A preliminary assessment of endangered sei whales (*Balaenoptera borealis*) in two candidate Key Biodiversity Areas in West Falkland

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ACRONYMS

AMAR	Autonomous Multichannel Acoustic Recorder
BAS	British Antarctic Survey
CITES	Convention for the International Trade for Endangered Species
cKBA	Candidate Key Biodiversity Area
CR	Cue Rate
DV	Distinctiveness Value
DVR	Digital Voice Recorder
EPD	Environmental Planning Department, Falkland Islands Government
ESB	Environmental Studies Budget
EtOH	Ethanol
FC	Falklands Conservation
FICZ	Falkland Islands Interim Conservation and Management Zone
FIG	Falkland Islands Government
FF	Focal Follow
FOCZ	Falkland Islands Outer Conservation Zone
IBI	Inter-Breath Interval
IUCN	International Union on the Conservation of Nature
KBA	Key Biodiversity Area
MDD	Minimum Dive Duration
MPS	Minimum Population Size
NBHF	Narrow-Band High-Frequency
NHM	Natural History Museum (London)
NICT	New Island Conservation Trust
PAM	Passive Acoustic Monitoring
PQ	Photographic Quality
QGIS	Quantum Geographic Information System
RA	Research Assistant
RIB	Rigid-hulled Inflatable Boat
RSPB	Royal Society for the Protection of Birds
SL	Survey Leader
SWPO	Sei Whale Project Officer
TA	Target Area
UAV	Unmanned Aerial Vehicle
UNID	Unidentified

NON-TECHNICAL SUMMARY

Introduction

- Interviews carried out with local inhabitants have indicated that Queen Charlotte Bay and King George Bay, located on the west coast of the Falkland Islands, may support good concentrations of baleen whales during the austral summer and autumn (Frans and Augé, 2016). In 2018, Falklands Conservation (FC), the Royal Society for the Protection of Birds (RSPB) and the Falkland Islands Government (FIG) Environmental Studies Budget (ESB) co-funded a vessel-based survey to the area to collect information on whale occurrence.
- The study area defined for the West Falkland survey was concentrated on the King George Bay and Queen Charlotte Bay candidate Key Biodiversity Areas (cKBAs) which had been proposed based on high densities of baleen whales. The study area also included the open waters located between West Point Island and New Island, and continuing westward to the 100 m depth isobath.
- The core objectives of the work were to: (1) identify the whale species occurring in the area; (2) collect data on whale distribution; (3) assess the number of whales in the region; and (4) carry out a whale behavioural study. Additionally, the survey work included faecal and biopsy sampling, and feasibility studies of acoustic and unmanned aerial vehicle (UAV or 'drone') techniques. The results were intended to provide information on the status of the two whale cKBAs.
- All of the sei whale fieldwork was led by the FC Sei Whale Project Officer (SWPO), and was carried out under FIG Environmental Planning Department (EPD) Research Licences No. R11/2017 and R05/2018.

Preliminary survey

- Prior to the main West Falkland survey, a preliminary visit was made to the West Falkland study area during January 2018 by the sailing vessel *Saoirse* and a team of volunteers. Standardised protocols were followed for the collection of whale survey effort and sightings.
- A total of 38.6 hr and 367.3 km of visual survey data were collected from the *Saoirse* between the 3rd and the 11th January 2018, occurring primarily between Saunders Island and King George Bay, with a single transit between King George Bay and Beaver Island.
- A total of 91 cetacean sightings was recorded, comprising three confirmed species. There were 23 sightings (55 individuals) of probable or confirmed sei whales (*Balaenoptera borealis*), and an additional 28 sightings of unidentified baleen whales that may also have been sei whales.
- The survey provided an initial dataset on sei whale occurrence in the West Falkland study area during the early phase of the 2018 season, demonstrating that sei whales were already present in good numbers during early January and including some sightings recorded within the King George Bay cKBA.

Visual sighting survey

- The main West Falkland sighting survey occurred between the 22 February and the 4 April 2018 (including outward and inward transits between the study area and Stanley), and was carried out from the 19.5 m live-aboard motor-sailing vessel *Golden Fleece*. Vessel-based survey effort was collected on 32 dates, with 10 days spent at anchor due to adverse weather conditions. In total, 233.3 hr and 2,591.7 km of survey effort (including non-systematic, transect, cetacean encounter and focal follow effort) was carried out during the West Falkland survey.
- A total of 183.1 hr and 2,305.7 km of visual search effort (i.e. combined non-systematic active search surveys and transect surveys) was collected, including a full circumnavigation of the Islands, a series of transects within the West Falkland study area, and a large amount of non-

systematic search effort in King George Bay, Queen Charlotte Bay, and to a lesser extent around Byron Sound, New Island, the Passage Islands, Dyke Island and Port Richards.

- A cumulative total of 1,342 cetacean sightings was recorded during the survey, confirming the occurrence of four species: sei whale, killer whale (*Orcinus orca*), Peale's dolphin (*Lagenorhynchus australis*) and Commerson's dolphin (*Cephalorhynchus commersonii*). Sei whales and unidentified baleen whales (most, if not at all, of which were considered likely to also comprise sei whales) were the most frequently-sighted species with 418 and 594 sightings respectively. The majority of sei whale sightings consisted either of single animals (53.8%), or small groups of two to three animals (38.8%).
- Sei and baleen whales were distributed throughout most areas where search effort occurred, including from the innermost coastal areas close to shore, to the 100 isobath at the westernmost extent of the study area. The relative abundance values (per 5 km grid cell) for combined sei and unidentified baleen whales ranged from 0.05 to 4.79 individuals/km, with 16 grid cells having values exceeding 2.0 animals/km. The grid cells of highest value were predominantly distributed in north-eastern King George Bay, to the east of New Island, and along the north coast of the Falklands from Cape Dolphin to Pebble Island. However, whales were widely-distributed across the West Falkland study area, with grid cells of high relative abundance scattered throughout the region. Sei whale and unidentified large baleen sightings occurred in mean water depths of 41.7 and 47.0 m respectively, and at mean distances from shore of 3.6 and 4.6 km respectively.

Photo-identification

- Photo-identification was carried out on 17 of the survey days, with whales carefully approached to acquire high-resolution images in an effort to identify individuals from the presence of distinctive markings on their dorsal fins and flanks. Over 13,300 images were taken, with between 1 and 26 individual whales photographed per date and a total of 147 animals initially catalogued. Following quality-control procedures, the minimum number of sei whales photographed within the West Falkland study area during the 2018 survey was 133 animals, comprising 112 permanently-marked animals and 21 animals for which right-side images of scar patterns were available.
- Twenty-two individual sei whales were photographically-captured on more than one survey date. One individual (WF-4) moved from Byron Sound to Queen Charlotte Bay, with a straight-line distance of 62 km between capture locations. Recapture analysis revealed a variety of spatial movements, with some animals repeatedly seen within relatively small areas of a few kilometres, while others travelled greater distances. Some animals were recaptured on successive dates, while others were recaptured over periods of up to four weeks. One individual (WF-75) was photographed from the *Saoirse* in King George Bay in January, and recaptured 76 days later in the same area during the main West Falkland survey.
- Two sei whales were photographically-recaptured between the Berkeley Sound cKBA in 2017, and the West Falkland study in 2018. These records demonstrate the movements of individuals between opposite coasts of the Falkland Islands, and repeat visits to the Islands in different years.

Behavioural study

- A total of 17 behavioural focal follows (with durations of ≥20 min) were carried out on sei whales in West Falkland between 25 February and 26 March 2018, to collect information on their dive and surfacing characteristics. The average linear swim speed recorded during the focal follows was 5.3 km h^{-1}.
- There were 19 occurrences of submergences exceeding 300 s (5.0 min) duration. The longest submergence recorded was 574 s (9.6 min). Whales usually exhibited sequences of shorter surface dives (mean of 49.3 s) and longer true dives (mean of 299.5 s). However, individual whales varied in their dive patterns, with some exhibiting striking patterns of surface and true

dives while others exhibited repeated dives of intermediate duration. The surfacing patterns were generally consistent with shallow diving behaviour, presumably related to foraging activity.

Faecal sampling

- A total of 48 sei whale faecal events were observed during the survey, of which only seven could be sampled due to limitations with weather and platform constraints. An initial basic visual inspection indicated that all of the samples contained the hard parts (e.g. pincers, carapaces and eyeballs) from lobster krill (*Munida gregaria*).
- The seven faecal samples were exported to the UK during June, and will be incorporated into a genetic (whale and prey DNA) and isotope analysis that is being funded by the RSPB and will be carried out by the British Antarctic Survey (BAS).

Bone sampling

- A total of 107 whale bones were sampled during the West Falkland survey, with the aim of extracting DNA to identify species and to investigate whale population identity, structure and genetic diversity in Falkland waters, along with trophic information via isotope analysis. Most samples originated from New Island, which was the site of a shore-based whaling station during the early 1900s.
- The whale bone samples were exported to the UK during June, and will be incorporated into ongoing genetic and isotope work in collaboration with the BAS.

Feasibility studies

- Acoustic feasibility studies were conducted from both the *Saoirse* and the *Golden Fleece*, using SoundTrap devices and a dip hydrophone. Initial analysis indicated that both methods were affected by a variety of low frequency noises that had the potential to mask sei whale calls. The results have already been used to inform plans for forthcoming acoustic monitoring of sei whales in the Falklands.
- An unmanned aerial vehicle (UAV or 'drone') study was carried out in the latter stages of the West Falkland survey, and successfully acquired aerial images of sei whales during four different sightings. The footage providing insights on the group sizes of submerged animals, their group formations, and their behaviour. A number of constraints were reported and will prove useful when considering the optimisation of additional UAV work in the future, with potential applicability to techniques such as photogrammetry and blow sampling.

Conclusions

- The spatial dataset produced by the West Falkland survey provided the first comprehensive assessment of sei whale distribution along the west coast of the Falklands. It revealed that the species was widely-dispersed from semi-enclosed waters along the coast, to the open waters at the westward limit of the study area, with whales being documented almost everywhere that survey effort occurred. Broad similarities in habitat (water depth and distance from shore) were apparent for sei whale sightings recorded in the West Falkland 2018 study area and in the Berkeley Sound 2017 study area, suggesting that the species may occupy broadly similar habitats on the east and west sides of the Falklands, which likely reflects the areas favoured by their target prey species.
- The success of some survey components was constrained by platform limitations. The *Golden Fleece* proved to be a good platform for the visual sighting survey, providing good eye height and better stability than smaller platforms. However, the biopsy and faecal sampling components of the work were very limited by the small size and lack of stability of the available 4.5 m zodiac (particularly in the prevailing weather conditions), with no biopsy samples acquired and only seven faecal samples collected. The West Falkland survey results therefore support the findings

from the Berkeley Sound survey, that platform availability has a significant influence on the applicability and success of different research components during whale research projects.

- The first evaluation of sei whale occurrence in the King George Bay and Queen Charlotte Bay cKBAs, found that neither of the cKBAs overlapped with particular hotspots of sei whale occurrence. Rather, the relative abundance of baleen whales was higher in some other areas, and they were generally widespread across the entire study area. Additionally, the current cKBA boundaries do not extend sufficiently far towards the shore to include the coastal waters used by many sei whales. Although the King George Bay cKBA was nominated solely for sei whales, the Queen Charlotte Bay cKBA was nominated for the presence of both sei and fin whales. The total absence of fin whales in the survey dataset, which was collected in the reported peak season for baleen whales in Falkland coastal waters, suggests that previous reports of fin whales in the cKBA may be a case of species misidentification. While support for full KBA status of the King George Bay and Queen Charlotte Bay cKBAs was not categorically demonstrated by the data (although it would undoubtedly be forthcoming for both sites with the collection of additional survey data), the wider area would qualify at present as a full status KBA based on the minimum population size (MPS) from photo-identification of 133 animals at the time of the survey. It is recommended that the appropriateness of the current, relatively small and discrete, whale cKBAs, should be revisited in light of recent whale survey work (this report and the Berkeley Sound survey), with the results indicating that larger-scale KBAs would: (1) be more relevant to the spatial scales used by sei whales; (2) be more applicable to the widespread distribution of whales over large parts of the Falklands shelf; and (3) take account of the proven connectivity between sites, demonstrated by movements of some individuals between opposite coasts of the Falklands.

1. INTRODUCTION

1.1. Rationale

The sei whale (*Balaenoptera borealis*) and the fin whale (*B. physalus*) are large baleen whale species that were decimated by commercial whaling operations in the 1900s. Both are currently listed on the IUCN Red List as globally endangered species (Reilly et al., 2008, 2013). Since 2000, local inhabitants in the Falkland Islands have anecdotally-reported an increased occurrence of baleen whales in coastal waters, with most animals identified as being either sei or fin whales (Frans and Augé, 2016). Based on those reports, the 2016 BEST Ecosystem Profile for the South Atlantic region proposed six candidate Key Biodiversity Areas (cKBAs) for whales in coastal shelf waters around the Falklands, including Berkeley Sound, King George Bay, Queen Charlotte Bay, Saunders Island Waters (North), Byron Sound and Falkland Sound (Figure 1.1; Taylor et al., 2016). Two of the sites, Berkeley Sound and Queen Charlotte Bay, were also proposed for fin whales. All of the cKBAs have been highlighted as priority areas for research due to their potential to qualify for full KBA status (Taylor et al., 2016).

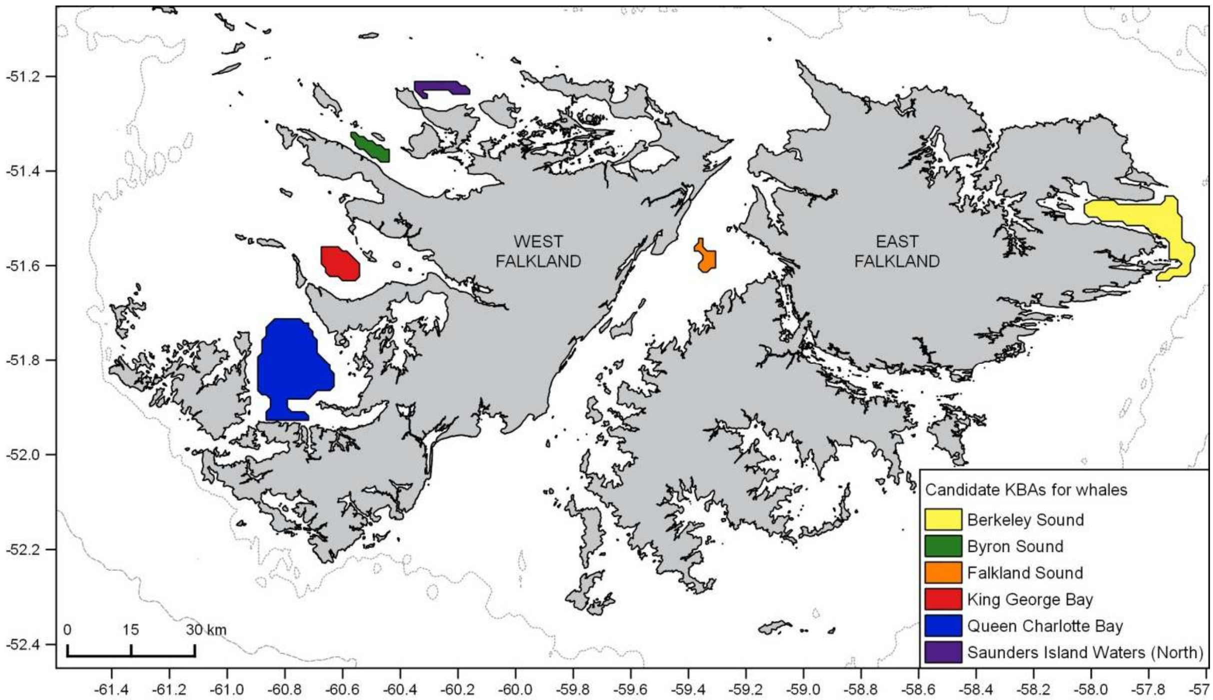


Figure 1.1. Location of the six candidate Key Biodiversity Areas (KBAs) proposed for sei and fin whales in the Falkland Islands.

Between January and May 2017, the first systematic field study of baleen whales in a Falkland cKBA was carried out by Falklands Conservation (FC) in the Berkeley Sound cKBA. That study photo-identified 87 individual sei whales at the site, but did not record any fin whales (Weir, 2017a). Discussions with stakeholders and community members indicated that during the 2017 season the main concentrations of baleen whales were located off the west coast of West Falkland, in an area that included Queen Charlotte Bay and King George Bay. Together with the local interview data collected by Frans and Augé (2016), the information highlighted Queen Charlotte Bay and King George Bay as potentially representing some of the most important areas for sei whales (and perhaps other baleen whale species) in the Falkland Islands.

Between February and April 2018, FC undertook a targeted survey of sei whales off the west coast of West Falkland, aiming to collect information on spatial distribution, abundance and behaviour. This report describes the survey results, and the evidence-based implications for the applicability of the Queen Charlotte Bay and King George Bay cKBAs to conserving whales.

1.2. Report format

The report includes data from two separate surveys carried out in West Falkland:

1. A preliminary survey carried out by the yacht *Saoirse* in January 2018; and
2. The main survey carried out by FC from the *Golden Fleece* between February and April 2018.

The methods, results and discussion for the visual sighting components of the preliminary and the main surveys are presented in Sections 4 and 5 respectively. Individual components of the main survey are then presented as separate standalone chapters covering photo-identification (Section 6), behavioural work (Section 7), faecal sampling (Section 8), bone sampling (Section 9), and the acoustic and drone feasibility studies (Sections 10 and 11 respectively).

1.3. Research permits

All of the survey work described within this report was carried out under two research licences issued to FC by the Falkland Island Government (FIG):

- Licence No. R11/2017, granted for ecological studies of baleen whales; and
- Licence No. R05/2018, granted for conducting biopsy sampling of baleen whales.

2. AIMS AND OBJECTIVES

The core objectives of the sei whale survey in the King George Bay and Queen Charlotte Bay cKBAs included:

1. To identify which species of baleen whale (and other cetaceans) occur;
2. To collect spatial information on whale distribution in order to examine the appropriateness of the current cKBA boundaries, assess habitat use and examine overlap with human activities;
3. To assess whale abundance via a visual sighting survey, group size estimates and photo-identification, that will provide a combined minimum estimate of how many individuals are using each cKBA at the time of the survey;
4. To carry out a behavioural focal follow study of sei whales to collect dive information and better understand why the whales are using the cKBAs;
5. To record data on feeding behaviour and conduct faecal sampling to establish diet;
6. To collect tissue samples from baleen whales to investigate the population identity, structure and diversity of sei whales (and other species as applicable) using Falkland waters;
7. To conduct additional feasibility studies where possible, including the potential use of acoustic methods and drones.

