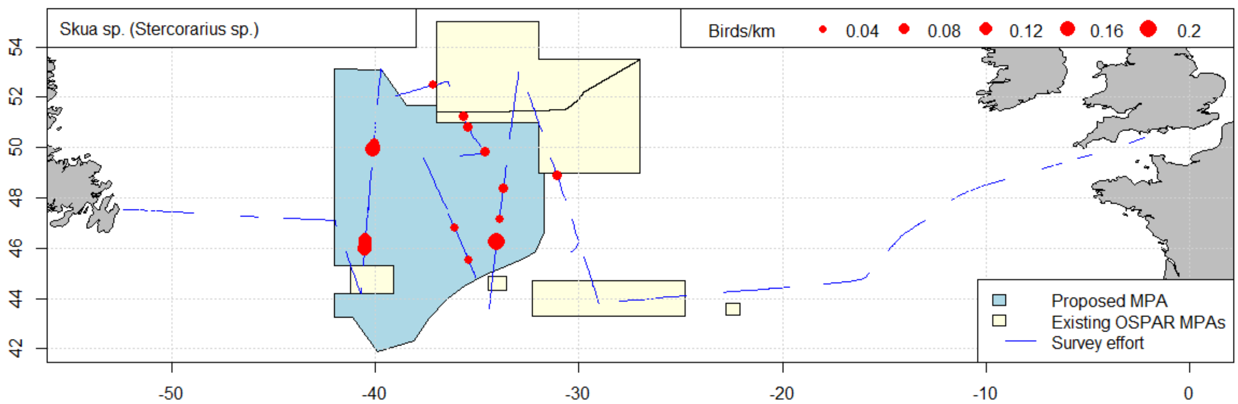

Manx Shearwater (Puffinus puffinus)
Birds/km 0.08 0.17 0.25 0.33 0.41
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

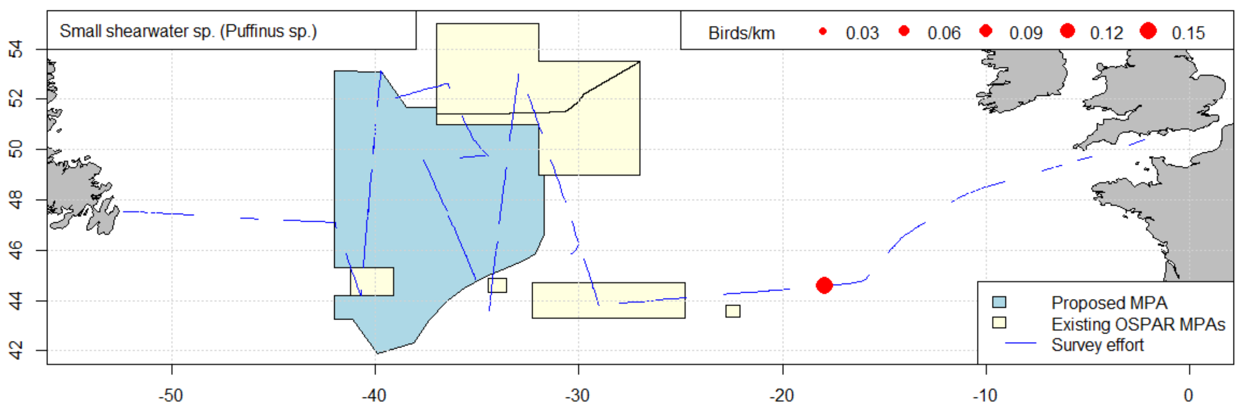

Northern Gannet (Morus bassanus)
Birds/km 0.09 0.18 0.27 0.37 0.46
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

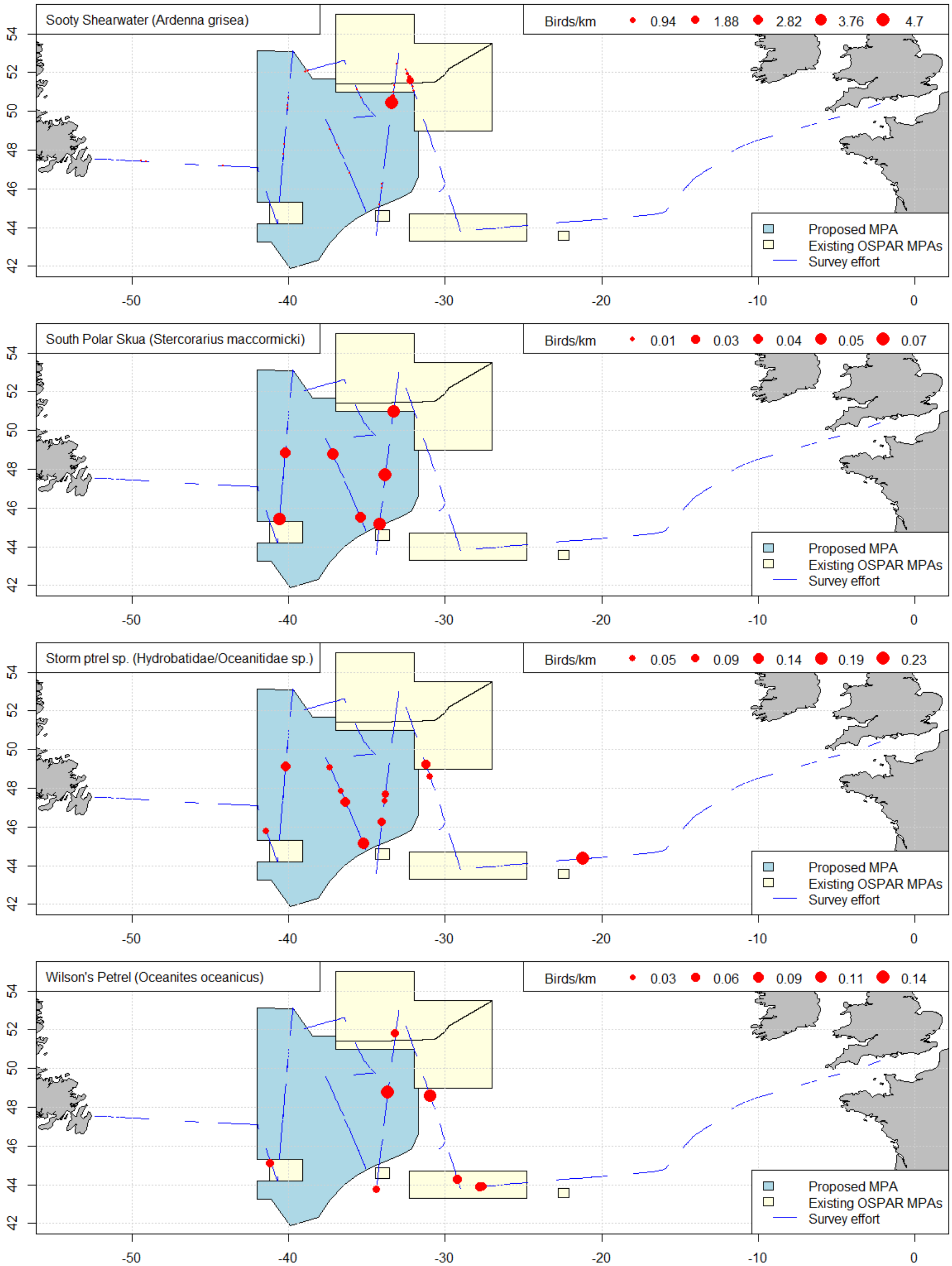

Pomarine Skua (Stercorarius pomarinus)
Birds/km 0.01 0.02 0.03 0.04 0.05
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

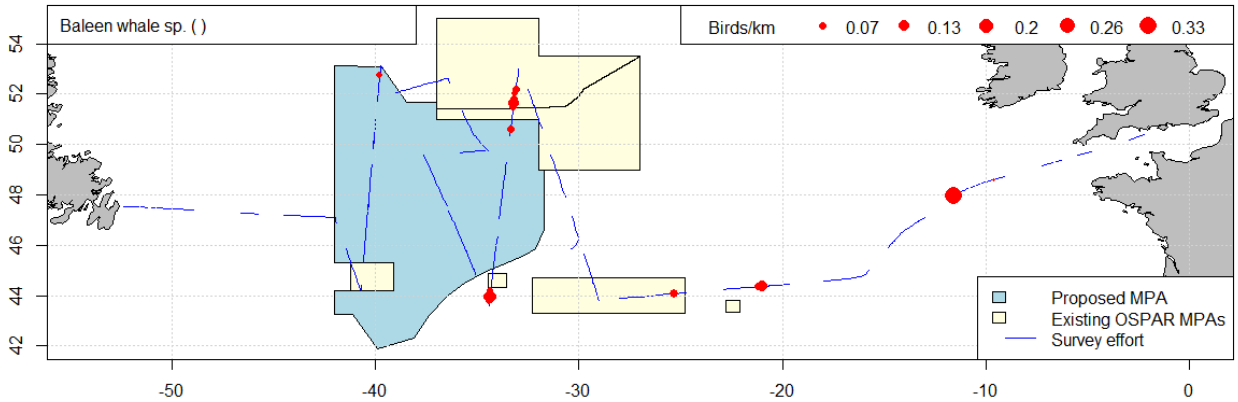

Puffin (Fratercula arctica)
Birds/km 0.35 0.71 1.06 1.41 1.77
Proposed MPA
Existing OSPAR MPAs
Survey effort