3. STUDY AREA

The Falkland Islands are located approximately 500 km east of South America's southern Patagonian coast, at latitudes of 51°S to 53°S and longitudes of between 57°W and 62°W (Figure 3.1). The Islands are situated in shallow (<200 m depth) waters that form an eastwards extension of the Patagonian continental shelf. The two main islands of East and West Falkland are divided by Falkland Sound, and the coastline of both islands is indented by a number of large bays and inlets. The FIG declared the Falkland Islands Interim Conservation and Management Zone (FICZ) in October 1986, comprising an area of 300 km radius around Falkland Sound (Figure 3.1). In 1990 the Falkland Islands Outer Conservation Zone (FOCZ) was declared in the area between the FICZ and the 200 nautical mile economic zone boundary (Figure 3.1).

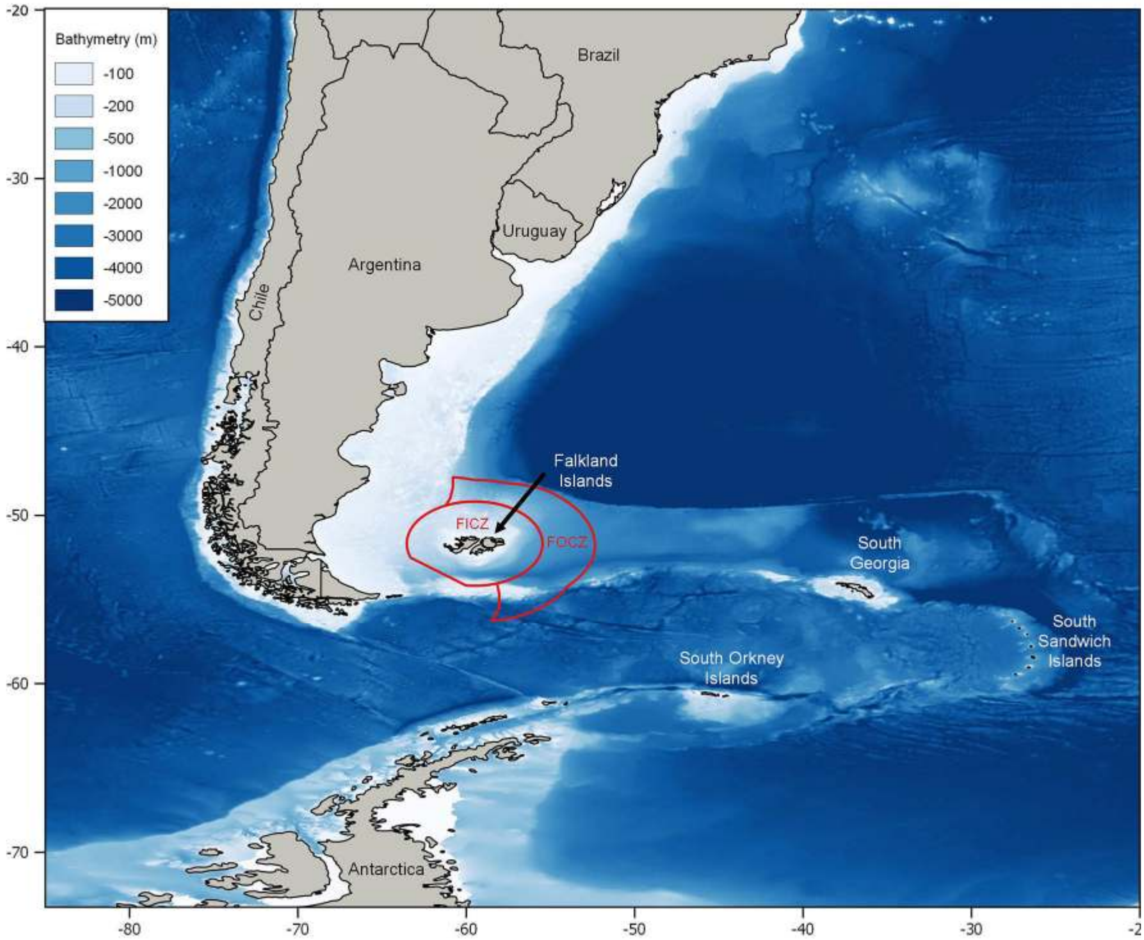


Figure 3.1. Geographic position of the Falkland Islands off South America, showing bathymetry and the locations of the Falkland Islands Interim Conservation and Management Zone (FICZ) and Falkland Islands Outer Conservation Zone (FOCZ).

The study area defined for the West Falkland sei whale survey was concentrated on the King George Bay and Queen Charlotte Bay cKBAs (Figure 1.1), but also included the open waters located between West Point Island and New Island, and the shelf waters westward as far as the 100 m depth isobath (Figure 3.2). The entire area comprised shallow, shelf waters (Figure 3.3), and consisted of a convoluted coastline of bays, inlets and islands.

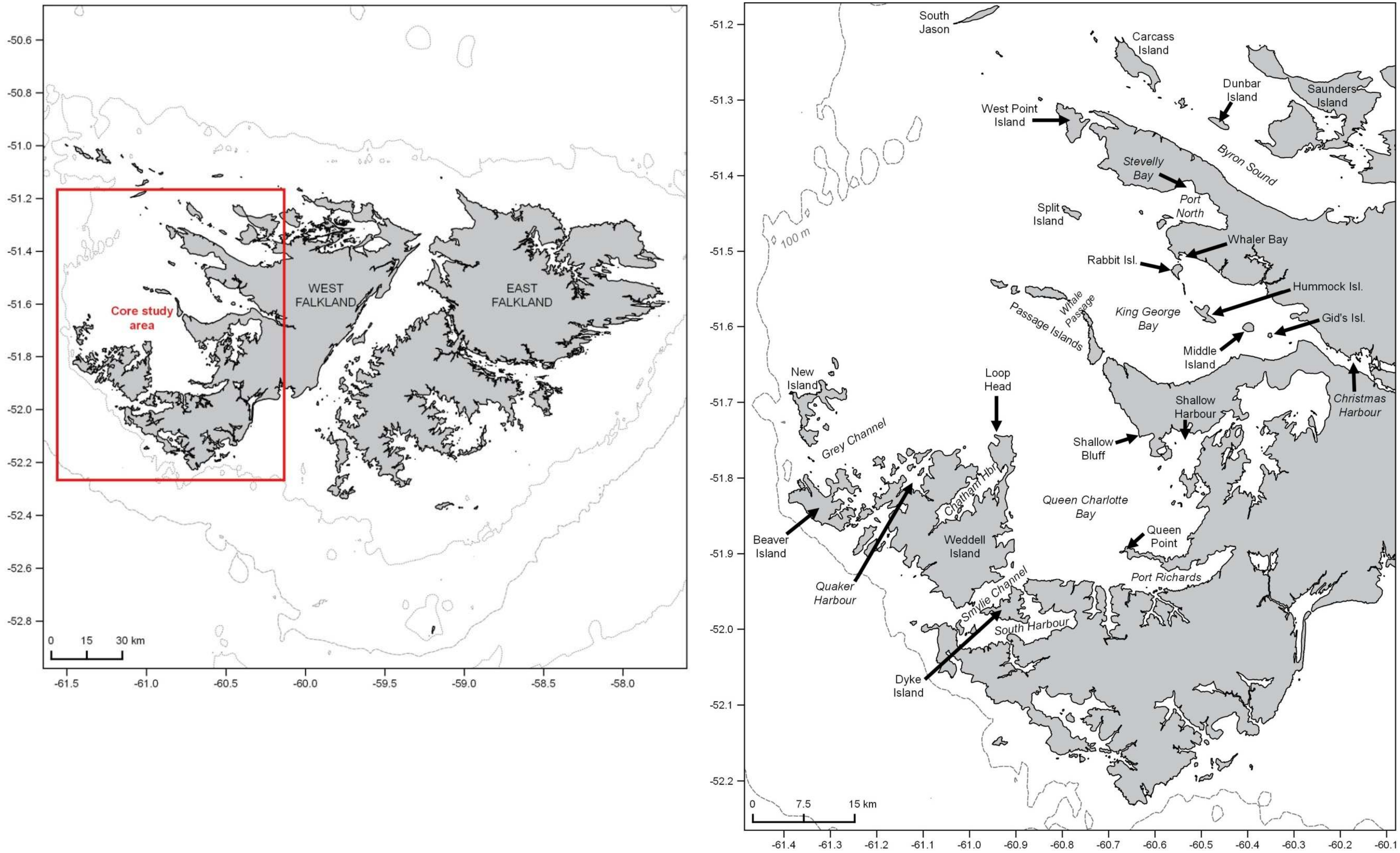


Figure 3.2. The West Falkland study area showing the place names mentioned in the text.

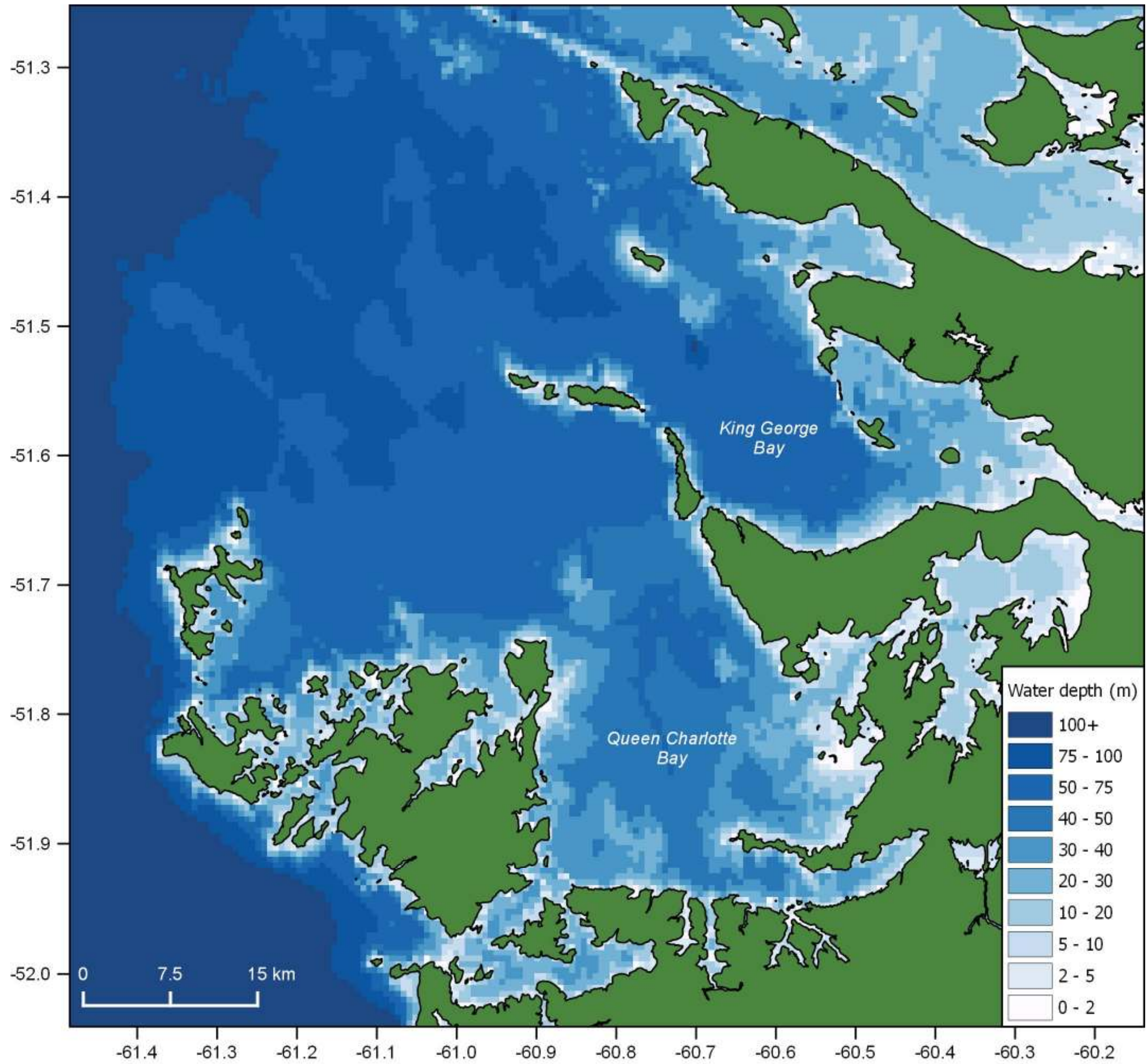


Figure 3.3. Bathymetry (presented as 500 m grid cells) of the West Falkland study area.

4. PRELIMINARY SURVEY

4.1. Introduction and aims

During 2017, FC were contacted by Keri Lee Pashuk and Greg Landreth who own and operate the sailing vessel *Saoirse*. The *Saoirse* was visiting the Falklands in December 2017, and the vessel was made available to FC for a collaboration on a short whale survey. The availability of the *Saoirse* represented a useful opportunity to conduct a preliminary visit to the West Falkland study area during the early part of the sei whale season, to acquire information for comparison with the larger dataset collected during the main February–April 2018 survey described in this report. As an exploratory expedition, the main objectives of the preliminary survey were:

1. To collect standardised data on effort and sightings of cetaceans in coastal Falkland waters during early January, to address a seasonal data gap. This included:
    a. Species identification, to clarify which species were present in the area at this time;
    b. Distributional data, to identify any hotspots of whale occurrence in early January.
2. The collection of photo-identification images where possible, to identify individual cetaceans and assess linkages with other areas.
3. The collection of ancillary data, such as acoustic data, on an ad hoc basis.

4.2. Methods

The 18 m sailing vessel *Saoirse* was used to conduct the preliminary whale survey. The survey was of a flexible nature with the coverage being determined daily according to weather conditions and logistical constraints. To ensure standardisation across the suite of Falkland whale survey work, both effort data and cetacean sighting data were collected whenever the survey was underway. A basic data collection protocol and recording forms were developed by the FC Sei Whale Project Officer (SWPO), and were completed in the field by the observation team which consisted of the skippers, Keri Lee Pashuk and Greg Landreth, and participants comprising:

- 3 to 5 January 2018: Benjamin Keningale, Thomas Farrugia and Nathan Murphy
- 9 to 11 January 2018: Andy Stanworth and Tara Boag

Watches were carried out by between 1 and 3 observers at a time, who searched for cetaceans from the main deck of the *Saoirse* at approximately 3 m eye height. The methods comprised:

- A GPS tracklog was recorded throughout periods of active search effort.
- The start and end times of all watches were recorded, together with the number of observers and basic environmental data comprising Beaufort sea state, swell height and visibility (as defined in Appendix 1). A watch was defined as a period of time that at least one person was actively scanning the sea surface in search of cetaceans (either with their naked eye or with binoculars). For every watch, the "effort status" was logged as: A = Actively searching for cetaceans with the naked eye and binoculars, or C = Cetacean Encounter, when concentrating on a specific sighting to collect information on species, group size, or for photo-identification.
- Data were collected on all cetaceans observed during the survey, including: start and end time of the sighting, initial distance to the sighting (m), species identification, group size (best estimate), group composition (adults, juveniles, calves, unknown age), and overall behaviour. Photographs were taken whenever feasible using a range of the participants own camera equipment.

All data were entered into an Excel spreadsheet by the survey participants, and provided to FC at the end of the survey with the GPS track logs and copies of photographs taken.

4.3. Results

A total of 38.6 hr and 367.3 km of visual survey data were collected from the *Saoirse* from 3 to 11 January 2018 (Table 4.1). The survey effort was distributed primarily between Saunders Island and King George Bay, with a single transit between King George Bay and Beaver Island (Figure 4.1). No survey effort was collected in Queen Charlotte Bay.

Table 4.1. Summary of the visual survey effort data collected from the *Saoirse*, 3–11 January 2018.

Date	Area	Total survey effort	
		hr	km
3 January	North of Saunders, past West Point Island, to Stevelly Bay	8.4	77.57
4 January	Stevelly Bay to King George Bay, back to West Point Island	8.9	68.71
5 January	Byron Sound	4.2	46.54
9 January	Saunders to West Point Island	5.5	58.37
10 January	West Point Island to Stevelly Bay to Hummock Island to Whaler Bay	3.3	33.50
11 January	Hummock Island to King George Bay to Beaver Island	8.4	82.58
Total		*38.6*	*367.29*

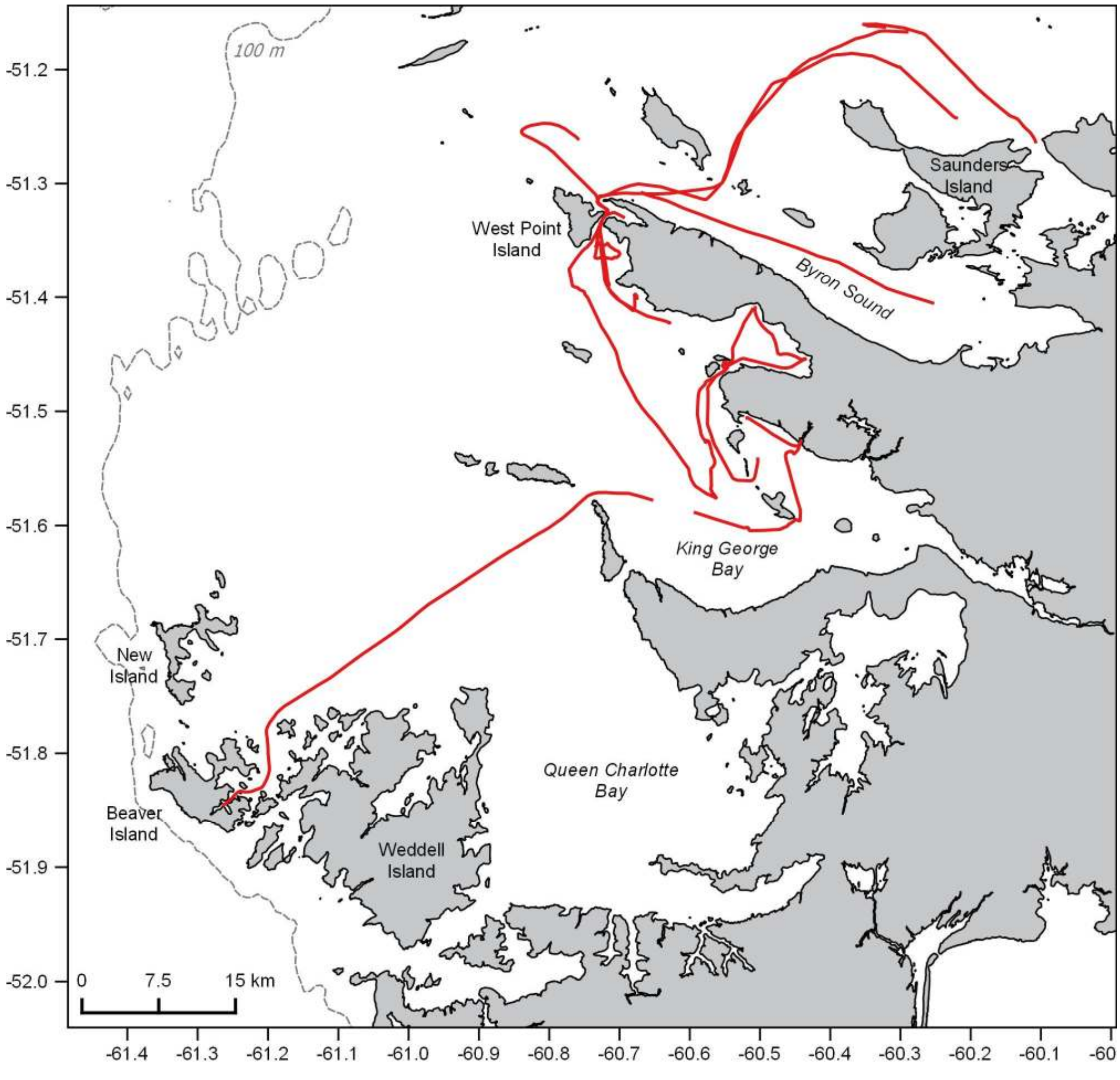


Figure 4.1. Spatial distribution of the visual search effort from the *Saoirse*, 3–11 January 2018.

A total of 91 cetacean sightings was logged during the survey, comprising three confirmed species (Table 4.2). The Commerson's dolphin (*Cephalorhynchus commersonii*) was the most numerous species recorded, with 26 sightings of at least 140 individuals. There were 23 sightings of probable or confirmed sei whales, comprising 55 individuals (Table 4.2). The group size for sei whales ranged from single animals to a group of seven. A further 28 sightings were identified as large baleen whales, and were also likely to have been sei whales.

Table 4.2. Summary of cetacean sightings recorded from the *Saoirse*, 3–11 January 2018.

Cetacean species	Total		Active search		Off effort	
	Sightings	Individuals	Sightings	Individuals	Sightings	Individuals
UNID large baleen whale	28	40	28	40	–	–
Sei whale	23	59	21	55	2	4
Peale's dolphin	8	20*	7	17*	1	3
Commerson's dolphin	26	140*	18	111*	8	29
UNID cetacean	2	2	2	2	–	–
UNID whale	4	5	4	5	–	–
All species combined	*91*	*266^*	*80*	*230^*	*11*	*36*

* Includes single sightings with no group size.
^ Includes two sightings with no group size.

The majority of sei and large baleen whale sightings were recorded to the south of West Point Island, in the northern part of King George Bay (around the Rabbit Islands and Hummock Island), and between the Passage Islands and Beaver Island (Figure 4.2). There were no sightings in Byron Sound. Peale's dolphins (*Lagenorhynchus australis*) and Commerson's dolphins were both recorded in more nearshore areas than the baleen whales (Figure 4.2), with most sightings of Commerson's dolphin occurring off Boxwood Point and in Port North as well as inside Port Egmont.

4.4. Discussion

The preliminary visual survey with the *Saoirse* was successful in acquiring some initial systematic data on the occurrence of sei whales in the West Falkland study area during the early phase of the 2018 season. Existing information on the temporal occurrence of sei whales around the Falklands originates primarily from anecdotal information and opportunistic datasets (i.e. where no measure of associated effort is available), and indicated a presence from December to June with a strong seasonal peak between February and April (Frans and Augé, 2016). The *Saoirse* dataset indicated that sei whales were already present in the West Falkland study area in good numbers during early January, including some sightings recorded within the boundaries of the King George Bay cKBA. Although the vessel did not venture into Queen Charlotte Bay, numerous baleen whale sightings, including some confirmed sei whales, were recorded during the transit between the Passage Islands and Beaver Island, supporting a likely distribution throughout the wider area during January.

This survey demonstrated the value of using platforms of opportunity to collect cetacean data in the Falklands, even over relatively short timeframes. Platforms of opportunity are especially useful to provide baseline information on species occurrence and seasonal variation in regions where the cetacean fauna is poorly-documented (Evans and Hammond, 2004). The success of the *Saoirse* survey suggests that placing observers on other visiting vessels or locally-based ships that are transiting around the Islands may be a useful, and relatively cost-effective, method of collecting additional information on sei whale spatio-temporal distribution in the Falklands.

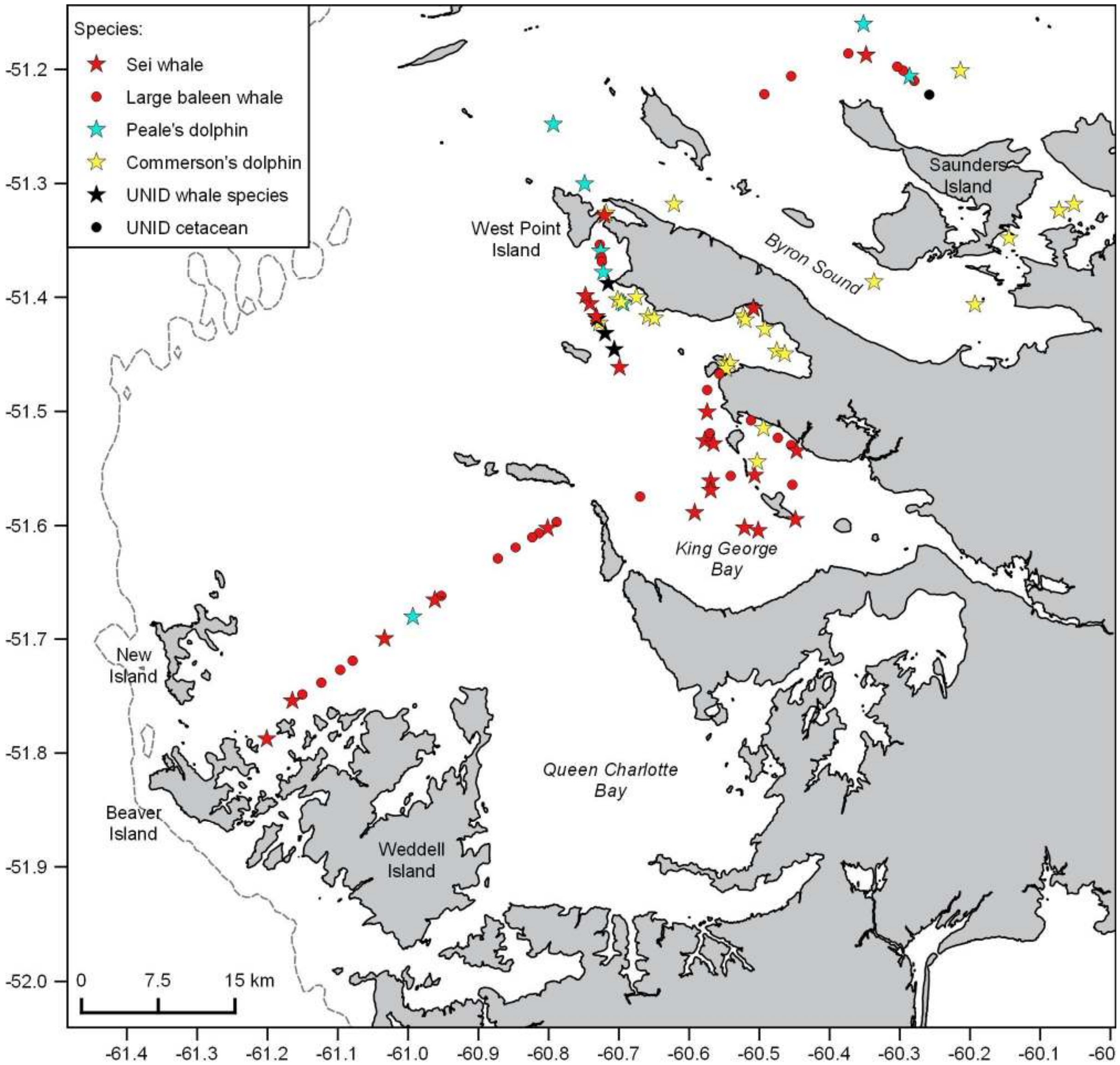


Figure 4.2. The distribution of cetacean sightings recorded from the *Saoirse*, 3–11 January 2018. The locations represent those of the boat when the sightings were initially observed, rather than the exact positions of the animals.

5. VISUAL SIGHTING SURVEY

5.1. Introduction and aims

The West Falkland survey incorporated a standard visual sighting survey to collect information on the spatial distribution and relative occurrence of all cetacean species in the region. The visual survey was also intended to identify suitable sei whale individuals and groups on which to conduct targeted focal follows and approaches for the behavioural, faecal sampling and biopsy sampling components of the project. The primary objectives of the visual survey were:

- To identify which species of baleen whale (and other cetaceans) occur in the study area;
- To assess cetacean spatial distribution and relative abundance;
- To collect data on cetacean group size and composition; and
- To collect information on human activities observed within the study area.

5.2. Methods

5.2.1. Visual survey methods

Dedicated visual watches for cetaceans were carried out every day that the vessel was at sea, including during the transits to and from the West Falkland study area from Stanley. The survey platform was a 19.5 m live-aboard motor-sailing vessel *Golden Fleece* (Figure 5.1), which had a fuel-efficient cruise speed of 7 knots (13 km hr^{-1}). A seated observation box was installed for the survey team on the wheelhouse roof, providing an eye height of 5.1 m above sea level. The vessel operated under motor throughout the survey, and the absence of sails provided a relatively clear view of the 180º observation area forward of the vessel (Figure 5.2). A 4.5 m zodiac was available for closer approaches to whales.

The survey team for the core 4.5 weeks of the project consisted of:

- Caroline Weir - SWPO and Survey Leader (SL);
- Maria Taylor - Research Assistant (RA); and
- Pamela Andrea Quilodrán Jelbes - RA.

During the final 1.5 weeks of the project, Maria Taylor was replaced by Andy Stanworth, and two teams of community participants came onboard the vessel to experience the whale survey work (see Appendix 2). During the latter period, the community participants were encouraged to assist with all aspects of the whale survey, but the core team continued to be responsible for maintaining survey effort and the data entry.

The visual sighting survey comprised two components: (1) a dedicated transect survey (described in Section 5.2.2); and (2) a non-systematic sighting survey (described in Section 5.2.3). The choice of survey type and route was determined on a day-to-day basis depending on the prevailing weather conditions and the distribution of whales at the time. In general, the transects were prioritised for completion as early in the survey as possible, so that a good overview of whale distribution throughout the wider area was acquired in order to inform subsequent behavioural and photo-identification work.

Figure 5.1. The survey vessel *Golden Fleece* at anchor in the study area, showing the observation box on the wheelhouse roof.

Figure 5.2. Observers conducting a visual sighting survey from the observation box.

Similar standardised observation and data recording methods were applied during both visual survey components. The vessel position was continuously logged at 1-min intervals using a handheld GPS, with all other data collected during the survey being linked to the GPS via a timestamp. During the majority of the survey, the effort and sightings data were entered directly into a spreadsheet on a laptop computer in the observation box. During occasional brief periods of rain, paper data recording forms were used instead.

The observation team operated on a rota system, with two observers on watch and one resting to ensure that concentration was maintained throughout the day. The effort status was continuously logged as: (1) Active Search effort (while at least one person was actively scanning the sea surface in search of cetaceans); (2) Cetacean Encounter effort (while working with cetaceans and not actively searching for new animals); or (3) Focal Follow effort (while engaged in a dedicated focal follow of whales with the specific purpose of collecting behavioural data). Periods where the observers were not actively engaged in any of these "on effort" activities (i.e. during rest periods, recovery of the small boat, sample processing etc.) were not entered on the data forms at all.

During periods of Active Search effort, two observers searched for cetaceans using the naked eye, with each scanning a separate 90° quarter (port and starboard) from the beam to the bow. Occasionally during the non-systematic surveys a reduced effort watch was carried out, during which the full 180° area forward of the yacht was scanned by a single observer. For every effort watch, the start and end times were recorded, along with the number of observers, environmental data and effort status. A new row of data was entered whenever conditions changed, for example during observer rotations and when changing from Active Search to Cetacean Encounter effort. Standardised environmental data were recorded throughout the survey in order to assess the quality of the effort data with regard to detecting the target cetacean species. Those data comprised Beaufort sea state, swell height (m), visibility (km), precipitation and sun glare (Appendix 1).

Whenever cetaceans were observed, the following standardised information was recorded: sighting start and end times (recorded directly from the GPS to ensure accurate correlation with positional data), initial bearing (using an angle board) and estimated distance to the sighting, vessel heading, effort status, species identification, group size (minimum, maximum, best estimate), group composition (adults, juveniles, calves, unknown age) and overall behaviour. Binoculars were used to check group sizes and confirm species identifications. Although the survey focus was on large baleen whales, sightings were logged of all cetaceans encountered. When mixed-species groups were observed, the data for each species were recorded as separate rows of data and allocated unique sighting reference numbers but a note of the association was made.

Data on the locations of vessels and any other marine human activities were recorded whenever observed during the visual sighting survey.

5.2.2. Transect survey

A series of predetermined transects were surveyed to ensure a representative distribution of survey effort across the study area in order to: (1) assess sei whale distribution within the cKBAs in the context of the wider area; and (2) ensure that some coverage was acquired in deeper shelf waters (offshore to the 100 m depth contour) where sei whale occurrence is currently largely undocumented in the Falklands.

A 10 km spacing was selected for the transects, based on the expectation that large baleen whale blows would be routinely visible at distances of up to 4 or 5 km from the vessel. A systematic random sampling design was used to plot the transects in the software Distance 6.2 (Thomas et al., 2010), at an angle of 145º (north-west to south-east). This angle was selected so that the transects ran from the coastline out to the 100 m depth contour. Ideally, separate strata would have been implemented for the two bays and for the offshore area, to ensure the most even habitat representation. However, a single strata was selected for practical reasons to minimise logistical constraints with the vessel.

Short transect sections (<1.5 km) were removed from the initial survey design produced by the software, due to the difficulties inherent with manoeuvring the vessel within such shallow enclosed areas. The final design consisted of seven transects, each comprising 1 to 7 separate legs (Table 5.1; Figure 5.3). The total of 353.5 km of trackline theoretically required 27.3 hr of active search effort to complete, at a survey speed of 7 knots (13 km hr^{-1}; Table 5.1). Transects were only surveyed in sea states of Beaufort ≤4 and in good visibility. The transect survey was conducted in passing mode (Dawson et al., 2008), with no deviations being made to approach animals.

Table 5.1. Parameters of the seven transects designed for the visual survey, including estimated survey lengths (calculated in Quantum Geographic Information System, QGIS) and durations.

Transect	Waypoint	Latitude	Longitude	Length (km)	Duration (hr) at 7 knots
1A	1	-51.31295	-60.94097	38.3	3.0
	2	-51.52464	-60.50627		
1B	3	-51.53636	-60.482	22.0	1.7
	4	-51.65708	-60.23058		
2	5	-51.30407	-61.19089	69.0	5.3
	6	-51.68546	-60.40817		
3	7	-51.42335	-61.18104	43.1	3.3
	8	-51.66234	-60.69196		
4	9	-51.46047	-61.33766	77.0	5.9
	10	-51.88713	-60.46126		
5A	11	-51.55105	-61.38627	41.7	3.2
	12	-51.78337	-60.91247		
5B	13	-51.80791	-60.8619	20.1	1.5
	14	-51.91885	-60.63214		
5C	15	-51.93276	-60.60318	8.2	0.6
	16	-51.97794	-60.50891		
6A	17	-51.68156	-61.35414	1.9	0.1
	18	-51.69214	-61.33267		
6B	19	-51.71096	-61.29444	13.4	1.0
	20	-51.78538	-61.14272		
6C	21	-51.787218	-61.138964	1.6	0.1
	22	-51.795992	-61.121003		
6D	23	-51.80024	-61.11231	4.3	0.3
	24	-51.82406	-61.0635		
6E	25	-51.850514	-61.009187	1.9	0.1
	26	-51.860903	-60.987832		
6F	27	-51.91717	-60.87185	7.4	0.6
	28	-51.9581	-60.78713		
7	29	-51.7896	-61.36755	3.7	0.3
	30	-51.81013	-61.32582		

5.2.3. Non-systematic sighting survey

Throughout the remainder of the survey, including the transits to and from West Falkland and non-transect work within the core study area, a non-systematic visual sighting survey was carried out. Vessel routes were selected on a daily basis according to: (1) prevailing weather conditions; (2) the desire to distribute survey effort across the entire area whenever possible; and (3) logistical constraints including crew changes and the availability of suitable moorings. The core aims of the non-systematic sighting survey were to: (1) collect information on sei whale distribution and occurrence throughout the region; and (2) locate sei whales that could be approached for targeted work including photo-identification and behavioural focal follows. Consequently, the surveys were often conducted in closing mode (Dawson et al., 2008), depending on weather conditions and time constraints.