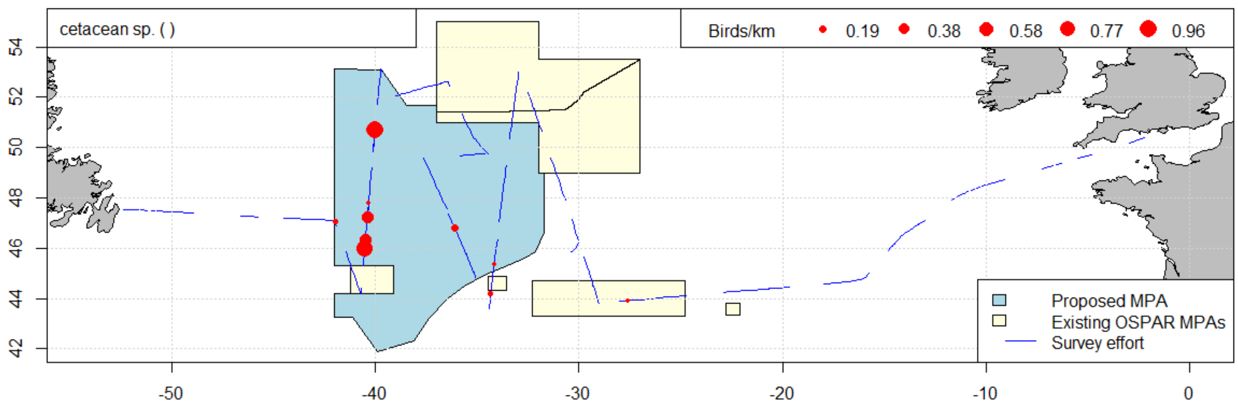

Razorbill (Alca torda)
Birds/km 0.02 0.05 0.07 0.09 0.11
Proposed MPA
Existing OSPAR MPAs
Survey effort

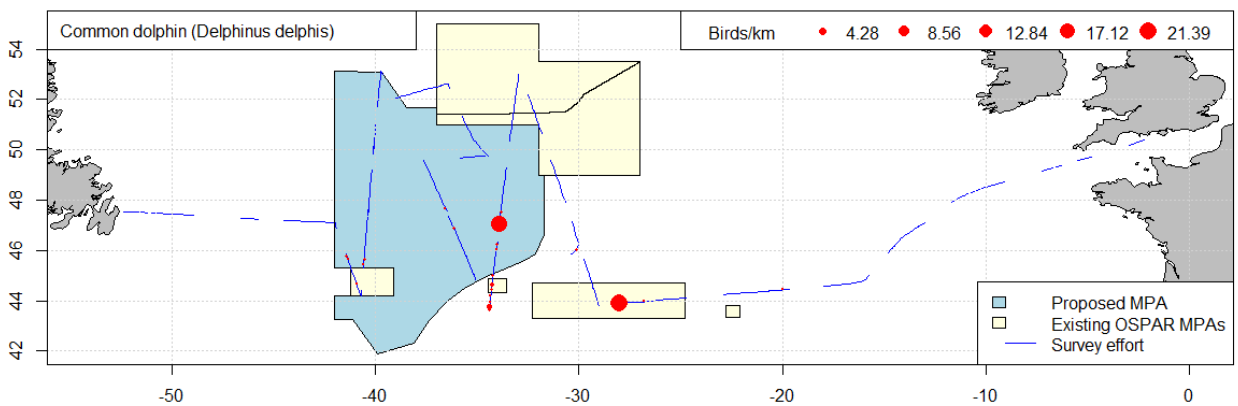

Skua sp. (Stercorarius sp.)
Birds/km 0.04 0.08 0.12 0.16 0.2
Proposed MPA
Existing OSPAR MPAs
Survey effort

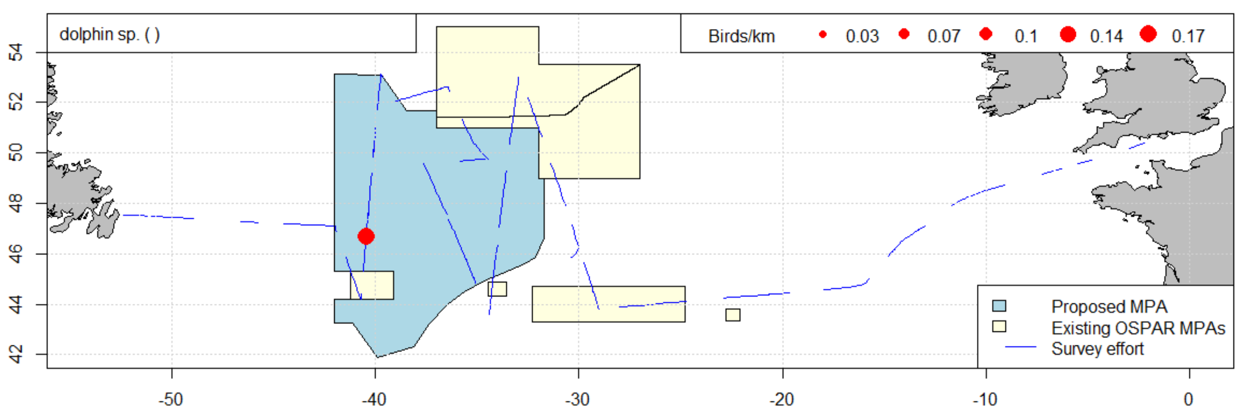

Small shearwater sp. (Puffinus sp.)
Birds/km 0.03 0.06 0.09 0.12 0.15
Proposed MPA
Existing OSPAR MPAs
Survey effort

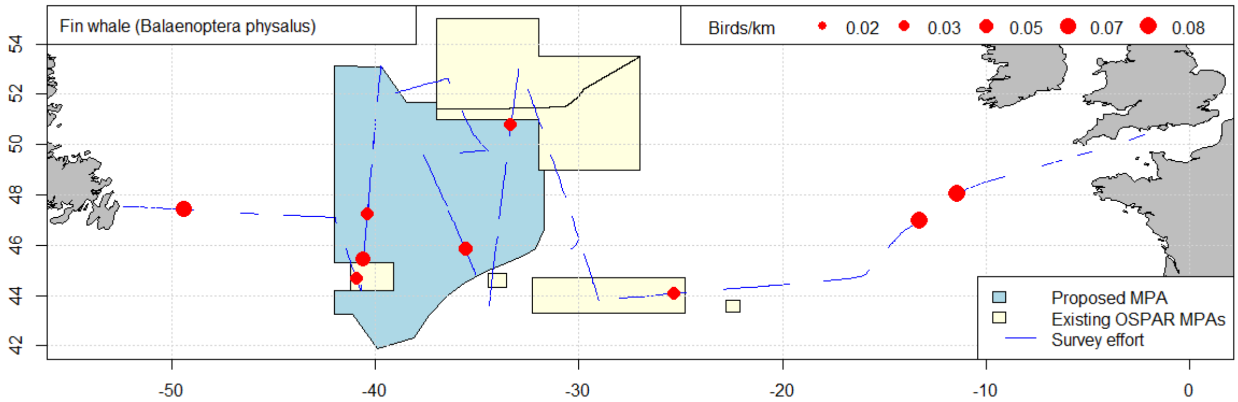

Sooty Shearwater (Ardenna grisea)
Birds/km 0.94 1.88 2.82 3.76 4.7
Proposed MPA
Existing OSPAR MPAs
Survey effort
South Polar Skua (Stercorarius maccormicki)
Birds/km 0.01 0.03 0.04 0.05 0.07
Proposed MPA
Existing OSPAR MPAs
Survey effort
Storm ptrel sp. (Hydrobatidae/Oceanitidae sp.)
Birds/km 0.05 0.09 0.14 0.19 0.23
Proposed MPA
Existing OSPAR MPAs
Survey effort
Wilson's Petrel (Oceanites oceanicus)
Birds/km 0.03 0.06 0.09 0.11 0.14
Proposed MPA
Existing OSPAR MPAs
Survey effort
54
52
50
48
46
44
42
-50
-40
-30
-20
-10
0