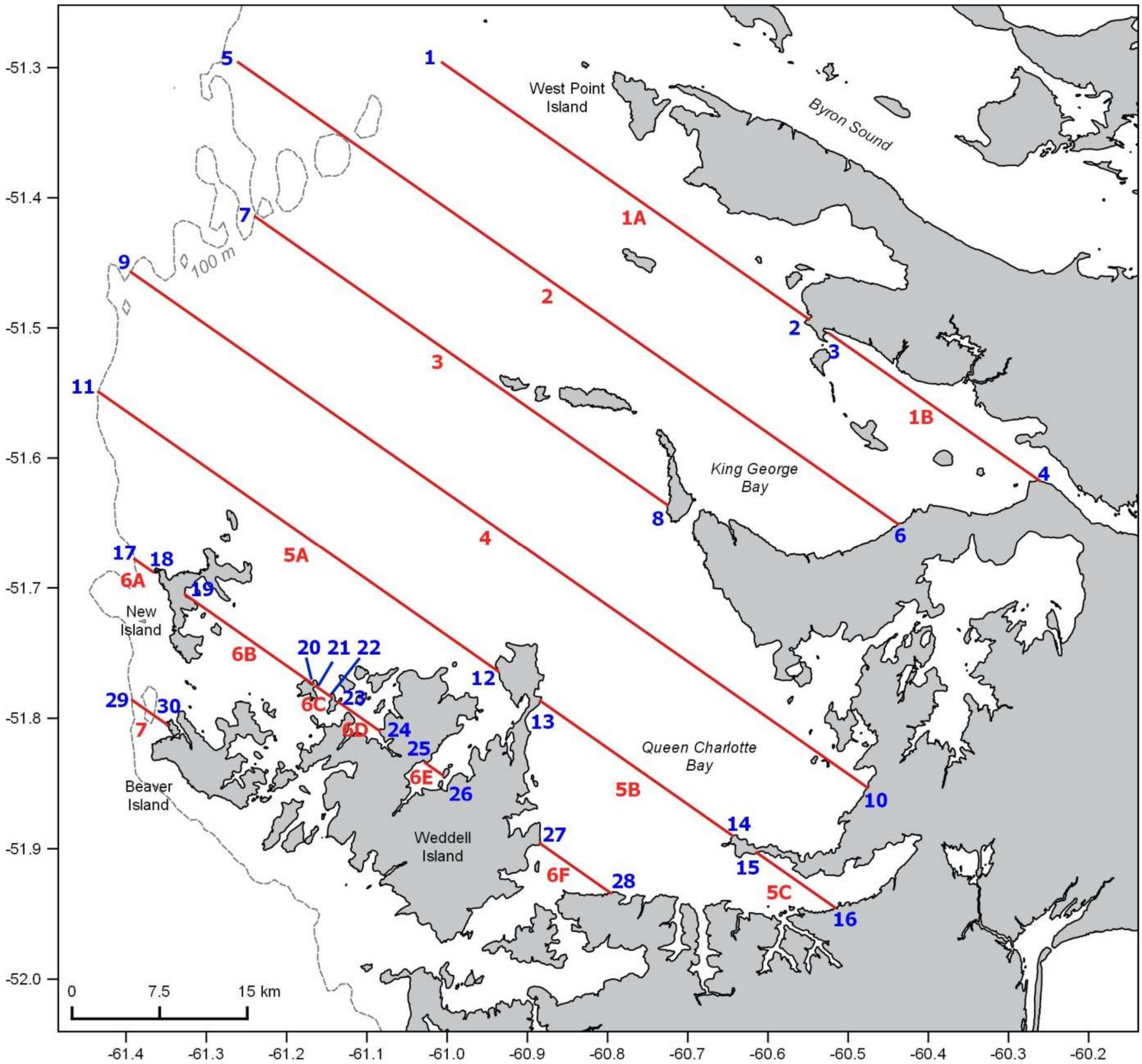


Figure 5.3. The spatial locations of the seven transects (red) and waypoints (blue) in the study area.

5.2.4. Data analysis

All effort and sightings data were entered into standardised Excel databases. A position for each sighting and vessel recorded during the survey was calculated by cross-referencing the observation times with the GPS track log. The positions of all cetacean sightings were recalculated using an Excel worksheet (MacLeod, 2011), based on the angle and estimated distance of the sighting from the vessel GPS position. For a small number of sightings (n = 14) there were no distance or bearing data available, since the sightings had been initially recorded while the survey was off-effort or noted opportunistically while the survey was engaged in a cetacean encounter or focal follow. The uncorrected vessel position was used for those sightings. All mapping was carried out in Quantum Geographic Information System (QGIS; https://qgis.org) using the WGS 84 / UTM zone 21S projection.

Where photo-identification images were available for sei whale encounters, the minimum group sizes obtained via photo-identification were compared with the group size "best estimates" obtained visually. The highest value produced by either method was used in the analysis. For cetacean species other than sei whales, only visual estimates of group size are presented in this report.

Cetacean relative abundance was calculated using various subsets of data, and presented as both the number of sightings and individuals recorded per km of trackline. This is a measure of relative abundance and is not a calculation of density or absolute abundance (Evans and Hammond, 2004). The feasibility of applying absolute abundance modelling to the dataset is being assessed separately during the ongoing analysis work. The most comprehensive relative abundance assessment was carried out using the combined search effort (non-systematic survey and transect survey) dataset, on a subset of effort and associated sightings data collected in favourable weather conditions for detecting cetaceans (Beaufort sea state ≤4, swell of ≤2.5 m, and visibility of >5 km). Relative abundance maps were produced in QGIS, with an initial series of maps developed using different-sized grid cells of 2.5 km, 5 km and 10 km. After initial evaluation, the 5 km grid cell size was selected as the most appropriate unit for analysis. The sighting positions used for relative abundance mapping were the uncorrected boat positions at the time of each initial sighting, since the sightings had to match the associated effort in each grid cell. Consequently, the actual (corrected) positions of cetacean sightings may have fallen in adjacent grid cells, if animals were observed several kilometres from the vessel or if the vessel was close to a grid cell boundary at the time of a sighting. The selection of a 5 km grid cell size meant that no sightings could have occurred further away than an adjacent grid cell, and this limitation should be considered when interpreting the maps. Only grid cells in which >1 km survey coverage was achieved were included in the maps, to minimise falsely-inflated relative abundance values when sightings occurred in grid cells where very small amounts of survey effort had occurred.

5.3. Results

5.3.1. Overview

The survey vessel departed from Stanley on the 22 February 2018 and transited westwards along the north coast of the Falklands towards the study area. Survey work was carried out within the core West Falkland study area from the 25 February to the 31 March. On the 1 April the vessel departed the study area and began transiting eastwards along the south coast of the Falklands, arriving back in Stanley on the morning of 4 April. Vessel-based survey effort was collected on 32 dates between the 22 February and the 4 April (Table 5.2). Ten of the yacht charter days were spent at anchor due to adverse weather conditions, although a small amount of focal follow data was collected from the anchorage on one of them (19 March; Table 5.2). In total, 233.3 hr and 2,591.7 km of survey effort (including non-systematic, transect, encounter and focal follow effort) was carried out during the West Falkland survey (Table 5.2).

5.3.2. Transect survey

The transects were surveyed during the early part of the West Falkland survey, on eight dates between 26 February and 13 March (Table 5.3). All of the transects were completed, comprising a total of 25.8 hr of active search effort and a total realised distance of 346.1 km of trackline (Table 5.3; Figure 5.4). All of the transect survey effort occurred in favourable sea conditions for detecting large whales, with 81.5% of the effort carried out in Beaufort sea states of 1–3 and the remainder in Beaufort 4. All effort was collected in swells of ≤2.5 m and in visibility of ≥11 km.

A total of 241 cetacean sightings was recorded during the transect survey, comprising 439 individuals of four confirmed species (Table 5.4). Sei whales and unidentified large baleen whales (the majority of which were probably also sei whales) were the most frequently-recorded species, and the combined sei whale-baleen whale dataset produced the highest relative abundances in the study area (Table 5.4). The spatial distribution of the transect-associated sightings indicated that sei (and unidentified large baleen) whales were found all along the transects from the coast to the offshore limit at the 100 m depth isobath (Figure 5.4). Sightings were generally more numerous in the central and offshore portions of the transects than in the innermost sections, with the exception of the transect through the northern part of King George Bay where multiple sightings occurred (Figure 5.4).

Table 5.2. Total vessel-based survey effort (all weather conditions) during the West Falkland survey.

Survey No.	Date	Survey effort (hr)				Total hr	Total km
		Active Search	Transect	Cetacean Encounter	Focal follow		
V_1	22 Feb	6.4	–	–	–	6.4	78.5
V_2	23 Feb	10.6	–	1.0	–	11.5	146.2
V_3	24 Feb	1.7	–	–	–	1.7	20.0
V_4	25 Feb	5.6	–	2.5	1.9	10.0	86.4
V_5	26 Feb	3.1	4.5	–	–	7.6	95.8
V_6	28 Feb	4.1	–	–	–	4.1	52.5
V_7	2 Mar	2.7	5.0	0.9	–	8.6	109.7
V_8	3 Mar	5.2	–	1.5	4.8	11.4	86.7
V_9	4 Mar	2.0	8.7	–	–	10.8	143.0
V_10	5 Mar	5.6	1.1	–	0.7	7.5	87.7
V_11	6 Mar	4.2	–	0.3	3.5	8.0	68.5
V_12	7 Mar	4.7	4.7	1.6	–	11.0	139.6
V_13	8 Mar	3.6	1.2	0.4	–	5.2	59.2
V_14	10 Mar	8.1	0.4	0.5	1.5	10.5	119.6
V_15	13 Mar	3.8	0.2	1.9	–	5.9	64.1
V_16	14 Mar	8.7	–	–	0.9	9.6	103.5
V_17	15 Mar	6.5	–	1.7	2.0	10.2	94.9
V_18	16 Mar	1.8	–	4.6	0.9	7.2	52.3
V_19	17 Mar	1.0	–	1.9	0.1	3.1	20.7
At anchor	19 Mar	–	–	–	0.6	0.6	0.0
V_20	20 Mar	3.0	–	2.5	–	5.5	52.4
V_21	23 Mar	9.9	–	–	–	9.9	124.2
V_22	24 Mar	2.8	–	0.4	1.4	4.5	46.2
V_23	25 Mar	6.4	–	0.3	1.7	8.3	96.0
V_24	26 Mar	2.5	–	1.1	1.2	4.8	46.5
V_25	27 Mar	6.5	–	1.2	–	7.7	90.3
V_26	28 Mar	1.2	–	4.4	0.1	5.7	37.8
V_27	29 Mar	3.5	–	–	–	3.5	44.5
V_28	31 Mar	4.0	–	–	–	4.0	44.7
V_29	1 Apr	9.6	–	–	–	9.6	129.6
V_30	2 Apr	9.1	–	0.4	–	9.5	120.2
V_31	3 Apr	7.8	–	–	–	7.8	107.0
V_32	4 Apr	1.8	–	–	–	1.8	23.3
Total		*157.2*	*25.8*	*29.1*	*21.1*	*233.3*	*2591.7*

Table 5.3. Summary of transect survey effort completed during the West Falkland survey.

Transect	Segment	Waypoints	Survey date	Realised survey effort	
				Duration (hr)	Distance (km)
1	A	2 to 1	26 Feb	2.87	37.75
1	B	3 to 4	26 Feb	1.67	21.54
2	Leg 1	5 to 6	2 Mar	3.53	49.23
2	Leg 2	–	2 Mar	1.45	19.77
3	–	8 to 7	4 Mar	3.28	42.76
4	Leg 1	9 to 10	4 Mar	5.18	72.07
4	Leg 2	–	4 Mar	0.27	3.51
5	A	12 to 11	7 Mar	3.17	41.65
5	B	14 to 13	7 Mar	1.48	19.10
5	C	15 to 16	5 Mar	0.58	7.93
6	A	18 to 17	10 Mar	0.15	2.00
6	B	19 to 20	8 Mar	0.8	10.93
6	C	21 to 22	8 Mar	0.08	1.09
6	D	23 to 24	8 Mar	0.33	4.17
6	E	27 to 28	13 Mar	0.17	2.01
6	F	27 to 28	5 Mar	0.53	7.08
7	–	30 to 29	10 Mar	0.28	3.53
Total				*25.82*	*346.13*

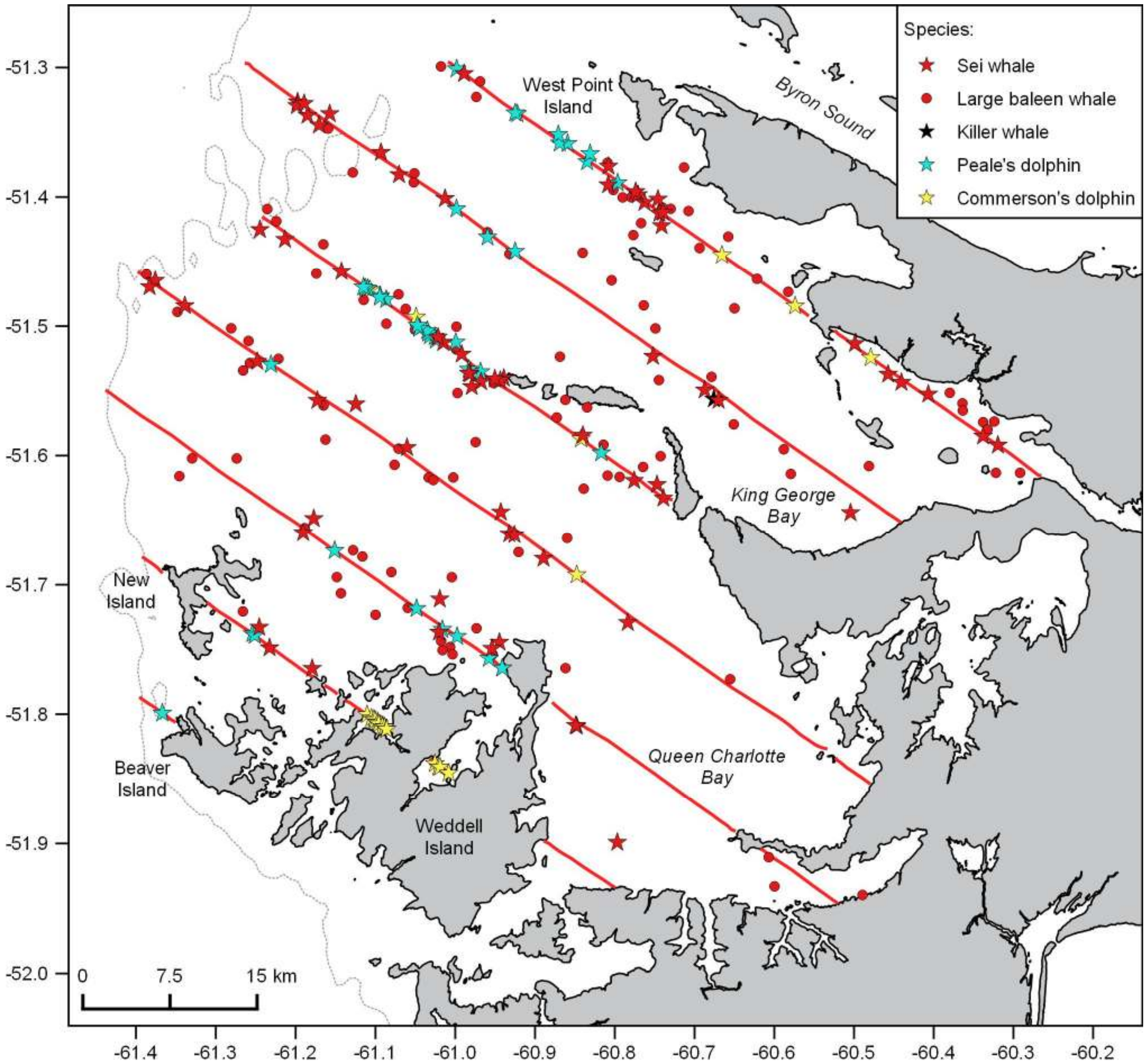


Figure 5.4. The spatial distribution of realised transect effort (25.8 hr) and associated cetacean sightings during the West Falkland survey.

Table 5.4. Summary of cetacean sightings recorded during the West Falkland transect survey.

Species	Total		Relative abundance	
	Sightings	Individuals	Sightings / km	Individuals / km
Sei whale	70	118	0.202	0.341
UNID baleen whale	106	130	0.306	0.376
Combined sei + UNID baleen whale	*176*	*248*	*0.508*	*0.717*
Killer whale	1	1	0.003	0.003
Peale's dolphin	39	132	0.113	0.381
Commerson's dolphin	25	58	0.072	0.168
Total	*241*	*439*	*0.696*	*1.268*

The distribution of Peale's and Commerson's dolphins along the transects revealed some apparent niche separation, with Peale's dolphins exhibiting a more pelagic occurrence in open waters, and Commerson's dolphins more numerous in the nearshore areas especially within Chatham Harbour and Quaker Harbour on the north coast of Weddell Island (Figure 5.4). However, the two species did also overlap; in the open waters northwest of the Passage Islands (Transect 3) there were several sightings of Commerson's and Peale's dolphins where each species was initially detected as separate groups but subsequently merged while bow-riding the yacht together. The only sighting of a killer whale

(*Orcinus orca*) during the transects was a single bull observed in King George Bay in proximity to sei whales.

5.3.3. Non-systematic sighting survey

Active search effort associated with the non-systematic (i.e. non transect) visual sighting survey was collected on all survey days when the vessel was at sea (Table 5.2). It was the predominant form of data collection during the circumnavigation of the Falklands, between the transect work, and when weather conditions were unsuitable for conducting whale approaches. A total of 157.2 hr and 1959.6 km of non-systematic active search effort was carried out, with up to 10.6 hr of effort per day (Table 5.2). The majority (89.8%) of the active search effort was collected in Beaufort sea states of 2–4, with 5.9% collected in unfavourable conditions of Beaufort 5 or 6 (Figure 5.5A). Most of the effort occurred in favourable swell and visibility conditions, but 1.8% of the data was collected in swell heights of >2.5 m, and 0.7% in visibility of ≤5 km (Figure 5.5). The spatial distribution of the non-systematic survey effort included a complete circumnavigation of the Falkland Islands (as a single trackline), together with more concentrated effort throughout the core West Falkland study area (Figure 5.6).

A total of 1,030 cetacean sightings, comprising a minimum of 1,998 individuals, was recorded in association with the non-systematic active search effort (Table 5.5). In agreement with the transect dataset, sei whales and unidentified large baleen whales were both the most frequently-recorded and numerous species (Table 5.5). The relative abundances recorded for cetaceans during the non-systematic survey were generally comparable with, but consistently lower, than those generated by the transect survey (Table 5.5). However, the relative abundance of both sightings and individual Peale's dolphins was much higher during the transect survey compared with the non-systematic survey, probably due to the more representative inclusion of open water habitat in the former survey type. Cetacean sightings were distributed all around the Falkland Islands, but with a relative scarcity of sightings along the south and south-west coasts where the 100 m depth isobath is located closer to shore compared to the other areas (Figure 5.6). The distribution of each cetacean species is considered further in Section 5.3.5.

Table 5.5. Summary of cetacean sightings recorded during the non-systematic visual sighting survey.