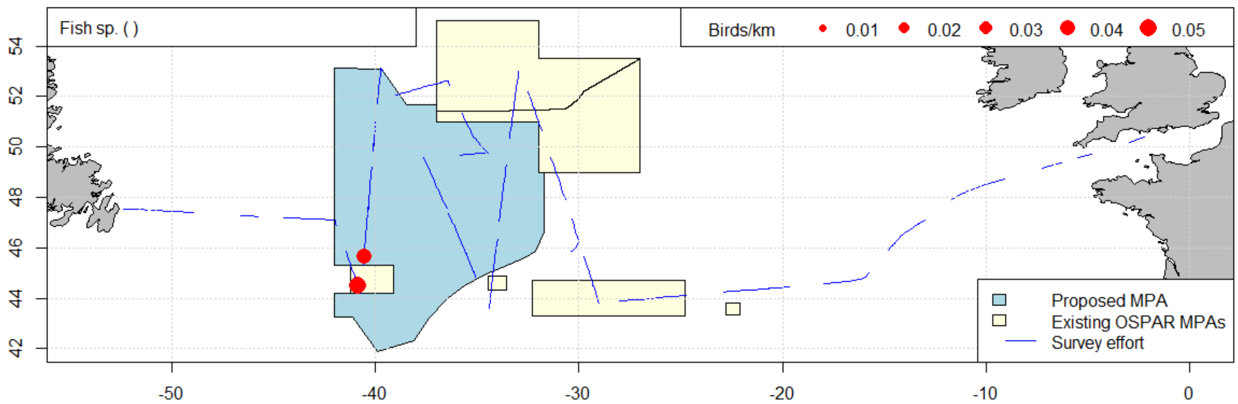

Baleen whale sp. ( )
Birds/km 0.07 0.13 0.2 0.26 0.33
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

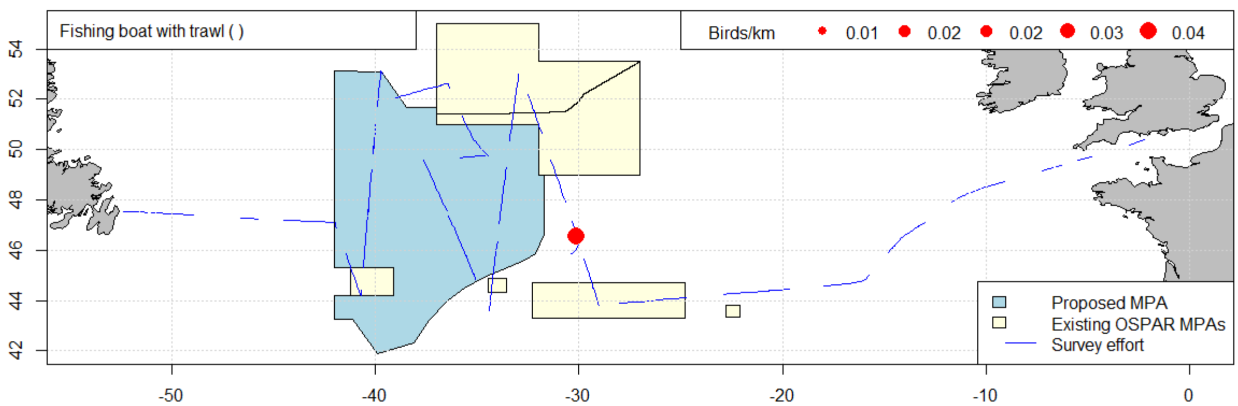

cetacean sp. ( )
Birds/km 0.19 0.38 0.58 0.77 0.96
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

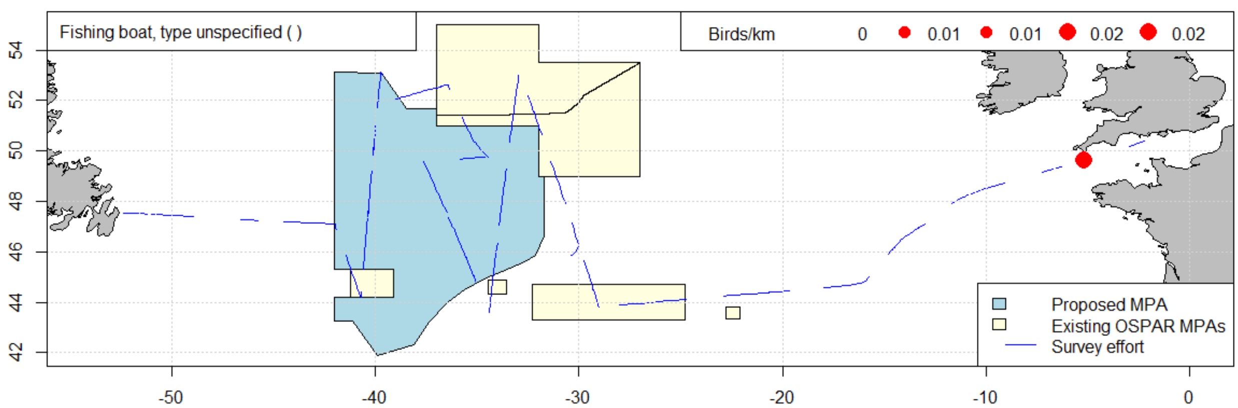

Common dolphin (Delphinus delphis)
Birds/km 4.28 8.56 12.84 17.12 21.39
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

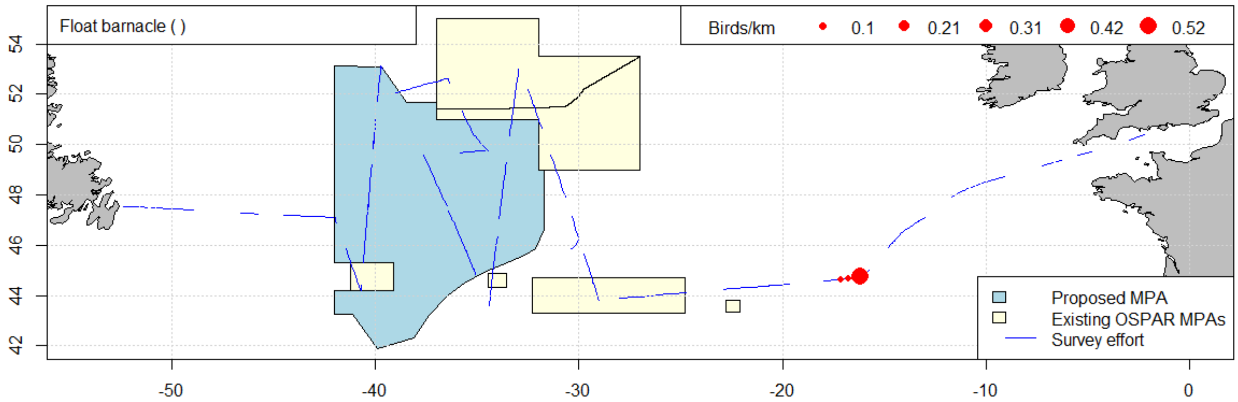

dolphin sp. ( )
Birds/km 0.03 0.07 0.1 0.14 0.17
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

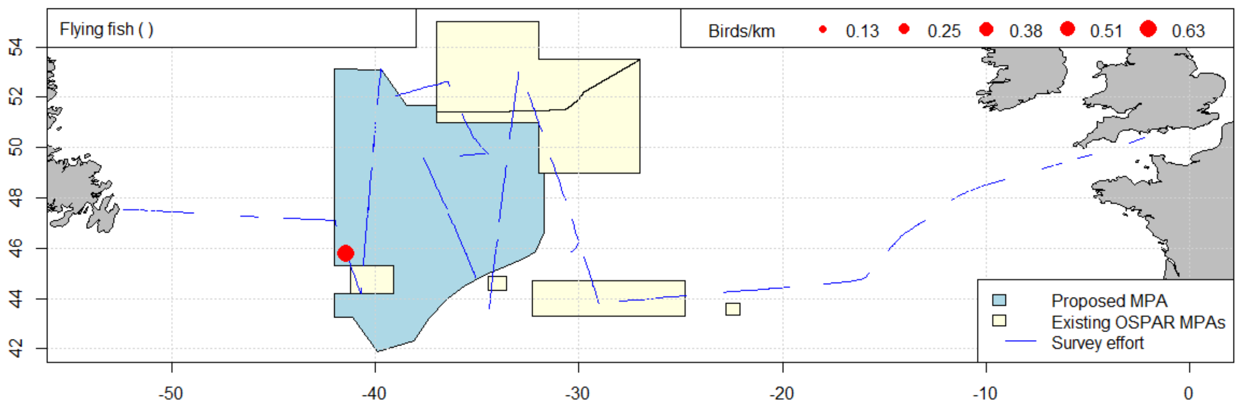

Fin whale (Balaenoptera physalus)
Birds/km 0.02 0.03 0.05 0.07 0.08
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