Species	Total		Relative abundance	
	Sightings	Individuals	Sightings / km	Individuals / km
Sei whale	315	559	0.161	0.285
UNID baleen whale	476	607	0.243	0.310
Combined sei + UNID baleen whale	*791*	*1,166*	*0.404*	*0.595*
Killer whale	2	12	0.001	0.006
Peale's dolphin	125	423	0.064	0.216
Peale's/dusky dolphin	1	7	0.001	0.004
Commerson's dolphin	109	383	0.056	0.195
UNID dolphin	2	7	0.001	0.004
Total	*1,030*	*1,998*	*0.526*	*1.020*

5.3.4. Combined search effort

Sections 5.3.2 and 5.3.3 provided a breakdown of the survey effort and associated cetacean sightings recorded during the transect and non-systematic survey methods respectively, to allow for comparison between, and individual assessment of, the two survey types with regard to coverage and approach. However, for calculating relative abundance and assessing overall cetacean distribution then a combined search effort database was used.

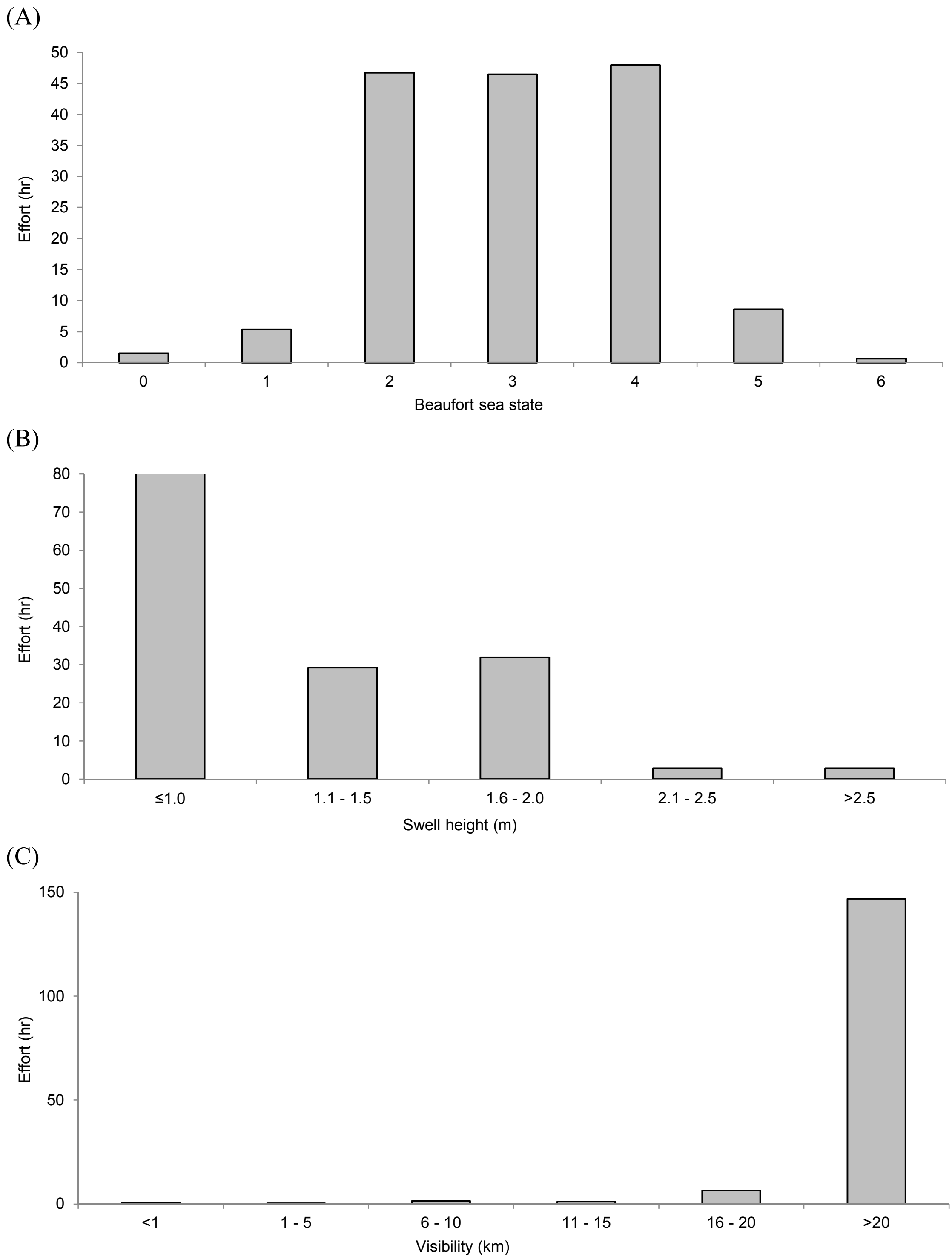


Figure 5.5. Weather conditions during the non-systematic active search effort (157.2 hr; Table 5.2): (A) Beaufort sea state; (B) swell height; and (C) visibility (km).

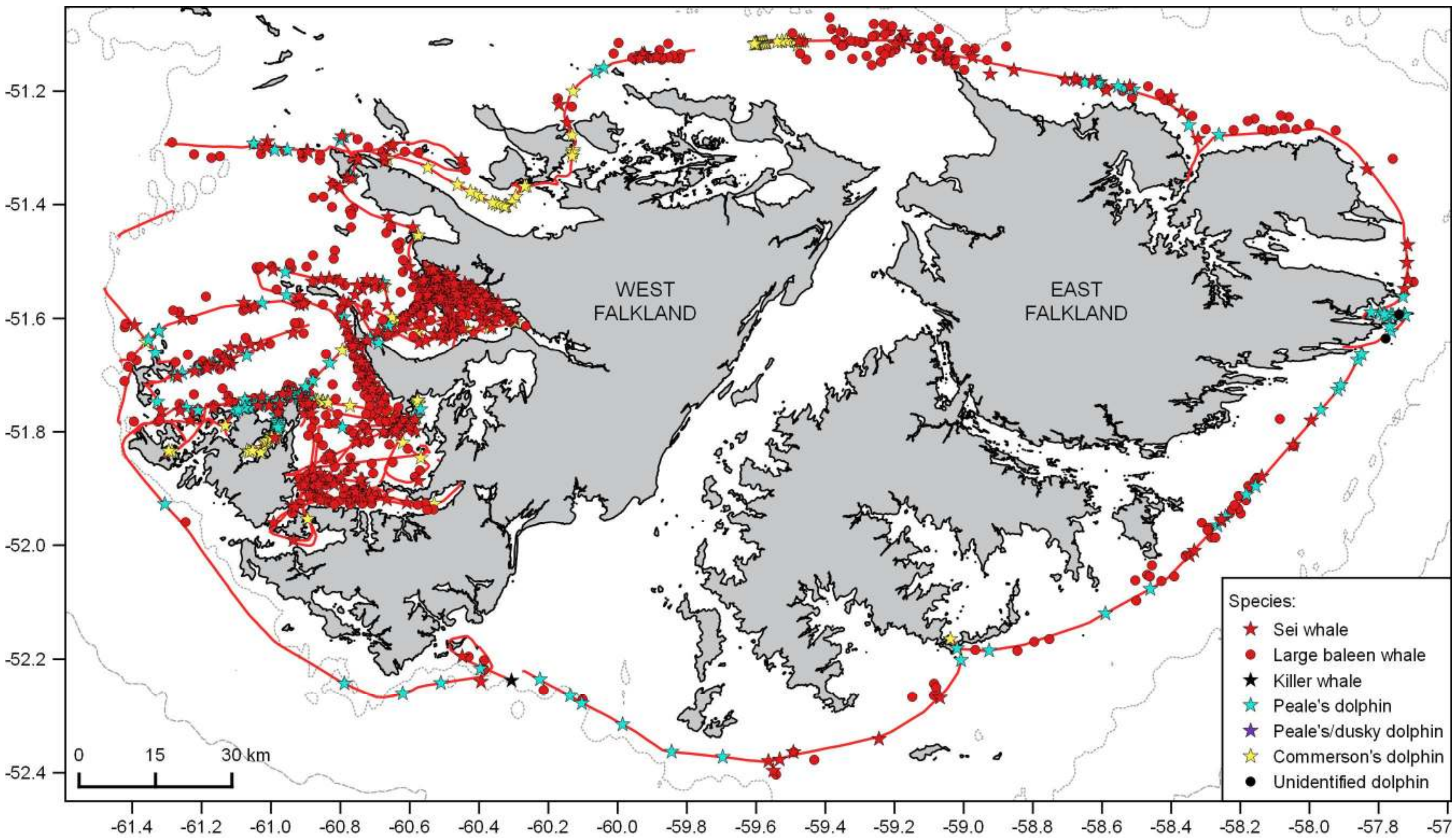


Figure 5.6. The spatial distribution of non-systematic active search effort (157.2 hr) and associated cetacean sightings during the West Falkland survey.

A total of 183.1 hr and 2,305.7 km of visual search effort (i.e. combined non-systematic active search surveys and transect surveys) was collected. The overall weather conditions during the combined search effort are shown in Figure 5.7. The majority of search effort occurred in relatively low swell heights of ≤2 m and in excellent visibility. However, only 32.8% of the total search effort was carried out in Beaufort sea states of ≤2, which are considered favourable for the visual detection of most cetaceans. The remaining 67.2% of search effort occurred in Beaufort sea states of 3 to 6, where the presence of whitecaps may affect the detection of animals, especially smaller species. A total of 5.2% of the search effort was in Beaufort sea state 5 or 6 (Figure 5.7), where significant white caps and spray may also have affected the visual detection of large whales. The total amount of combined search effort collected in weather conditions considered favourable for calculating cetacean relative abundance (Beaufort sea state ≤4, swell of ≤2.5 m, and visibility of >5 km) was 171.8 hr and 2,168.3 km.

The spatial distribution of the combined search effort is shown in Figure 5.8. The effort includes the full circumnavigation of the Islands, the transect coverage, and all of the non-systematic search effort in King George Bay, Queen Charlotte Bay, and to a lesser extent around Byron Sound, New Island, the Passage Islands, Dyke Island and Port Richards. Small parts of the circumnavigation around the Islands were omitted when only the search effort collected in favourable weather conditions was mapped (Figure 5.8B).

When summed as 5 km grid cells (i.e. for cetacean relative abundance calculations), most of the grid cells surveyed on the circumnavigation around the Falklands contained fewer than 6 km of total combined search effort (Figure 5.9). The highest concentrations of search effort occurred in King George Bay and the south-western part of Queen Charlotte Bay, with moderate amounts of search effort acquired throughout most of the core West Falkland survey area (Figure 5.9).

5.3.5. Cetacean sightings

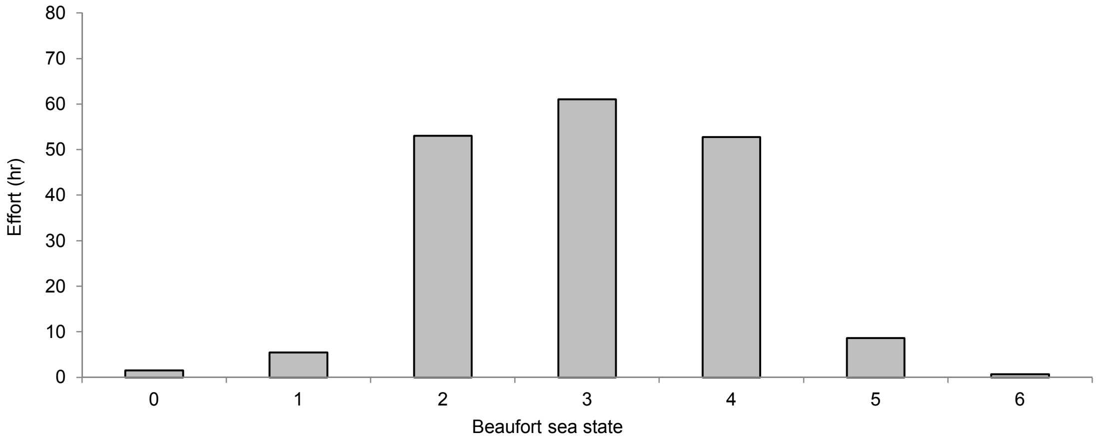
5.3.5.1. Overview

A cumulative total of 1,342 cetacean sightings was recorded during the West Falkland survey, confirming the occurrence of four species: sei whale, killer whale, Peale's dolphin and Commerson's dolphin (Table 5.6). The majority (94.7%) of cetacean sightings were associated with combined visual search effort from either the transect survey (n = 241) or the non-systematic visual sighting survey (n = 1,030). A further 44 sightings were initially-recorded while the survey was already engaged with cetacean groups, either during encounter effort or focal follows. The remaining 27 sightings were recorded opportunistically and outside of the targeted survey effort. These mostly comprised dolphins observed at the anchorages, or sei whales that were recorded when effort had been suspended due to poor weather or to avoid duplicate counting when the vessel did a return trip through exactly the same area.

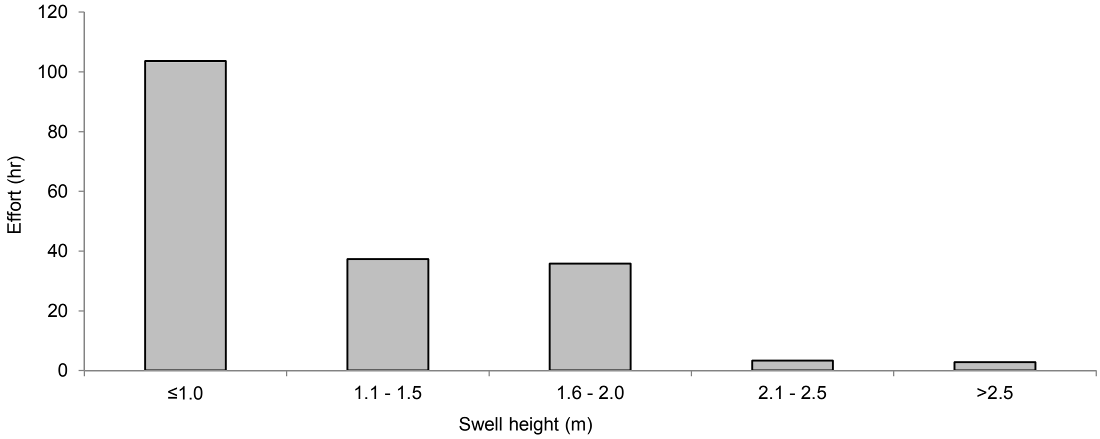
Table 5.6. Summary of cetacean sightings recorded during the West Falkland survey, February to April 2018.

Species	Total		No. of sightings by survey status			
	Sightings	Indiv.	Active Search	Transect	Cetacean encounter / Focal follow	Off effort
Sei whale	418	758	315	70	18	15
UNID baleen whale	594	751	476	106	11	1
Killer whale	3	13	2	1	0	0
Peale's dolphin	170	581	125	39	5	1
Peale's/dusky dolphin	1	7	1	0	0	0
Commerson's dolphin	154	602	109	25	10	10
UNID dolphin	2	7	2	0	0	0
Total	*1,342*	*2,719*	*1,030*	*241*	*44*	*27*

(A)



(B)



(C)

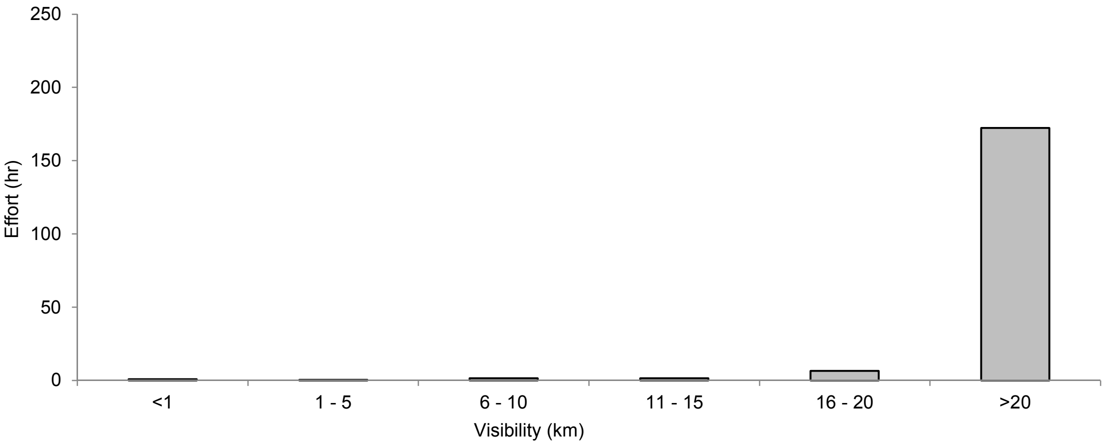
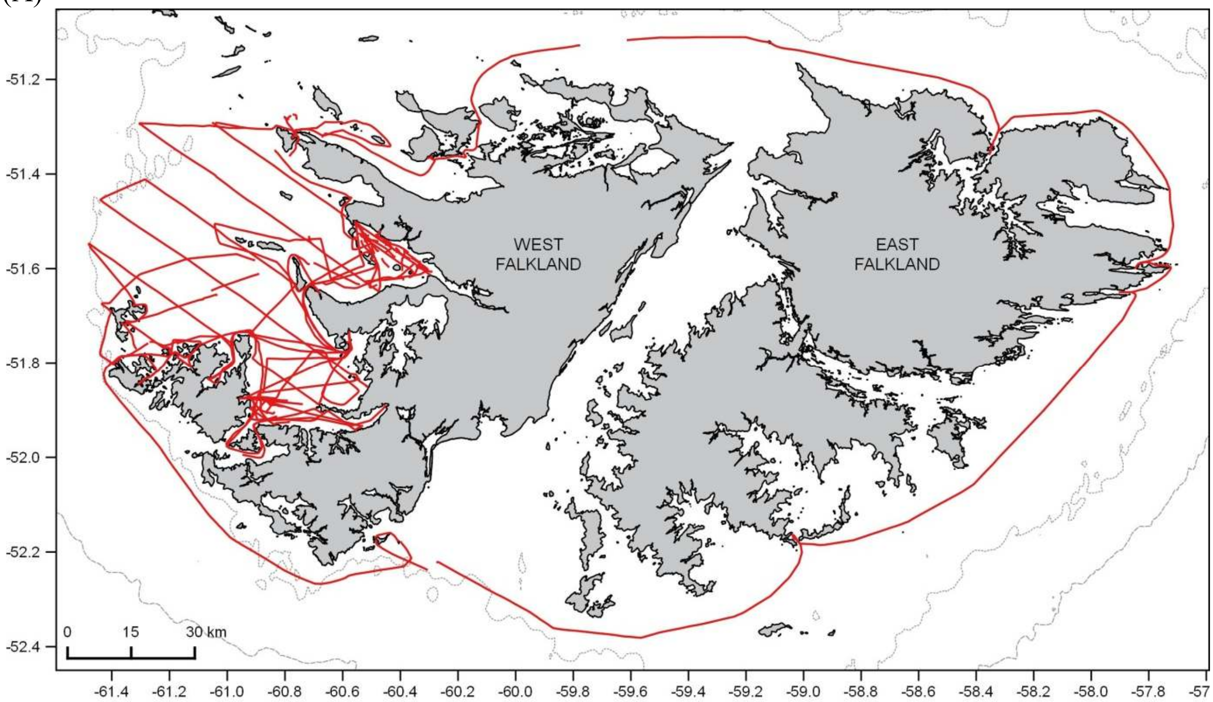


Figure 5.7. Weather conditions during all combined visual search effort (non-systematic search and transect effort: 183.1 hr): (A) Beaufort sea state; (B) swell height; and (C) visibility (km).

(A)



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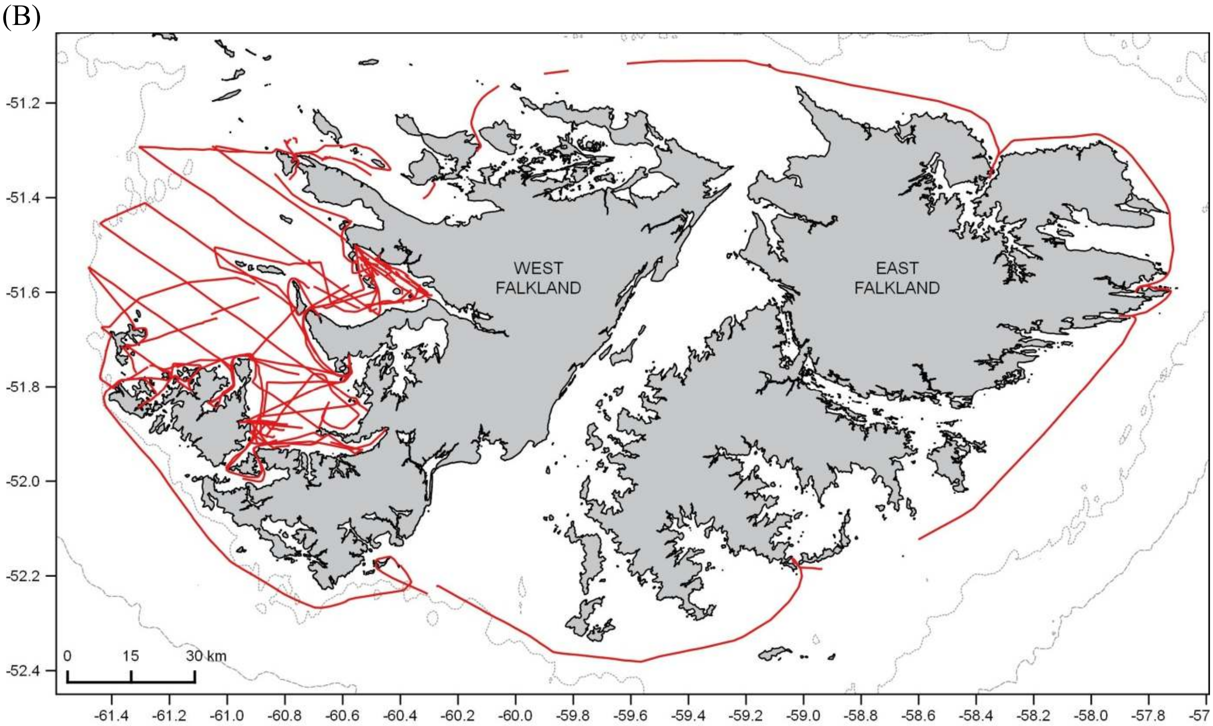


Figure 5.8. The spatial distribution of: (A) all combined search effort (183.1 hr); and (B) combined search effort in favourable weather conditions (Beaufort sea state ≤4, swell of ≤2.5 m, and visibility of >5 km: 171.8 hr).

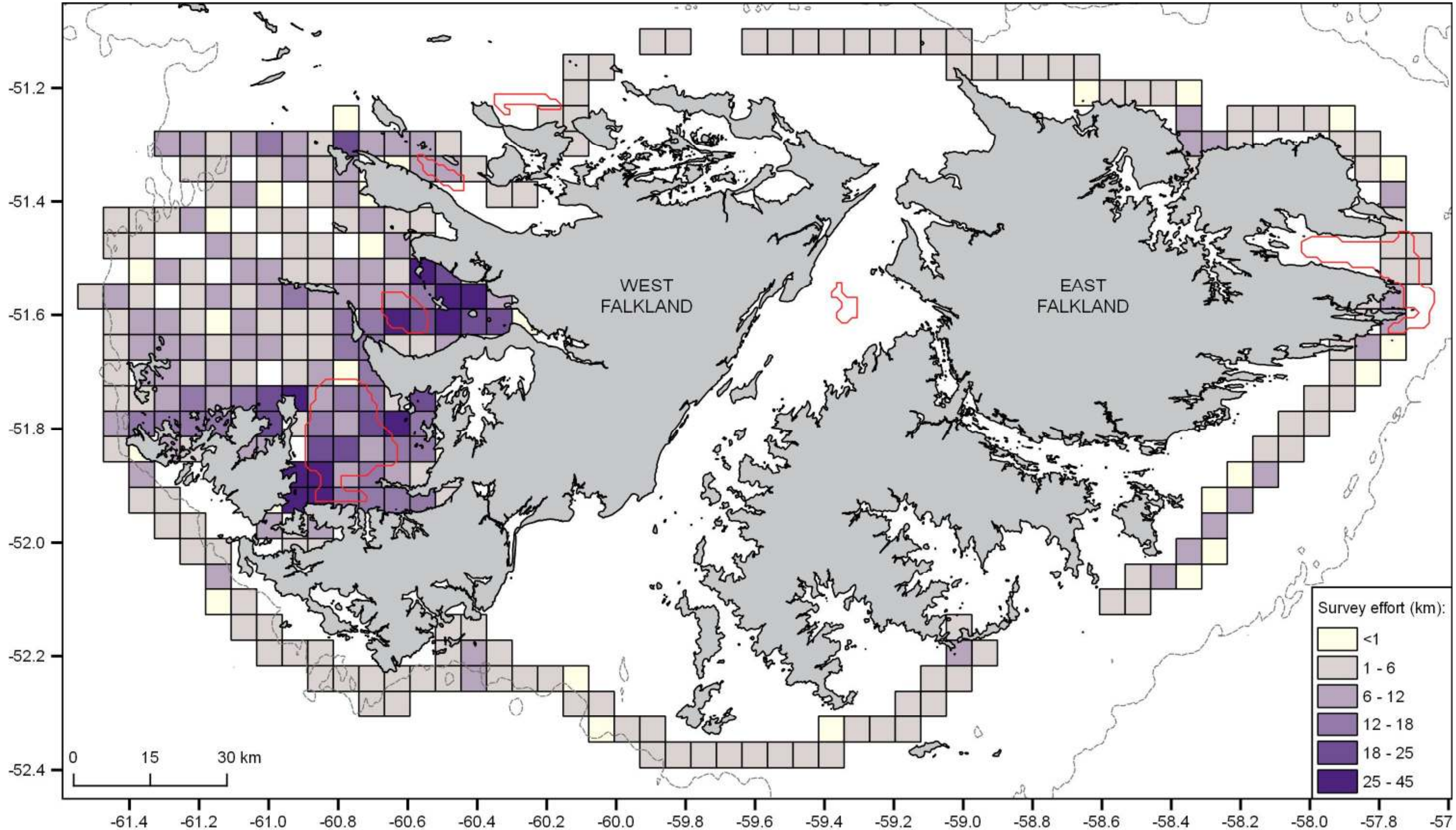


Figure 5.9. The spatial distribution (5 km grid cells) of combined search effort collected in favourable weather conditions (Beaufort sea state ≤4, swell of ≤2.5 m, and visibility of >5 km: 171.8 hr).

The sei whale was both the most frequently-sighted and the most numerous species recorded (Table 5.6). A large number of unidentified large baleen whales were also observed; in most cases these comprised vertical blows seen at distance or on days where swell prevented the back and dorsal fin from being observed to confirm the species. However, since the sei whale was the only baleen whale species to be positively-identified during the survey work, it is considered likely that most, if not all, of the unidentified large baleen whales also comprised sei whales.

Three species of dolphin were recorded during the survey, with Peale's and Commerson's dolphins comprising most of the sightings and being observed in similar numbers. There were three sightings of killer whales; all were of typical morphological appearance with no individuals having unusual eye patches or dorsal capes indicative of Antarctic Type B or C whales (Pitman and Ensor, 2003; Figure 5.10).

Some of the sei whale sightings recorded during the survey comprised encounters with the same animals (as proven by photo-identification), and consequently there are known to be some repeat sightings of individuals within the total dataset. This is also the likely to be true for the smaller dolphin species. However, photo-identification during the three killer whale sightings confirmed that each sighting of that species was comprised of unique individuals.

5.3.5.2. Group size and composition

All of the cetacean species recorded during the West Falkland study area were generally observed in small groups, with mean and median values of fewer than five animals (Table 5.7).

Table 5.7. Cetacean group sizes recorded during the West Falkland survey.

Species	Sightings	Group size				
		Mean	SD	Median	Min.	Max.
Sei whale	418	1.8	1.2	1.0	1.0	11.0
UNID baleen whale	594	1.3	0.6	1.0	1.0	5.0
Killer whale	3	4.3	2.0	4.0	1.0	8.0
Peale's dolphin	170	3.4	2.1	3.0	1.0	20.0
Peale's/dusky dolphin	1	7.0	–	–	7.0	7.0
Commerson's dolphin	154	3.9	4.8	3.0	1.0	50.0
UNID dolphin	2	3.5	2.1	3.5	2.0	5.0
Total	*1,342*	*2.0*	*2.2*	*1.0*	*1.0*	*50.0*

The majority of sei whale sightings consisted either of single animals (53.8%), or small groups of two to three animals (38.8%: Figure 5.11A). The overall mean and median group sizes were 1.8 and 1.0 animals respectively (Table 5.7). The maximum group size recorded was a loose group of 11 feeding animals. In general, it proved challenging to age sei whales in the field due to the distance and brevity of many of the sightings, and because animals considered to be adults showed noticeable variation in overall length, robustness and proportions (i.e. relative dorsal fin size). However, no obvious calves were observed during the survey. The majority of animals were considered to be adults, but three sightings contained at least one juvenile.

The three killer whale sightings comprised a single bull, and groups of four and eight animals. Most Peale's dolphin sightings comprised two to four animals (67.6%; Figure 5.11B), with overall mean and median group sizes of 3.4 and 3.0 animals respectively (Table 5.7). There was only one sighting that contained more than 10 animals; a group of 20 Peale's dolphins recorded on 7 March. Calves were observed in 23 sightings and juveniles in 22 sightings. Commerson's dolphins primarily occurred in schools of one to five animals (85.1% of sightings; Figure 5.11C). Three schools exceeded 12 animals; groups of 20, 25 and 50 animals that likely represented numerous smaller units that aggregated while bow-riding, socialising or foraging. Thirty-eight Commerson's dolphin sightings included calves, and 15 included juveniles.

(A)

(B)

(C)

Figure 5.10. Photographs of killer whales from the three sightings during the West Falkland survey, showing the appearance of their eye and saddle patches: (A) 2 March 2018; (B) 7 March 2018; and (C) 2 April 2018.

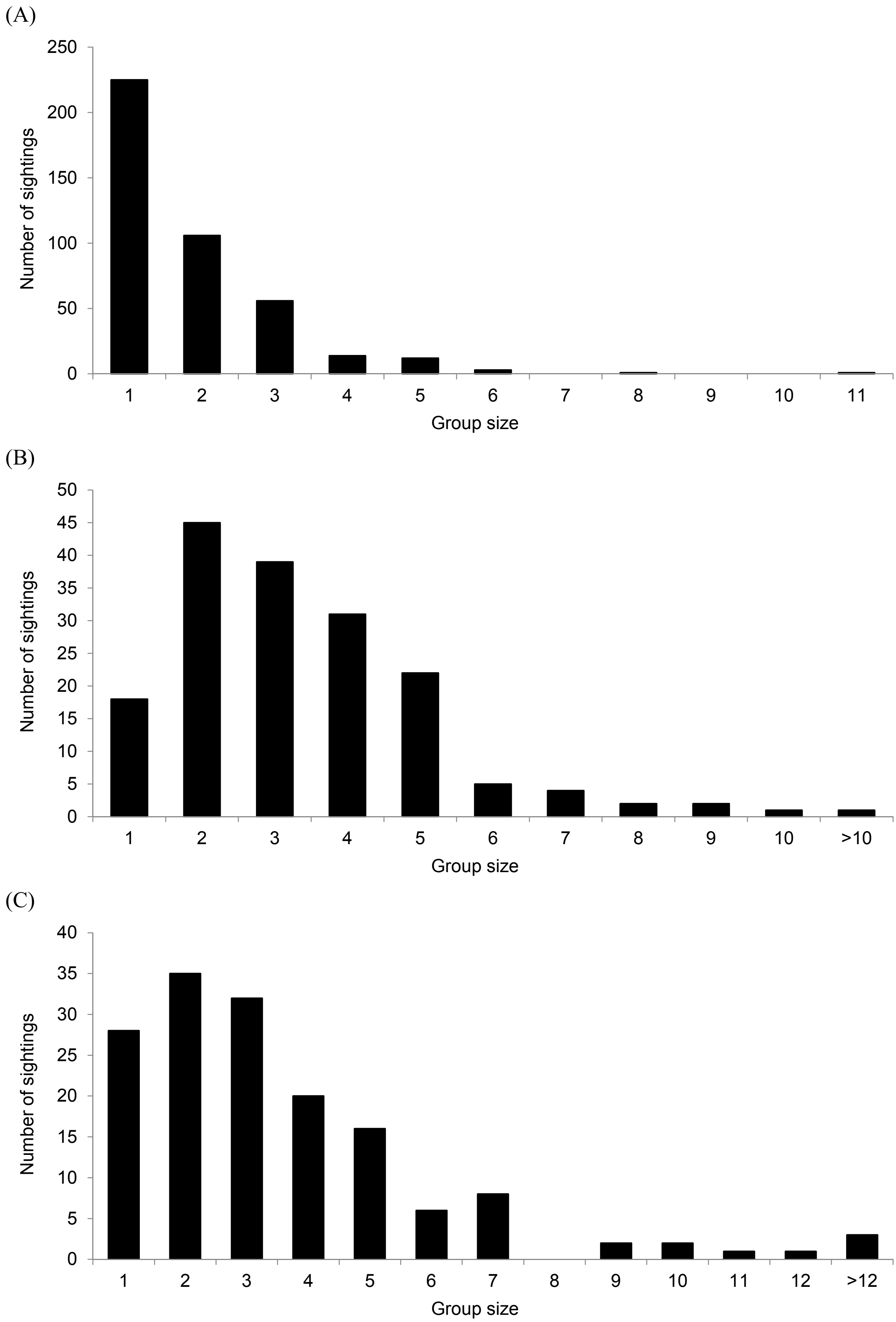


Figure 5.11. Group sizes for the three most frequently-sighted cetacean species recorded during the sightings survey: (A) sei whale; (B) Peale's dolphin; and (C) Commerson's dolphin.

5.3.5.3. Sei and baleen whale distribution

Since it is likely that most, if not all, unidentified baleen whales were sei whales, the distributions of all baleen whales are evaluated here together. Sei and baleen whales were distributed throughout most areas where search effort occurred, including the mouth of Berkeley Sound, along the north coast of the Falklands, throughout the core study area off the west coast of West Falkland, and along the south-east coast (Figures 5.12 and 5.13). Gaps in occurrence were most notable in the central area of Byron Sound, and along the south and south-west coasts of the Falklands. On the circumnavigation, particular concentrations of sightings were recorded north of the northern entrance to Falkland Sound (around Eddystone Rock), north-west of Pebble Island and to the east of Lively Island. Within the core West Falkland study area, sei and baleen whales were distributed from the innermost coastal areas close to shore, to the 100 depth isobath at the offshore boundary of the survey area (Figures 5.12 and 5.13). Nearshore sightings were documented inside Port Richards, at the entrances to Christmas Harbour and Shallow Harbour, in Hope Harbour near West Point Island, in East Passage between the Passage Islands and West Falkland, inside Smylie Channel and South Harbour near Dyke Island, and in Chatham Harbour. While Figures 5.12 and 5.13 indicate that the north-eastern part of King George Bay, to the north-east of Rabbit Island, Hummock Island and Middle Island, produced the highest number of sightings in the survey area, it should be emphasised that relatively more survey time was spent in that area than elsewhere. This was partially the result of the region being more sheltered from weather than more exposed parts of the study area, which meant that it was sometimes workable for photo-identification purposes when sea conditions elsewhere were too poor.

To account for variation in survey effort between the areas, the relative abundance of baleen whales was calculated (Figures 5.14 to 5.16). The overall relative abundance of sei whales in the study area was 0.17 sightings/km and 0.31 individuals/km (Table 5.8). The relative abundance per 5 km grid cell ranged from 0.05 to 2.06 individuals/km, with north-east King George Bay and the waters east of New Island producing adjacent grid cells of high relative abundance (Figure 5.14). Unidentified large baleen whales had a relative abundance per 5 km grid cell of 0.06 to 2.95 individuals/km, with similar core areas as for sei whales but also with high relative abundance to the north of Falkland Sound (Figure 5.15). Finally, when combined sei and unidentified large baleen whales were considered together, the relative abundance values ranged from 0.05 to 4.79 individuals/km, with 16 grid cells having values that exceeded 2.0 animals/km (Figure 5.16). The grid cells of highest value were predominantly distributed in north-eastern King George Bay, to the east of New Island, and along the north coast of the Falklands from Cape Dolphin westwards to the north of Pebble Island (Figure 5.16). However, it is apparent that confirmed and probable sei whales were widely-distributed across the West Falkland study area, with grid cells of high relative abundance scattered throughout the region.

Table 5.8. Overall relative abundance of cetaceans calculated using combined search effort collected in favourable weather conditions (171.8 hr / 2,168.3 km).