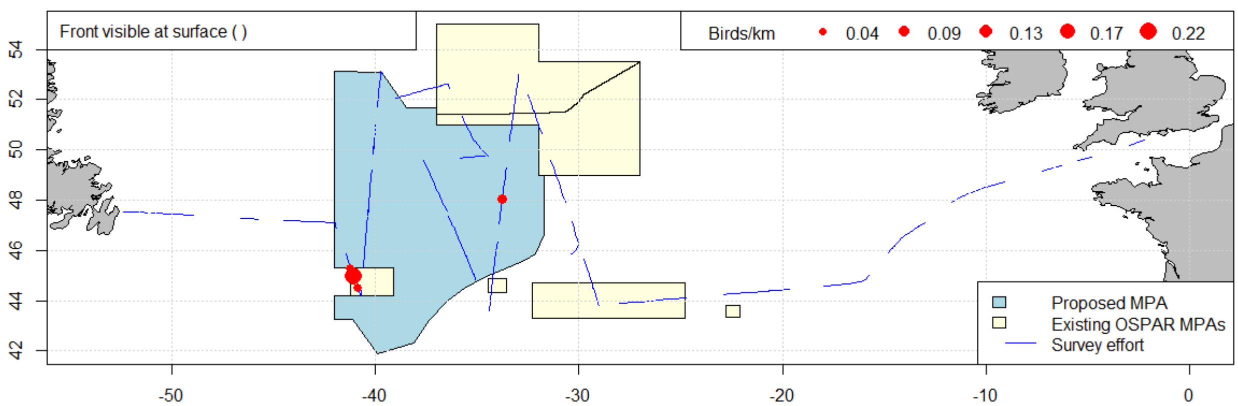

Fish sp. ( )
Birds/km 0.01 0.02 0.03 0.04 0.05
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

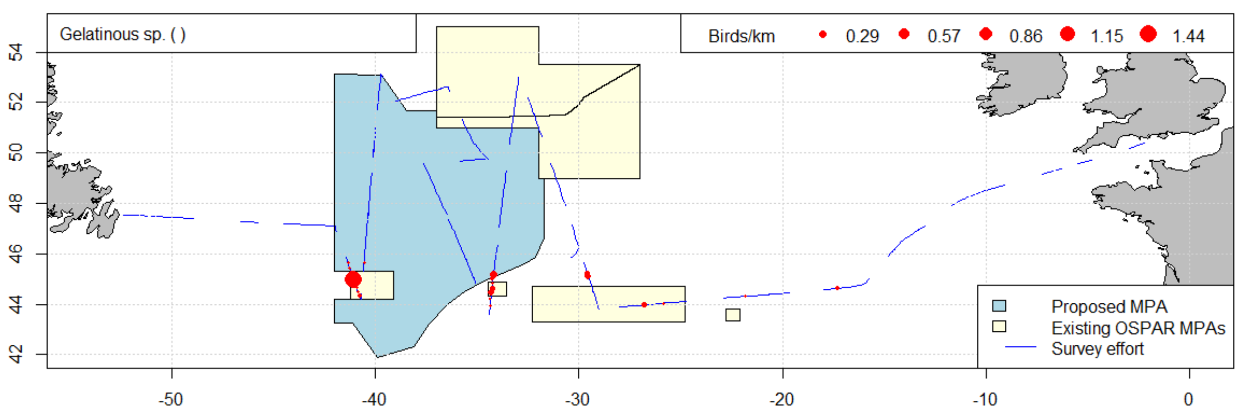

Fishing boat with trawl ( )
Birds/km 0.01 0.02 0.02 0.03 0.04
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

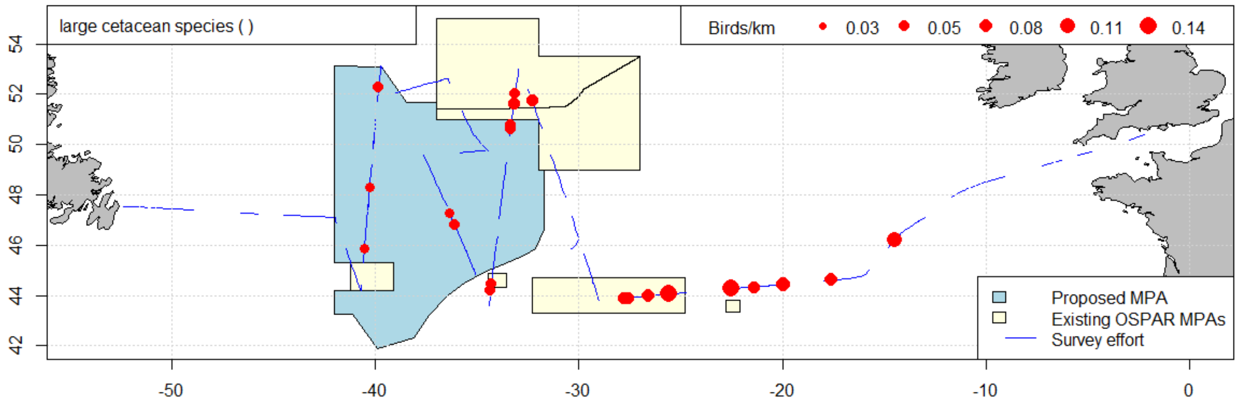

Fishing boat, type unspecified ( )
Birds/km 0 0.01 0.01 0.02 0.02
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

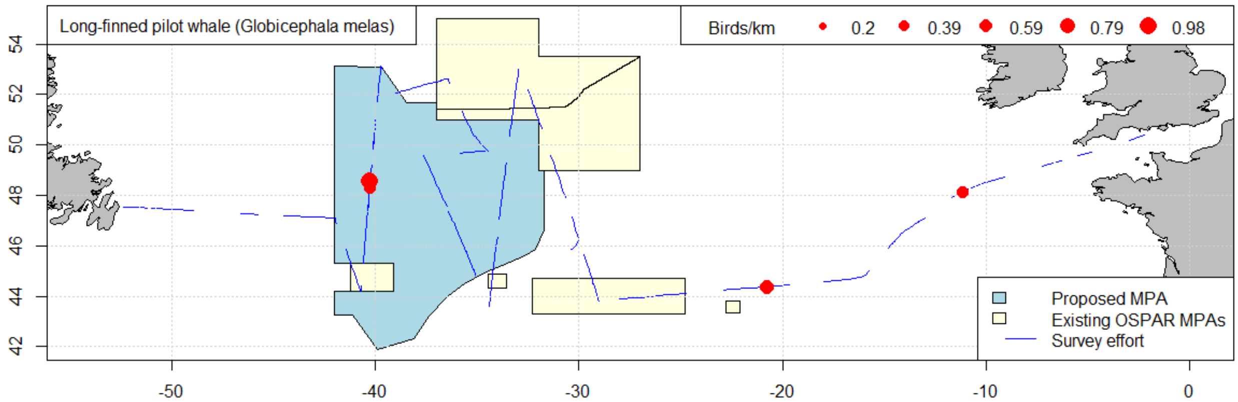

Float barnacle ( )
Birds/km
0.1
0.21
0.31
0.42
0.52
Proposed MPA
Existing OSPAR MPAs
Survey effort
54
52
50
48
46
44
42
-50
-40
-30
-20
-10
0

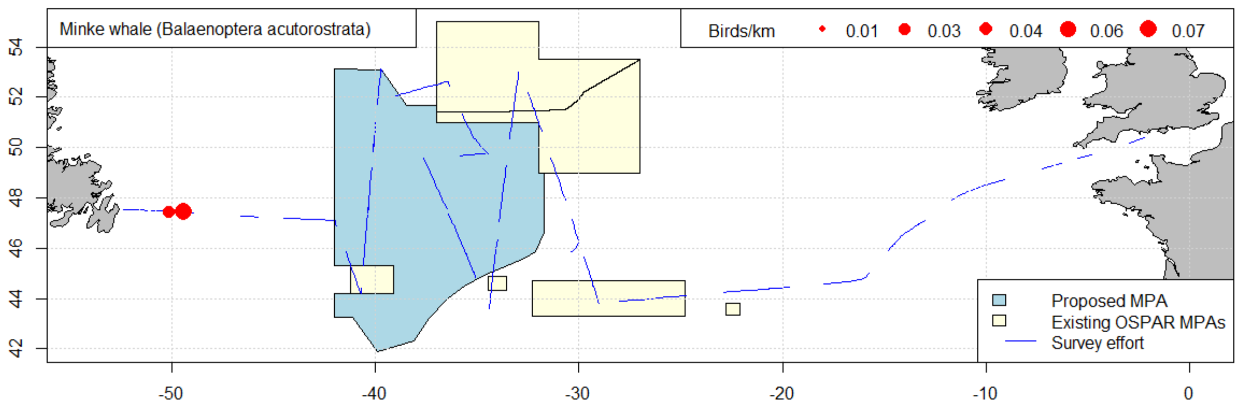

Flying fish ( )
Birds/km
0.13
0.25
0.38
0.51
0.63
Proposed MPA
Existing OSPAR MPAs
Survey effort
54
52
50
48
46
44
42
-50
-40
-30
-20
-10
0

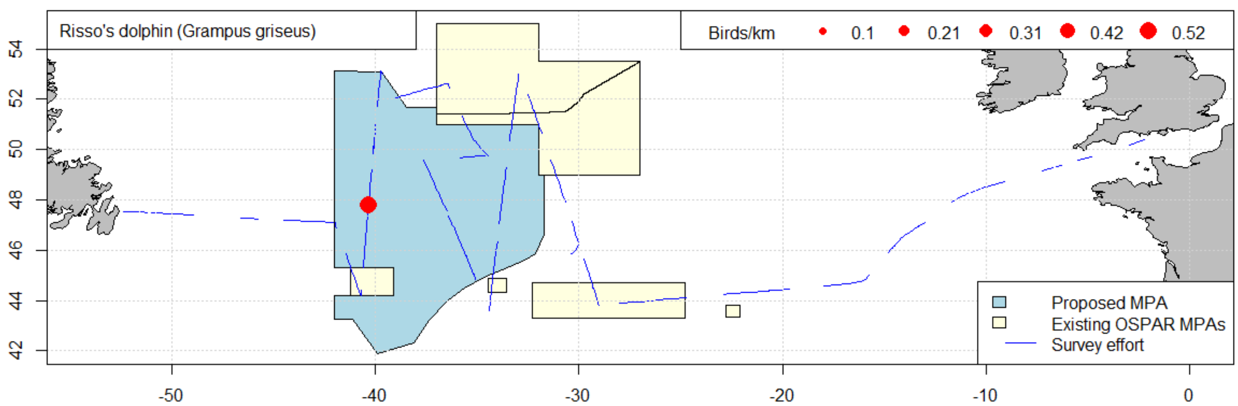

Front visible at surface ( )
Birds/km
0.04
0.09
0.13
0.17
0.22
Proposed MPA
Existing OSPAR MPAs
Survey effort
54
52
50
48
46
44
42
-50
-40
-30
-20
-10
0

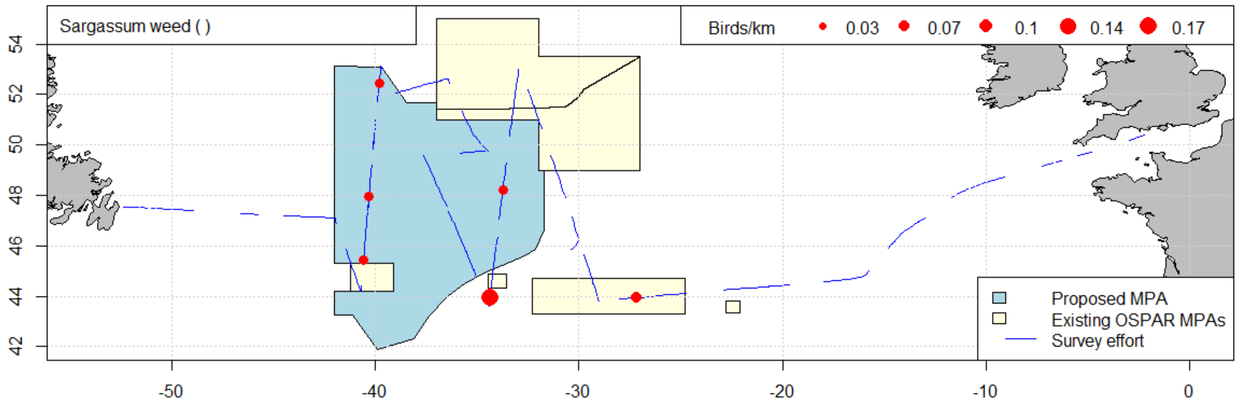

Gelatinous sp. ( )
Birds/km
0.29
0.57
0.86
1.15
1.44
Proposed MPA
Existing OSPAR MPAs
Survey effort
54
52
50
48
46
44
42
-50
-40
-30
-20
-10
0

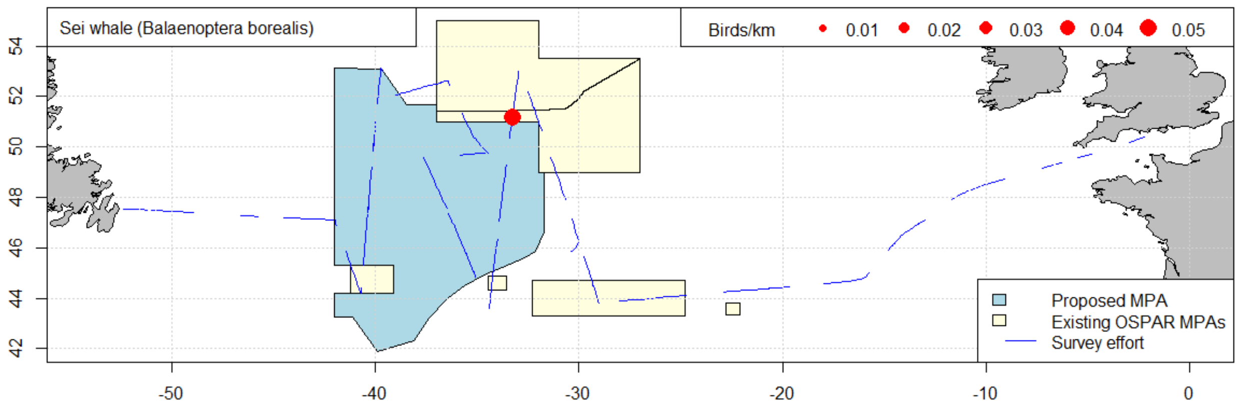

large cetacean species ( )
Birds/km 0.03 0.05 0.08 0.11 0.14
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

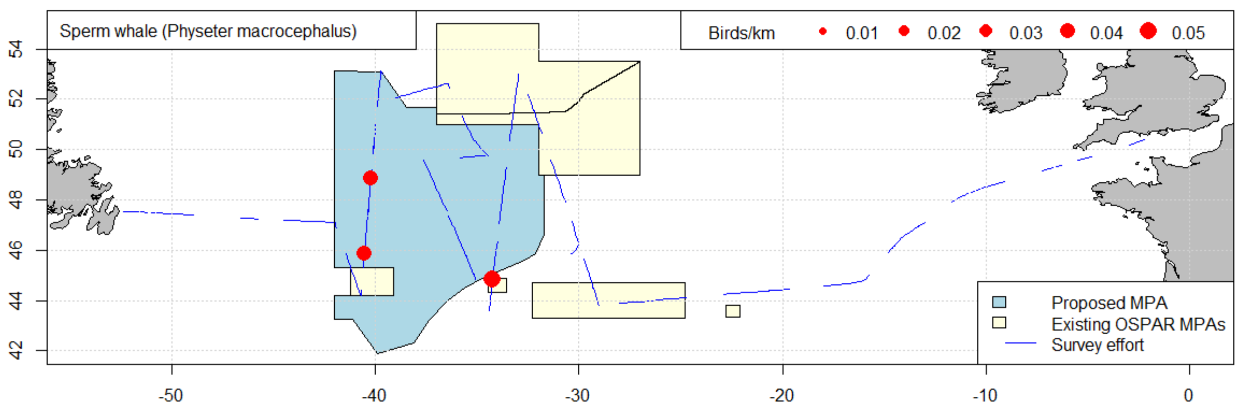

Long-finned pilot whale (Globicephala melas)
Birds/km 0.2 0.39 0.59 0.79 0.98
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

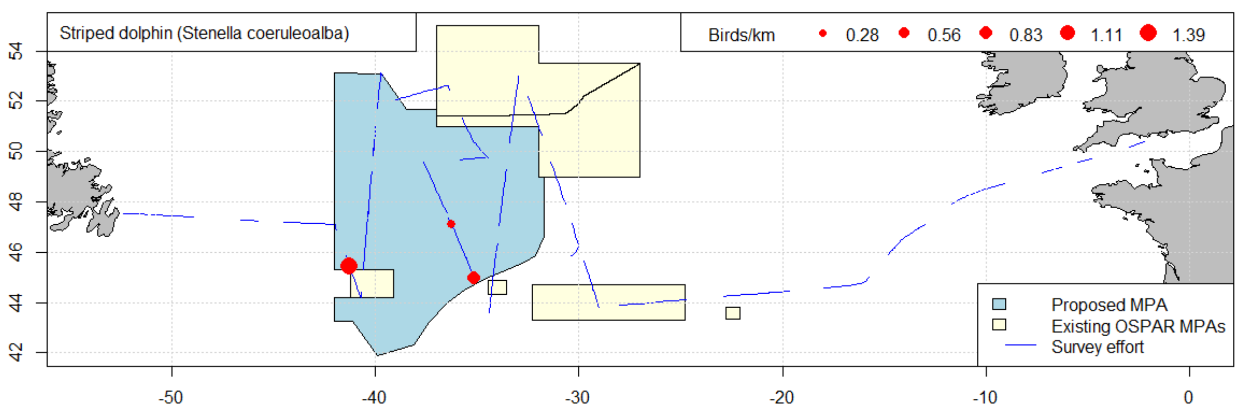

Minke whale (Balaenoptera acutorostrata)
Birds/km 0.01 0.03 0.04 0.06 0.07
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