Species	Total		Relative abundance	
	Sightings	Individuals	Sightings / km	Individuals / km
Sei whale	377	664	0.174	0.306
UNID baleen whale	552	702	0.255	0.324
Combined sei + UNID baleen whale	*929*	*1,366*	*0.428*	*0.630*
Killer whale	3	13	0.001	0.006
Peale's dolphin	162	551	0.075	0.254
Commerson's dolphin	117	399	0.054	0.184

Similar values for water depth and distance from shore were produced for the sei whale and unidentified large baleen whale datasets, with sightings occurring in mean water depths of 41.7 and 47.0 m respectively, and at mean distances from shore of 3.6 and 4.6 km respectively (Table 5.9). Sei whale sightings were widely-distributed across depth bands (using raw data, uncorrected for effort), with most sightings (83.3%) initially located in water depths of 20 to 69 m (Figure 5.17).

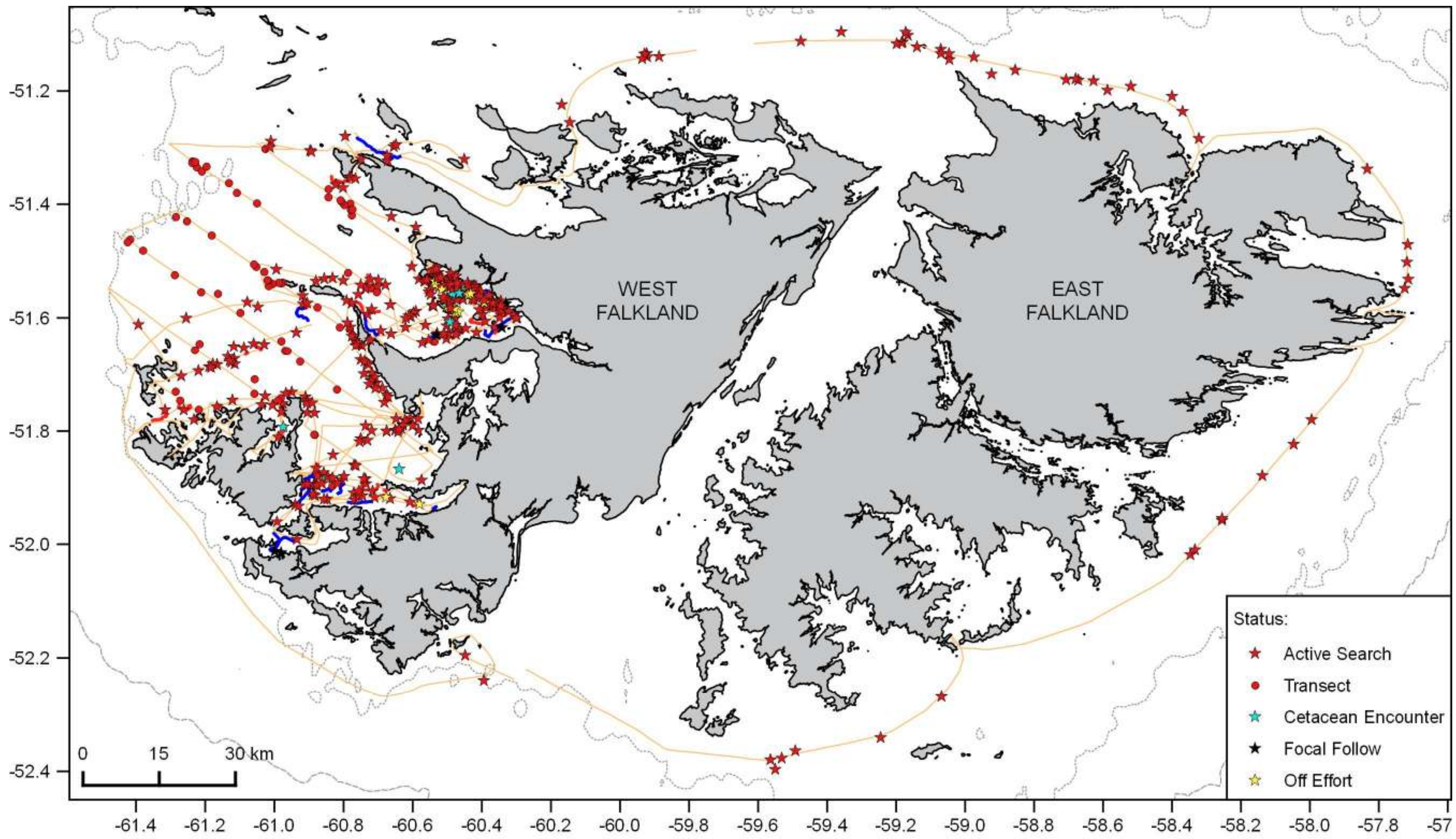


Figure 5.12. The spatial distribution of sei whale sightings, sei whale encounter effort (red) and sei whale focal follow effort (blue), in relation to the cetacean search effort (orange) during the West Falkland 2018 survey.

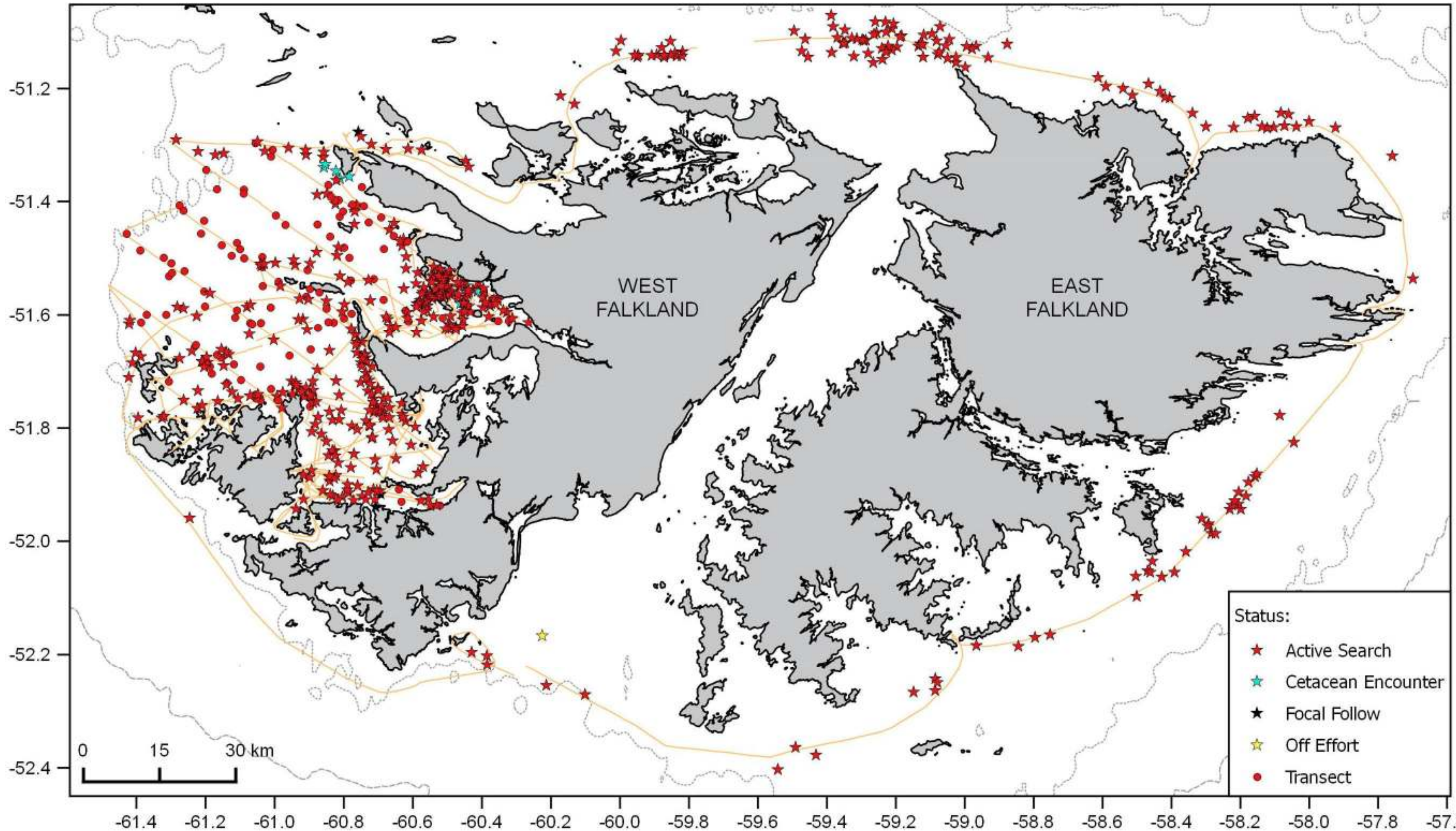


Figure 5.13. The spatial distribution of unidentified large baleen whale sightings, in relation to cetacean search effort (orange) during the West Falkland 2018 survey.

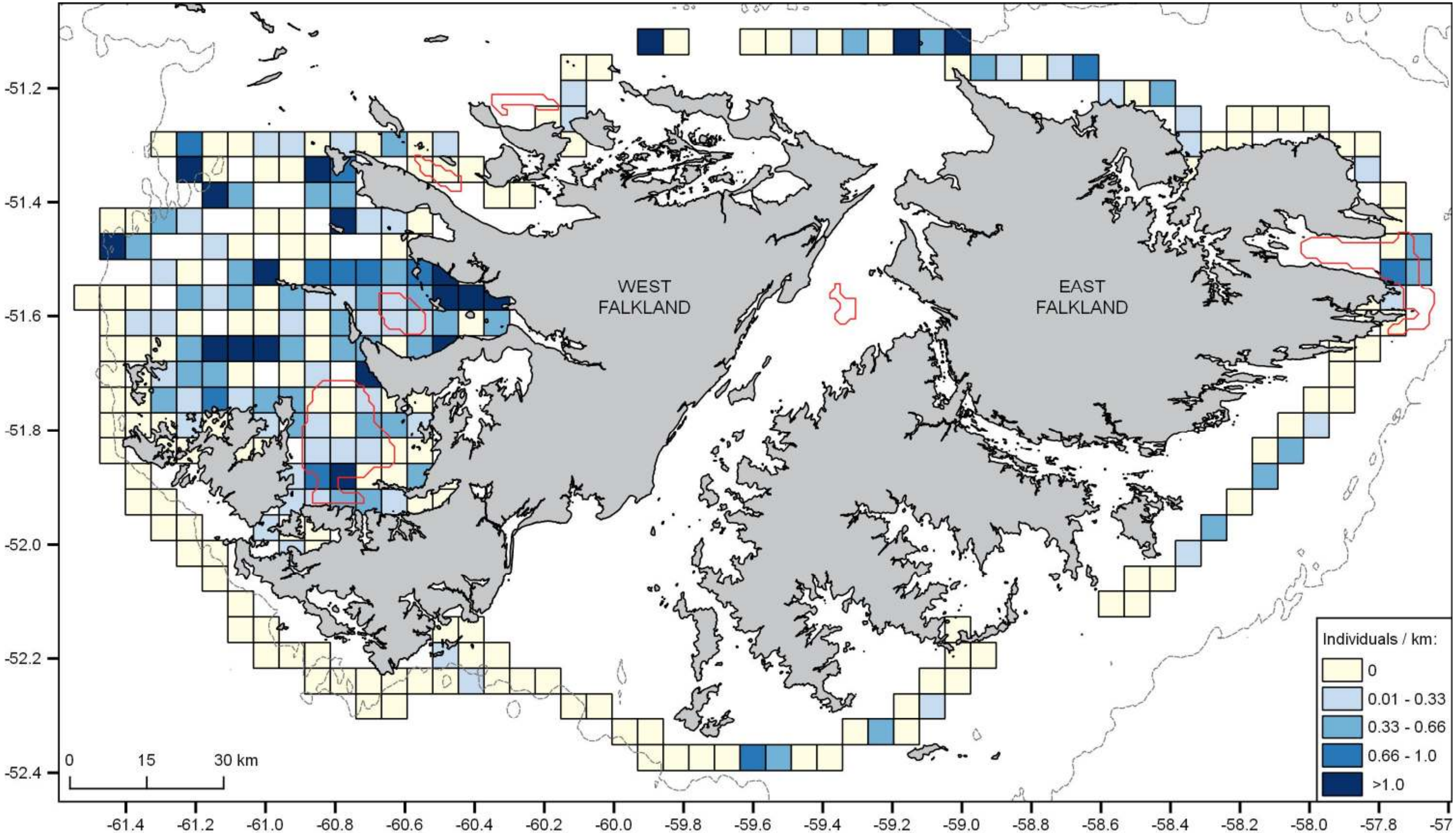


Figure 5.14. The relative abundance of sei whales in 5 km grid cells, calculated using only search effort collected in favourable weather conditions (171.8 hr / 2,168.3 km). Only grid cells in which ≥1 km survey coverage was achieved are shown. The cKBAs for whales are shown in red.

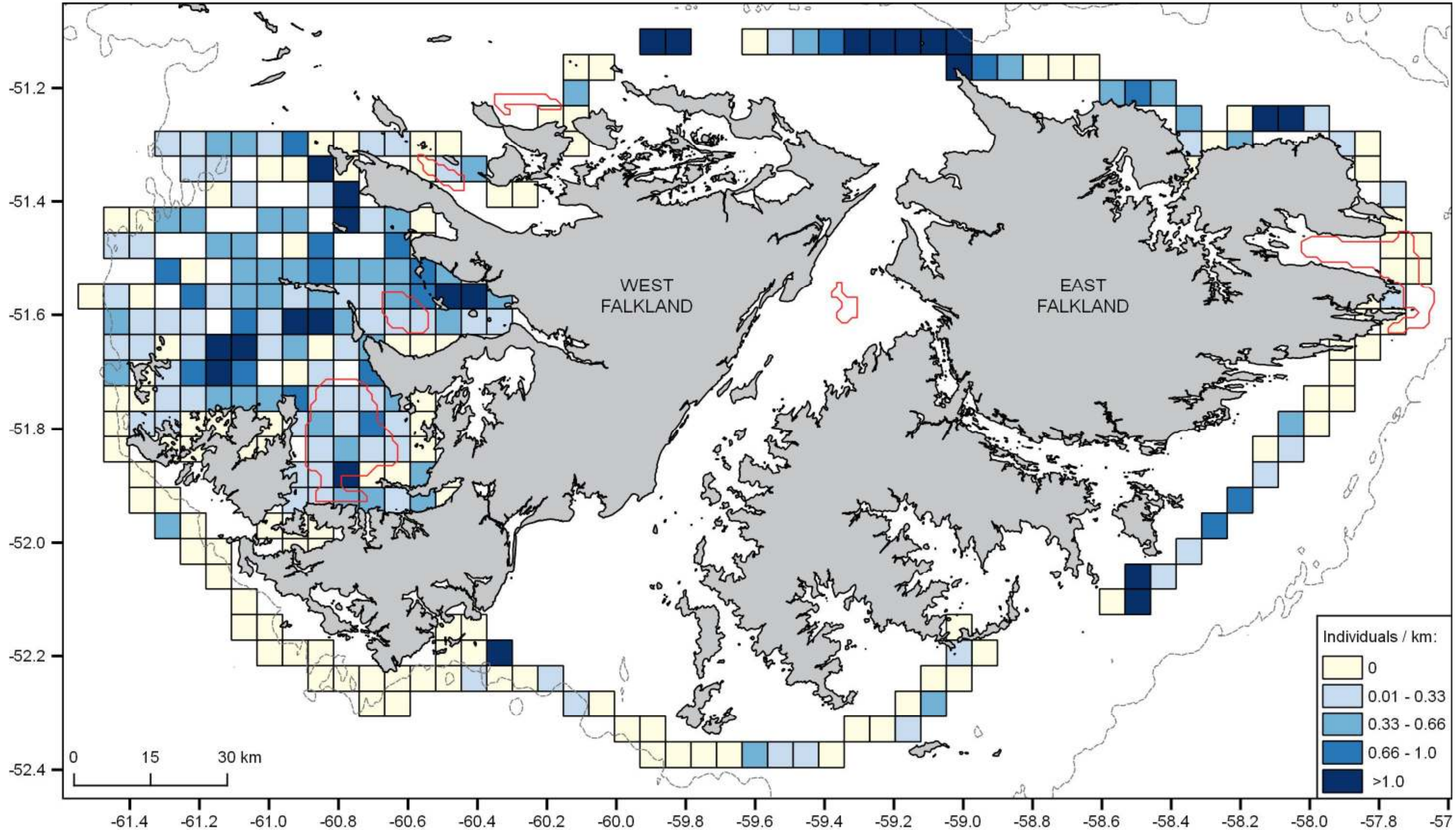


Figure 5.15. The relative abundance of unidentified large baleen whales in 5 km grid cells, calculated using only search effort collected in favourable weather conditions (171.8 hr / 2,168.3 km). Only grid cells in which ≥1 km survey coverage was achieved are shown. The cKBAs for whales are shown in red.