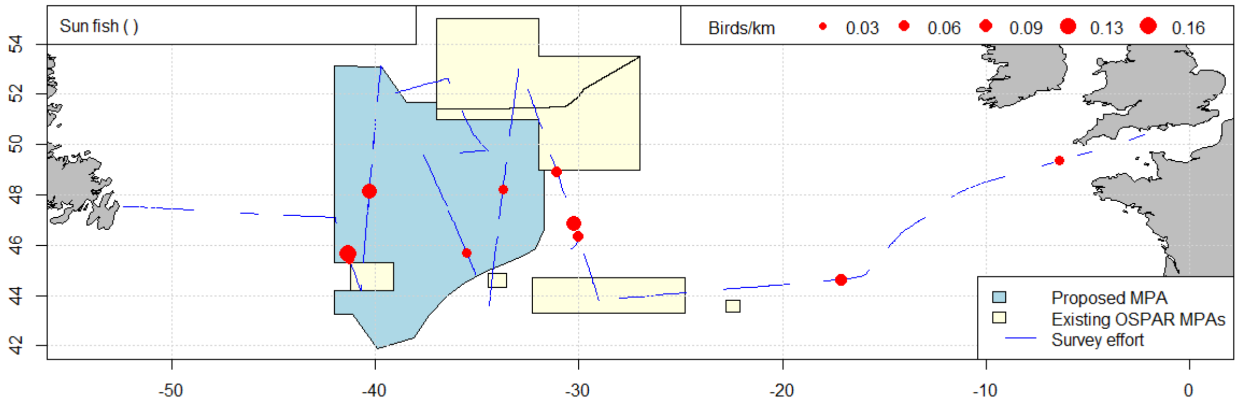

Risso's dolphin (Grampus griseus)
Birds/km 0.1 0.21 0.31 0.42 0.52
Proposed MPA
Existing OSPAR MPAs
Survey effort
54 52 50 48 46 44 42
-50 -40 -30 -20 -10 0

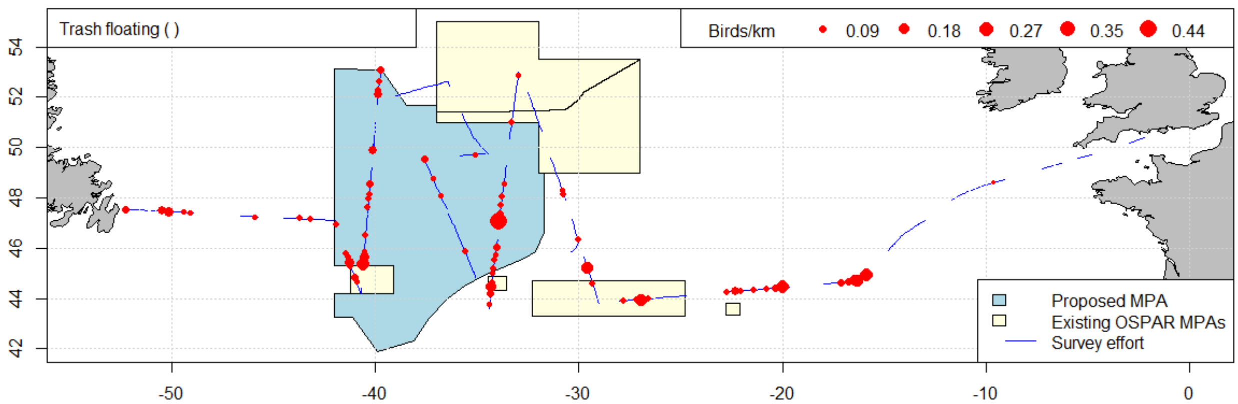

Sargassum weed ( )
Birds/km
0.03
0.07
0.1
0.14
0.17
Proposed MPA
Existing OSPAR MPAs
Survey effort
54
52
50
48
46
44
42
-50
-40
-30
-20
-10
0

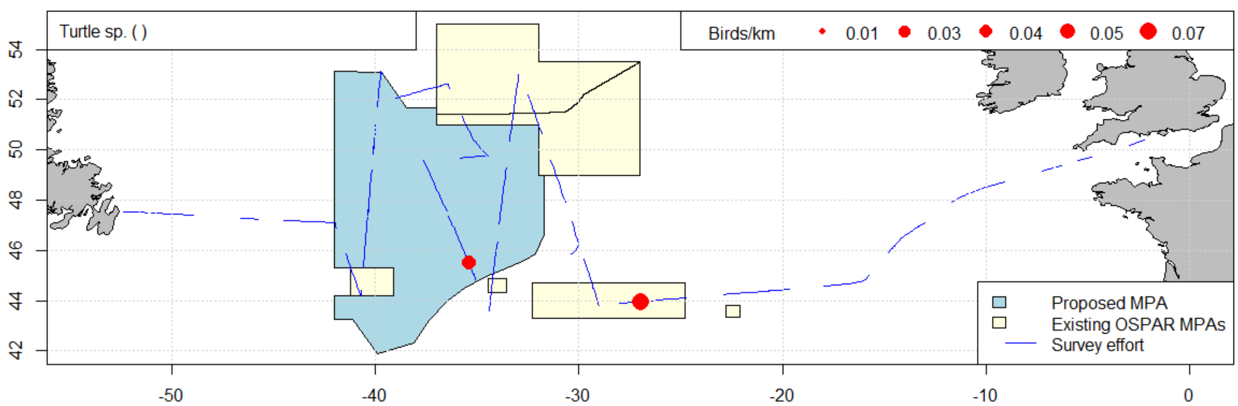

Sei whale (Balaenoptera borealis)
Birds/km
0.01
0.02
0.03
0.04
0.05
Proposed MPA
Existing OSPAR MPAs
Survey effort
54
52
50
48
46
44
42
-50
-40
-30
-20
-10
0


Sperm whale (Physeter macrocephalus)
Birds/km
0.01
0.02
0.03
0.04
0.05
Proposed MPA
Existing OSPAR MPAs
Survey effort
54
52
50
48
46
44
42
-50
-40
-30
-20
-10
0


Striped dolphin (Stenella coeruleoalba)
Birds/km
0.28
0.56
0.83
1.11
1.39
Proposed MPA
Existing OSPAR MPAs
Survey effort
54
52
50
48
46
44
42
-50
-40
-30
-20
-10
0


Sun fish ( )
Birds/km
0.03
0.06
0.09
0.13
0.16
Proposed MPA
Existing OSPAR MPAs
Survey effort


Trash floating ( )
Birds/km
0.09
0.18
0.27
0.35
0.44
Proposed MPA
Existing OSPAR MPAs
Survey effort


Turtle sp. ( )
Birds/km
0.01
0.03
0.04
0.05
0.07
Proposed MPA
Existing OSPAR MPAs
Survey effort

17.2 Appendix: Summary of watch hours for single platform effort conducted throughout the survey

Ship time	UTC	Activity	Duration	Notes
07/06/2017 13:40:49	07/06/2017 12:40:49	Start SP effort		
07/06/2017 17:30:39	07/06/2017 16:30:39	End SP effort	03:49:50	End of day
08/06/2017 05:37:15	08/06/2017 04:37:15	Start SP effort		
08/06/2017 07:30:32	08/06/2017 06:30:32	End SP effort	01:53:17	Meal break
08/06/2017 08:51:12	08/06/2017 07:51:12	Start SP effort	01:20:40	
08/06/2017 11:29:20	08/06/2017 10:29:20	End SP effort	02:38:08	Meal break
08/06/2017 12:21:35	08/06/2017 11:21:35	Start SP effort	00:52:15	
08/06/2017 13:35:08	08/06/2017 12:35:08	End SP effort	01:13:33	Ship stationary for equipment deployment
08/06/2017 13:59:59	08/06/2017 12:59:59	Start SP effort	00:24:51	
08/06/2017 15:14:01	08/06/2017 14:14:01	End SP effort	01:14:02	Ship stationary for equipment deployment
08/06/2017 15:58:53	08/06/2017 14:58:53	Start SP effort	00:44:52	
08/06/2017 17:28:20	08/06/2017 16:28:20	End SP effort	01:29:27	Meal break
08/06/2017 18:32:43	08/06/2017 17:32:43	Start SP effort	01:04:23	
08/06/2017 20:30:51	08/06/2017 19:30:51	End SP effort	01:58:08	End of day
09/06/2017 05:44:02	09/06/2017 04:44:02	Start SP effort		
09/06/2017 07:30:08	09/06/2017 06:30:08	End SP effort	01:46:06	Meal break
09/06/2017 08:29:38	09/06/2017 07:29:38	Start SP effort	00:59:30	
09/06/2017 09:58:55	09/06/2017 08:58:55	End SP effort	01:29:17	Weather induced stop
10/06/2017 06:12:09	10/06/2017 05:12:09	Start SP effort	20:13:14	
10/06/2017 07:30:56	10/06/2017 06:30:56	End SP effort	01:18:47	Weather induced stop
10/06/2017 13:39:36	10/06/2017 12:39:36	Start SP effort	06:08:40	
10/06/2017 17:32:09	10/06/2017 16:32:09	End SP effort	03:52:33	Meal break
10/06/2017 18:31:05	10/06/2017 17:31:05	Start SP effort	00:58:56	
10/06/2017 21:30:04	10/06/2017 20:30:04	End SP effort	02:58:59	End of day
11/06/2017 05:23:32	11/06/2017 05:23:32	Start SP effort		
11/06/2017 07:33:53	11/06/2017 07:33:53	End SP effort	02:10:21	Meal break
11/06/2017 08:27:00	11/06/2017 08:27:00	Start SP effort	00:53:07	
11/06/2017 08:54:45	11/06/2017 08:54:45	End SP effort	00:27:45	Ship stationary for equipment deployment
11/06/2017 09:16:23	11/06/2017 09:16:23	Start SP effort	00:21:38	
11/06/2017 11:30:04	11/06/2017 11:30:04	End SP effort	02:13:41	Meal break
11/06/2017 12:31:38	11/06/2017 12:31:38	Start SP effort	01:01:34	
11/06/2017 17:30:32	11/06/2017 17:30:32	End SP effort	04:58:54	Meal break
11/06/2017 18:30:33	11/06/2017 18:30:33	Start SP effort	01:00:01	
11/06/2017 20:30:24	11/06/2017 20:30:24	End SP effort	01:59:51	End of day
12/06/2017 05:54:14	12/06/2017 05:54:14	Start SP effort		
12/06/2017 07:30:28	12/06/2017 07:30:28	End SP effort	01:36:14	Meal break
12/06/2017 08:32:08	12/06/2017 08:32:08	Start SP effort	01:01:40	
12/06/2017 09:41:24	12/06/2017 09:41:24	End SP effort	01:09:16	Weather induced stop
12/06/2017 12:37:50	12/06/2017 12:37:50	Start SP effort	02:56:26	

12/06/2017 17:32:09	12/06/2017 17:32:09	End SP effort	04:54:19	Meal break
12/06/2017 18:32:40	12/06/2017 18:32:40	Start SP effort	01:00:31	
12/06/2017 20:30:18	12/06/2017 20:30:18	End SP effort	01:57:38	End of day
14/06/2017 06:45:12	14/06/2017 07:45:12	Start SP effort	11:14:54	
14/06/2017 07:35:34	14/06/2017 08:35:34	End SP effort	00:50:22	Meal break
14/06/2017 08:04:16	14/06/2017 09:04:16	Start SP effort	00:28:42	
14/06/2017 09:27:50	14/06/2017 10:27:50	End SP effort	01:23:34	Weather induced stop
14/06/2017 10:31:44	14/06/2017 11:31:44	Start SP effort	01:03:54	
14/06/2017 11:31:17	14/06/2017 12:31:17	End SP effort	00:59:33	Meal break
14/06/2017 12:06:40	14/06/2017 13:06:40	Start SP effort	00:35:23	
14/06/2017 14:49:16	14/06/2017 15:49:16	End SP effort	02:42:36	End of day
16/06/2017 06:00:53	16/06/2017 07:00:53	Start SP effort		Delayed start due to weather
16/06/2017 14:07:50	16/06/2017 15:07:50	End SP effort	08:06:57	Weather induced stop
16/06/2017 15:25:22	16/06/2017 16:25:22	Start SP effort	01:17:32	
16/06/2017 16:38:28	16/06/2017 17:38:28	End SP effort	01:13:06	Stop for bird catching
17/06/2017 06:18:27	17/06/2017 07:18:27	Start SP effort		
17/06/2017 17:48:59	17/06/2017 18:48:59	End SP effort	11:30:32	Meal break
17/06/2017 18:40:32	17/06/2017 19:40:32	Start SP effort	00:51:33	
17/06/2017 20:30:40	17/06/2017 21:30:40	End SP effort	01:50:08	End of day
18/06/2017 06:04:30	18/06/2017 07:04:30	Start SP effort		
18/06/2017 12:53:58	18/06/2017 13:53:58	End SP effort	06:49:28	Stop for bird catching
18/06/2017 16:38:42	18/06/2017 17:38:42	Start SP effort	03:44:44	
18/06/2017 17:30:09	18/06/2017 18:30:09	End SP effort	00:51:27	Meal break
18/06/2017 18:23:13	18/06/2017 19:23:13	Start SP effort	00:53:04	
18/06/2017 20:31:39	18/06/2017 21:31:39	End SP effort	02:08:26	End of day
19/06/2017 06:01:16	19/06/2017 07:01:16	Start SP effort		
19/06/2017 20:07:59	19/06/2017 21:07:59	End SP effort	14:06:43	End of day
20/06/2017 06:02:06	20/06/2017 07:02:06	Start SP effort		
20/06/2017 12:35:47	20/06/2017 13:35:47	End SP effort	06:33:41	Weather induced stop
20/06/2017 19:33:28	20/06/2017 20:33:28	Start SP effort	06:57:41	
20/06/2017 21:13:03	20/06/2017 22:13:03	End SP effort	01:39:35	End of day
21/06/2017 06:24:40	21/06/2017 07:24:40	Start SP effort		
21/06/2017 06:35:14	21/06/2017 07:35:14	End SP effort	00:10:34	Weather induced stop
21/06/2017 09:24:52	21/06/2017 10:24:52	Start SP effort	02:49:38	
21/06/2017 10:47:03	21/06/2017 11:47:03	End SP effort	01:22:11	Meal break
21/06/2017 12:15:03	21/06/2017 13:15:03	Start SP effort	01:28:00	Delayed start due to weather
21/06/2017 12:29:36	21/06/2017 13:29:36	End SP effort	00:14:33	Weather induced stop
21/06/2017 14:31:24	21/06/2017 15:31:24	Start SP effort	02:01:48	
21/06/2017 14:47:23	21/06/2017 15:47:23	End SP effort	00:15:59	Weather induced stop
21/06/2017 15:29:47	21/06/2017 16:29:47	Start SP effort	00:42:24	
21/06/2017 15:45:03	21/06/2017 16:45:03	End SP effort	00:15:16	Weather induced stop
21/06/2017 15:55:17	21/06/2017 16:55:17	Start SP effort	00:10:14	
21/06/2017 16:01:59	21/06/2017 17:01:59	End SP effort	00:06:42	Weather induced stop

21/06/2017 16:19:58	21/06/2017 17:19:58	Start SP effort	00:17:59	
21/06/2017 16:36:20	21/06/2017 17:36:20	End SP effort	00:16:22	End of day
22/06/2017 05:07:29	22/06/2017 06:07:29	Start SP effort		
22/06/2017 10:30:15	22/06/2017 11:30:15	End SP effort	05:22:46	Meal break
22/06/2017 10:42:21	22/06/2017 11:42:21	Start SP effort	00:12:06	
22/06/2017 13:50:10	22/06/2017 14:50:10	End SP effort	03:07:49	Ship stationary for equipment deployment
22/06/2017 15:01:08	22/06/2017 16:01:08	Start SP effort	01:10:58	
22/06/2017 17:30:12	22/06/2017 18:30:12	End SP effort	02:29:04	Meal break
22/06/2017 18:02:46	22/06/2017 19:02:46	Start SP effort	00:32:34	
22/06/2017 19:59:02	22/06/2017 20:59:02	End SP effort	01:56:16	End of day
23/06/2017 05:03:21	23/06/2017 06:03:21	Start SP effort		
23/06/2017 06:06:41	23/06/2017 07:06:41	End SP effort	01:03:20	Ship stationary for equipment deployment
23/06/2017 09:01:10	23/06/2017 10:01:10	Start SP effort	02:54:29	
23/06/2017 10:38:46	23/06/2017 11:38:46	End SP effort	01:37:36	Weather induced stop
23/06/2017 10:43:46	23/06/2017 11:43:46	Start SP effort	00:05:00	
23/06/2017 17:22:56	23/06/2017 18:22:56	End SP effort	06:39:10	Bird catching after dinner
24/06/2017 08:17:32	24/06/2017 09:17:32	Start SP effort		Delayed start due to CTD deployment
24/06/2017 11:55:46	24/06/2017 12:55:46	End SP effort	03:38:14	Weather induced stop
24/06/2017 12:09:15	24/06/2017 13:09:15	Start SP effort	00:13:29	
24/06/2017 12:23:03	24/06/2017 13:23:03	End SP effort	00:13:48	Weather induced stop
24/06/2017 12:29:18	24/06/2017 13:29:18	Start SP effort	00:06:15	
24/06/2017 14:32:04	24/06/2017 15:32:04	End SP effort	02:02:46	Weather induced stop
24/06/2017 15:02:32	24/06/2017 16:02:32	Start SP effort	00:30:28	
24/06/2017 16:45:08	24/06/2017 17:45:08	End SP effort	01:42:36	Bird catching after dinner
25/06/2017 06:06:14	25/06/2017 07:06:14	Start SP effort		
25/06/2017 14:55:12	25/06/2017 15:55:12	End SP effort	08:48:58	Bird catching
25/06/2017 20:19:02	25/06/2017 21:19:02	Start SP effort	05:23:50	
25/06/2017 20:34:42	25/06/2017 21:34:42	End SP effort	00:15:40	End of day
26/06/2017 06:04:24	26/06/2017 08:04:24	Start SP effort		
26/06/2017 08:46:33	26/06/2017 10:46:33	End SP effort	02:42:09	Ship stationary for equipment deployment
26/06/2017 10:35:43	26/06/2017 12:35:43	Start SP effort	01:49:10	
26/06/2017 16:53:02	26/06/2017 18:53:02	End SP effort	06:17:19	Bird catching
26/06/2017 19:35:22	26/06/2017 21:35:22	Start SP effort	02:42:20	
26/06/2017 20:30:12	26/06/2017 22:30:12	End SP effort	00:54:50	End of day
27/06/2017 05:08:38	27/06/2017 07:08:38	Start SP effort		
27/06/2017 07:15:54	27/06/2017 09:15:54	End SP effort	02:07:16	Ship stationary for equipment deployment
27/06/2017 09:03:14	27/06/2017 11:03:14	Start SP effort	01:47:20	
27/06/2017 18:14:54	27/06/2017 20:14:54	End SP effort	09:11:40	Bird catching
28/06/2017 04:57:47	28/06/2017 06:57:47	Start SP effort		
28/06/2017 06:47:37	28/06/2017 08:47:37	End SP effort	01:49:50	Ship stationary for equipment deployment
28/06/2017 08:09:34	28/06/2017 10:09:34	Start SP effort	01:21:57	
28/06/2017 12:38:37	28/06/2017 14:38:37	End SP effort	04:29:03	Bird catching
28/06/2017 13:47:49	28/06/2017 15:47:49	Start SP effort	01:09:12	

28/06/2017 13:58:52	28/06/2017 15:58:52	End SP effort	00:11:03	Bird catching
28/06/2017 14:22:40	28/06/2017 16:22:40	Start SP effort	00:23:48	
28/06/2017 18:48:22	28/06/2017 20:48:22	End SP effort	04:25:42	Bird catching
29/06/2017 05:02:57	29/06/2017 07:02:57	Start SP effort		
29/06/2017 06:45:12	29/06/2017 08:45:12	End SP effort	01:42:15	Ship stationary for equipment deployment
29/06/2017 08:04:16	29/06/2017 10:04:16	Start SP effort	01:19:04	
29/06/2017 11:30:36	29/06/2017 13:30:36	End SP effort	03:26:20	Meal break
29/06/2017 12:34:39	29/06/2017 14:34:39	Start SP effort	01:04:03	
29/06/2017 17:43:22	29/06/2017 19:43:22	End SP effort	05:08:43	End of day
30/06/2017 16:46:59	30/06/2017 19:16:59	Start SP effort		
30/06/2017 17:33:42	30/06/2017 20:03:42	End SP effort	00:46:43	
30/06/2017 18:36:33	30/06/2017 21:06:33	Start SP effort	01:02:51	
30/06/2017 20:30:07	30/06/2017 23:00:07	End SP effort	01:53:34	End of day
01/07/2017 05:33:04	01/07/2017 08:03:04	Start SP effort		
01/07/2017 07:29:50	01/07/2017 09:59:50	End SP effort	01:56:46	Meal break
01/07/2017 08:33:32	01/07/2017 11:03:32	Start SP effort	01:03:42	
01/07/2017 11:30:26	01/07/2017 14:00:26	End SP effort	02:56:54	Meal break
01/07/2017 12:31:23	01/07/2017 15:01:23	Start SP effort	01:00:57	
01/07/2017 15:30:00	01/07/2017 18:00:00	End SP effort	02:58:37	End of effort for survey

17.3 Appendix: Combinations of Sea state, visibility and sightability combined to make overall environmental conditions categories.

Sea state		Visibility		Sightability		category
<5		Good		Excellent		
<5		Good		Good		
<5		Good		Moderate		
<5	+	Moderate	+	Excellent	=	Good
<5		Moderate		Good		
<5		Moderate		Moderate		
<5		poor		Excellent		
<5		poor		Good		
<5		poor		Moderate		
<5		Good		poor		
<5		Moderate		poor		
<5	+		+		=	moderate
<5		poor		Moderate		
5		Good		poor		
5		Moderate		poor		
5		poor		Moderate		
5		poor		poor		
6		Good		Moderate		
6	+	Moderate	+	Moderate	=	poor
6		poor		Moderate		
6		Good		poor		
6		Moderate		poor		
6		poor		poor		

17.4 Appendix: Summary of watch hours for point transect effort conducted throughout the survey.

Date (Times in UTC)		Duration
15/06/2017 19:42	Start	
15/06/2017 21:46	End	02:03:30
16/06/2017 19:25	Start	
16/06/2017 21:28	End	02:02:07
24/06/2017 19:52	Start	
24/06/2017 21:50	End	01:58:16
25/06/2017 19:20	Start	
25/06/2017 21:06	End	01:45:27
26/06/2017 20:33	Start	
26/06/2017 21:31	End	00:57:53
27/06/2017 20:52	Start	
27/06/2017 22:32	End	01:39:55
28/06/2017 15:07	Start	
28/06/2017 15:58	End	00:51:36
28/06/2017 20:55	Start	
28/06/2017 21:27	End	00:32:01
28/06/2017 21:36	Start	
28/06/2017 22:00	End	00:24:01
30/06/2017 11:34	Start	
30/06/2017 11:41	End	00:07:02
30/06/2017 12:05	Start	
30/06/2017 18:59	End	06:54:34
Total effort		19:16:22

17.5 Appendix: Summary of hours of hydrophone recordings collected throughout the survey.

Time (UTC)	Action	Duration (hh:mm:ss)
07/06/2017 12:16:33	Start	
08/06/2017 12:10:24	End	23:53:51
08/06/2017 15:12:25	Start	
09/06/2017 13:14:54	End	22:02:29
11/06/2017 09:14:50	Start	
13/06/2017 04:44:45	End	19:29:55
13/06/2017 06:59:21	Start	
14/06/2017 05:22:22	End	22:23:01
14/06/2017 06:50:04	Start	
14/06/2017 16:03:43	End	09:13:39
15/06/2017 00:03:56	Start	
15/06/2017 05:18:38	End	05:14:42
15/06/2017 06:45:29	Start	
15/06/2017 17:41:00	End	10:55:31
15/06/2017 22:57:51	Start	
16/06/2017 05:03:34	End	06:05:43
16/06/2017 06:24:32	Start	
16/06/2017 14:44:44	End	08:20:12
16/06/2017 16:25:19	Start	
16/06/2017 17:37:16	End	01:11:57
17/06/2017 05:13:49	Start	
17/06/2017 22:00:00	End	16:46:11
18/06/2017 00:16:20	Start	
18/06/2017 01:52:11	End	01:35:51
18/06/2017 05:15:50	Start	
18/06/2017 13:44:44	End	08:28:54
18/06/2017 17:30:04	Start	
18/06/2017 22:07:27	End	04:37:23
19/06/2017 06:15:07	Start	
19/06/2017 21:07:27	End	14:52:20
19/06/2017 23:07:27	Start	
20/06/2017 22:14:54	End	23:07:27
21/06/2017 06:25:28	Start	
21/06/2017 19:03:43	End	12:38:15
21/06/2017 23:58:30	Start	
23/06/2017 07:07:27	End	07:08:57
24/06/2017 09:06:49	Start	
24/06/2017 12:44:44	End	03:37:55

25/06/2017 00:36:02	Start	
25/06/2017 05:21:38	End	04:45:36
25/06/2017 06:05:38	Start	
25/06/2017 15:44:44	End	09:39:06
26/06/2017 00:04:50	Start	
26/06/2017 10:44:44	End	10:39:54
26/06/2017 12:26:05	Start	
26/06/2017 18:37:16	End	06:11:11
27/06/2017 06:50:55	Start	
27/06/2017 09:14:54	End	02:23:59
27/06/2017 10:58:15	Start	
27/06/2017 12:44:44	End	01:46:29
27/06/2017 14:09:31	Start	
27/06/2017 20:33:33	End	06:24:02
28/06/2017 00:46:53	Start	
28/06/2017 08:41:00	End	07:54:07
28/06/2017 09:49:39	Start	
28/06/2017 10:22:22	End	00:32:43
28/06/2017 12:15:38	Start	
28/06/2017 14:41:00	End	02:25:22
28/06/2017 16:18:01	Start	
28/06/2017 17:37:16	End	01:19:15
28/06/2017 19:02:02	Start	
28/06/2017 20:33:33	End	01:31:31
29/06/2017 00:12:22	Start	
29/06/2017 08:52:11	End	08:39:49
29/06/2017 09:41:20	Start	
29/06/2017 16:48:28	End	07:07:08
30/06/2017 19:13:20	Start	
01/07/2017 05:33:33	End	10:20:13
01/07/2017 07:53:19	Start	
01/07/2017 18:11:11	End	10:17:52
Total recordings		361:42:50