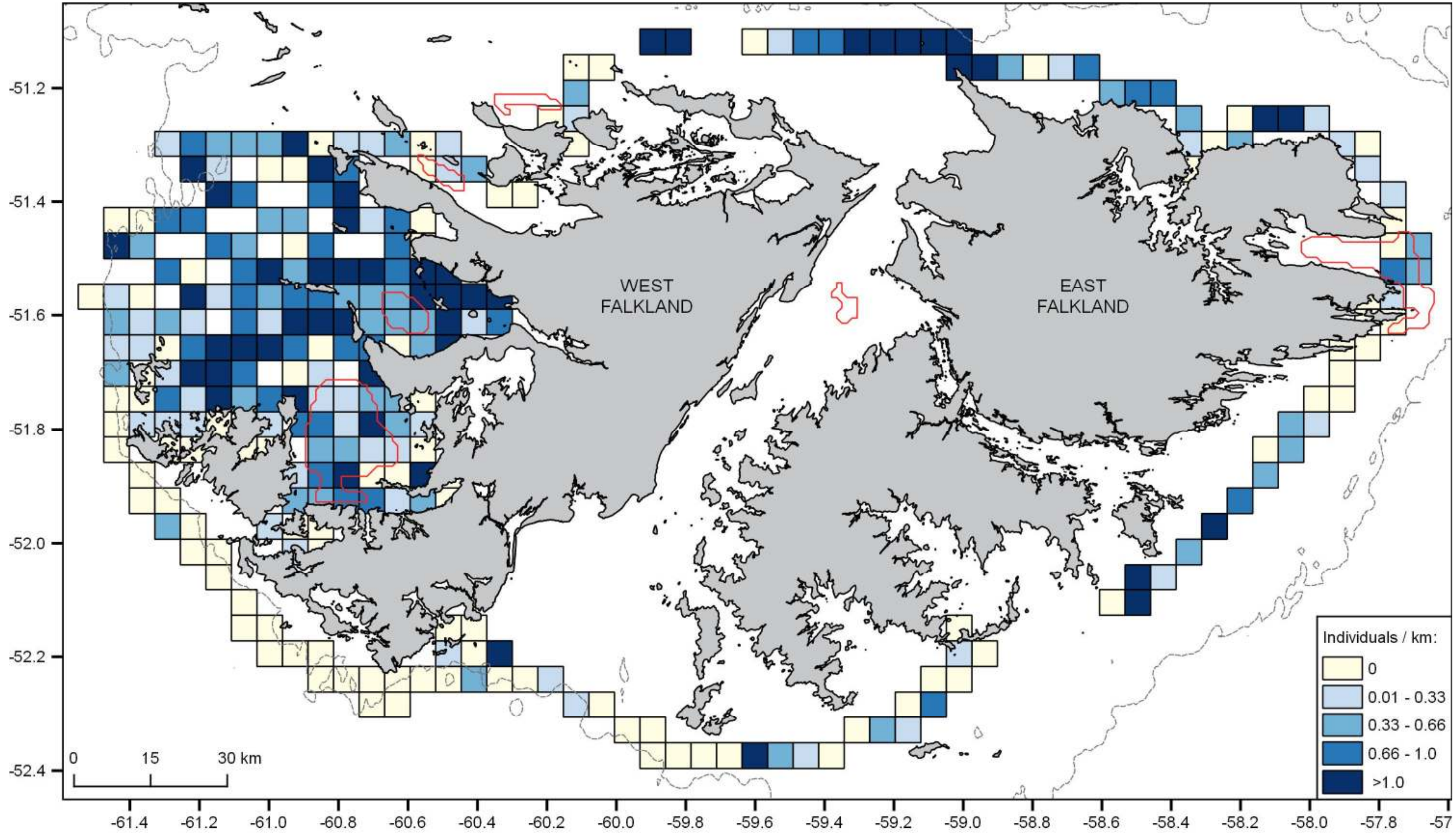


Figure 5.16. The relative abundance of combined sei and unidentified large baleen whales in 5 km grid cells, calculated using only search effort collected in favourable weather conditions (171.8 hr / 2,168.3 km). Only grid cells in which ≥1 km survey coverage was achieved are shown. The cKBAs for whales are shown in red.

Table 5.9. Water depth (as a mean value per 500 m grid cell) and distance from shore for the initial locations of cetacean sightings recorded during the West Falkland survey.

Species	Sightings	Water depth (m)				Distance from shore (km)			
		Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Sei whale	418	41.7	18.7	2.9	104.4	3.6	4.0	0.03	24.1
UNID baleen whale	594	47.0	19.1	2.0	106.8	4.6	4.1	0.04	25.2
Killer whale	3	71.0	26.8	47.9	100.4	5.7	3.0	3.4	9.1
Peale's dolphin	170	44.2	25.4	0.7	115.8	3.9	4.1	0.07	20.4
Peale's/dusky dolphin	1	42.5	–	42.5	42.5	3.9	–	3.9	3.9
Commerson's dolphin	154	29.7	19.9	0.7	81.2	3.4	4.2	0.05	14.1
UNID dolphin	2	15.0	7.1	10.0	20.1	0.9	0.9	0.3	1.5

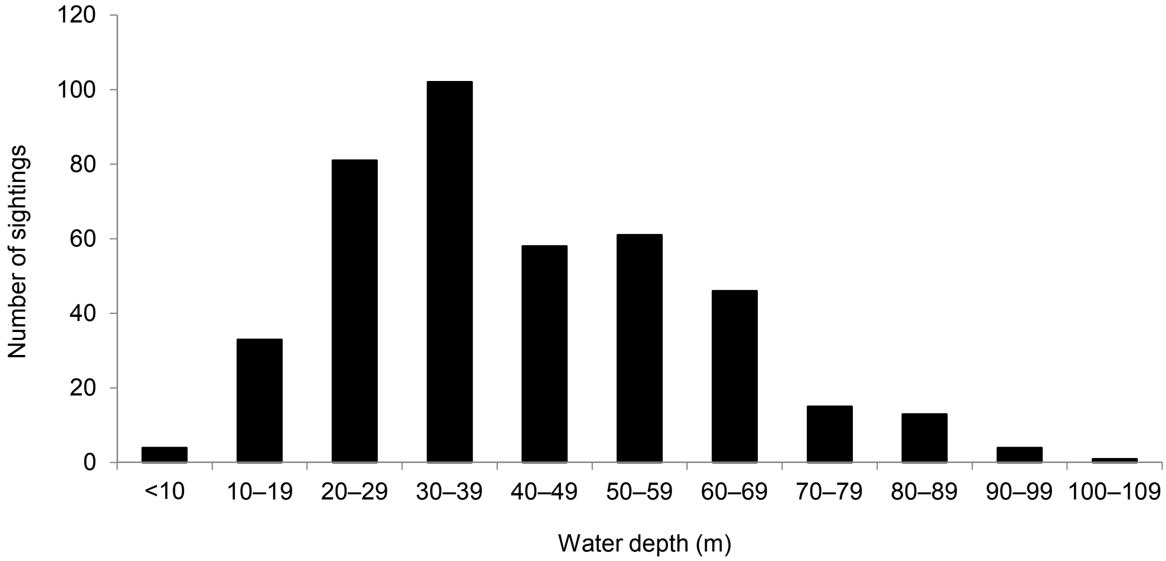


Figure 5.17. Distribution by water depth (500 m grid cells) of the initial sighting locations for sei whales (n = 418) during the West Falkland survey.

5.3.5.3. Killer whale distribution

Three killer whale sightings were recorded during the survey, occurring in King George Bay, Queen Charlotte Bay, and at the southern end of Falkland Sound (Figure 5.18). The water depth for the initial sighting locations ranged from 47.9 to 100.4 m, with a mean of 71.0 m (Table 5.9).

5.3.5.3. Peale's dolphin distribution

The distribution of Peale's dolphin sightings was predominantly centred in the more open and exposed regions of the study area (Figure 5.19), as reflected by a relatively deep mean water depth of 44.2 m (Table 5.9). This was the most common cetacean species recorded along the south coast of the Falklands during the circumnavigation, particularly at the southern end of Falkland Sound. There were also multiple sightings around the coast of Cape Pembroke as the yacht returned to Stanley, emphasising the importance of this area for Peale's dolphins. Within the core West Falkland study area, Peale's dolphins appeared to be relatively scarce inside King George and Queen Charlotte Bays compared with other cetaceans, although they were seen twice inside Shallow Harbour (Figure 5.19). However, there were numerous sightings along the offshore segments of the transects, around New Island, and especially in coastal waters along the north coast of Weddell Island between Quaker Island and Loop Head, including the outer half of Chatham Harbour (Figure 5.19).

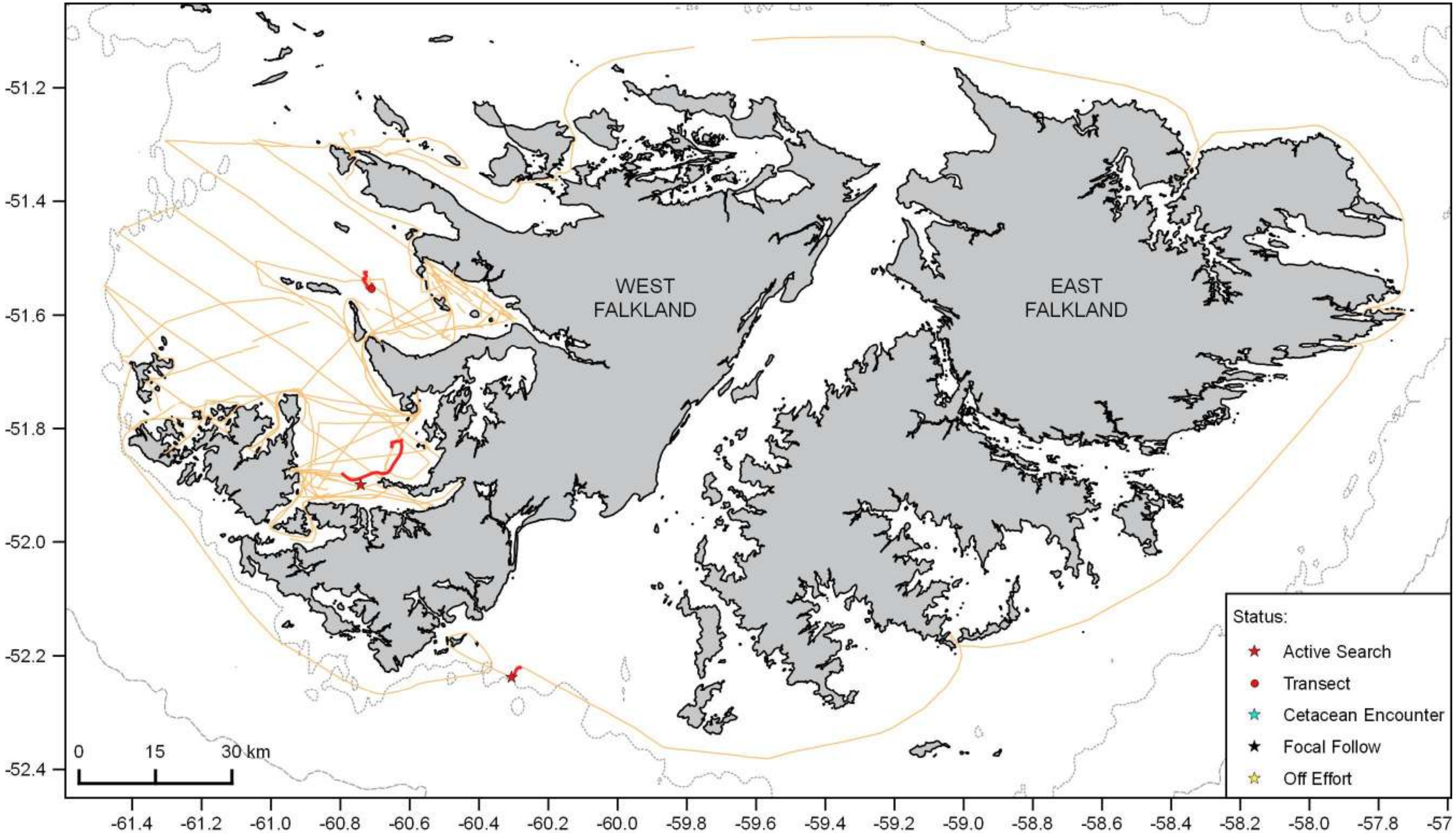


Figure 5.18. The spatial distribution of killer whale sightings and encounter effort (red) in relation to the cetacean search effort (orange) during the West Falkland 2018 survey.

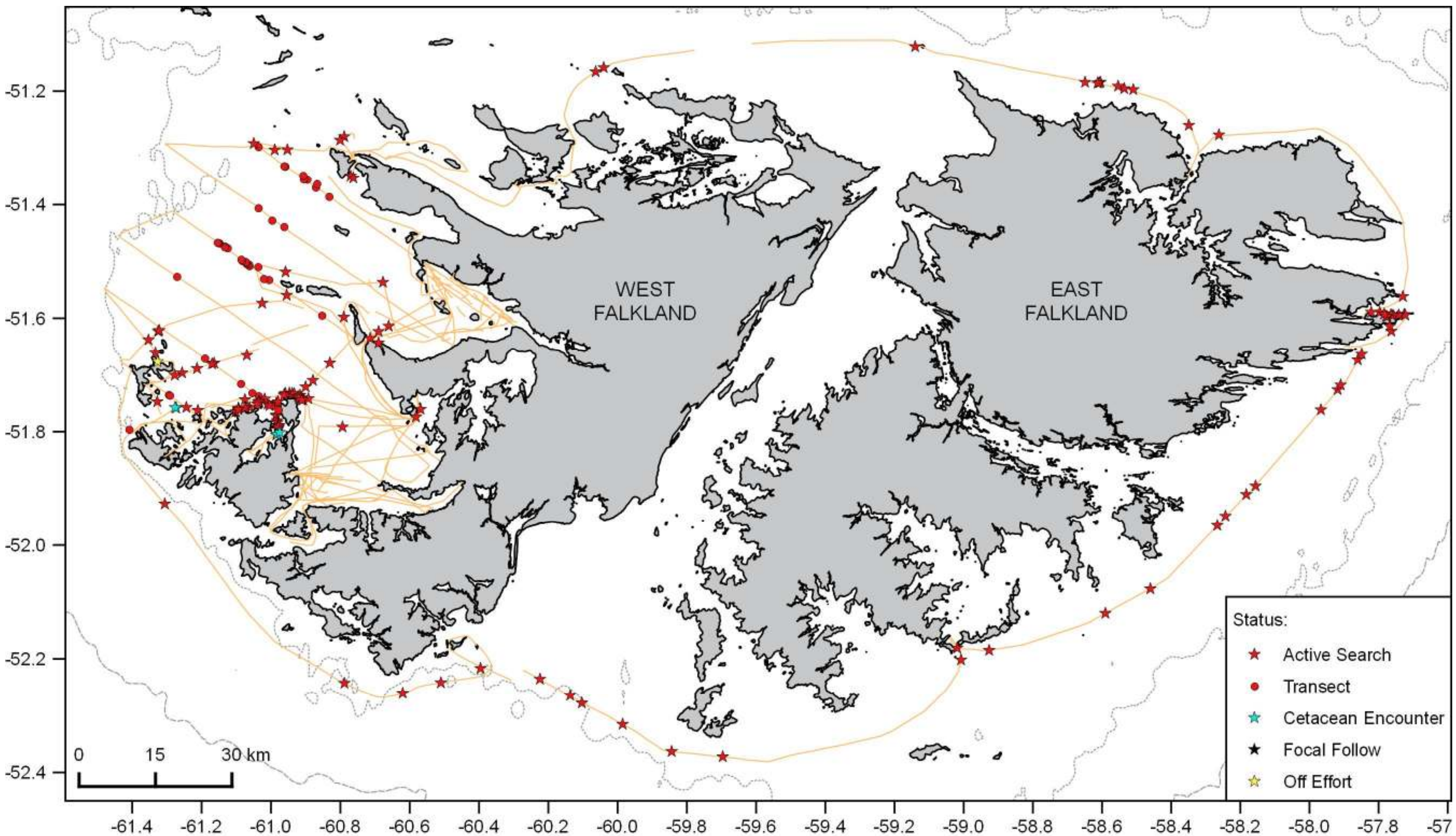


Figure 5.19. The spatial distribution of Peale's dolphin sightings in relation to the cetacean search effort (orange) during the West Falkland 2018 survey.

When corrected for variation in survey effort, the relative abundance of Peale's dolphin was highest in offshore areas west of the Passage Islands, to the south-west of West Point Island, and around Cape Pembroke, with moderate values in the grid cells along the north coast of Weddell, around New Island, and along the south-east coast of the Falklands (Figure 5.20). The overall relative abundance of Peale's dolphins in the study area was 0.08 sightings/km and 0.25 individuals/km (Table 5.8).

The distribution of three unidentified dolphin sightings is shown in Figure 5.21. At least one of those was identified as comprising either Peale’s or dusky dolphin. The two additional sightings were also likely to have been Peale’s dolphins, but were unconfirmed due to poor views and the need to apply particular care when distinguishing between Peale’s and dusky dolphins at sea (Weir and Black, 2018). All confirmed Peale's dolphin sightings were carefully checked for the presence of dusky dolphins, and observers were asked to check all individuals before logging the species identification as Peale's dolphin. This was possible in almost all sightings due to the propensity of the species to bow-ride, and consequently few dolphin sightings remained unidentified to species level.

5.3.5.3. Commerson’s dolphin distribution

Commerson's dolphins were recorded primarily in nearshore areas, including between Saunders Island and Byron Sound, throughout King George Bay, inside Shallow Harbour, in Port Richards, near Dyke Island, at Beaver Island, and particularly in the inlets along the north coast of Weddell Island including Quaker Harbour and Chatham Harbour (Figure 5.22). However, the species was also recorded in more exposed waters, between Shallow Harbour and Weddell Island, south of the Passage Islands, and to the north-west of the Passage Islands and New Island (Figure 5.22). Additionally, a large aggregation (conservatively estimated at well over 60 Commerson's dolphins) was recorded in the open waters to the north of Pebble Island during the transit to the study area on 23 February, with a succession of animals escorting the vessel for 2.5 hr. None were recorded during the transit along the south-west, south or south-east coasts of the Falklands, with the exception of a sighting at the anchorage close to Bleaker Island and an opportunistic record inside Stanley harbour at the end of the survey (Figure 5.22). When corrected for search effort, the relative abundance of the Commerson's dolphin was highest in offshore waters to the north of Pebble Island, and in the nearshore areas around Weddell Island especially within the inlets on the north coast (Figure 5.23). The overall relative abundance in the study area was 0.05 sightings/km and 0.18 individuals/km (Table 5.8).

Sightings occurred in mean water depths of 29.7 m (Table 5.9), which was the shallowest of any of the cetacean species recorded during the survey and reflects the use of very shallow nearshore habitat. However, sightings were also recorded in depths of up to 81.2 m, and at distances of up to 14.1 km from the coast (Table 5.9), further supporting some occurrence of Commerson's dolphins in offshore, open areas. There were significant differences between the water depth (Mann-Whitney test; $P<0.001$) and distance from shore (Mann-Whitney test; $P<0.05$) of Peale’s and Commerson’s dolphin sightings, with Commerson’s dolphins being recorded in shallower water depths and closer to shore than Peale’s dolphins (Table 5.9).

5.4. Human activities

Human activities were recorded whenever they were observed, commencing when the vessel passed Volunteer Point on the 22 February, and ending on return to Stanley on the 4 April. A total of 18 observations were logged, of which 17 related to vessels, and a single record comprised a marker buoy (Table 5.10). All of the jiggers were observed in proximity to one another and travelling northwards off the north-east coast of the Falklands on the 22 February (Figure 5.24). No human activities were recorded at all along the north coast of the Islands. A minimum amount of vessel activity was logged in the West Falkland study area, comprising the catamaran "*Seaquest*" transiting between West Point and Carcass, the supply vessel "*Concordia Bay*" servicing the settlements, and two cruise/expedition ships travelling between New Island and West Point (Figure 5.24). A single marker buoy was recorded nearshore off Tussac Point in eastern Queen Charlotte Bay on 4 March.

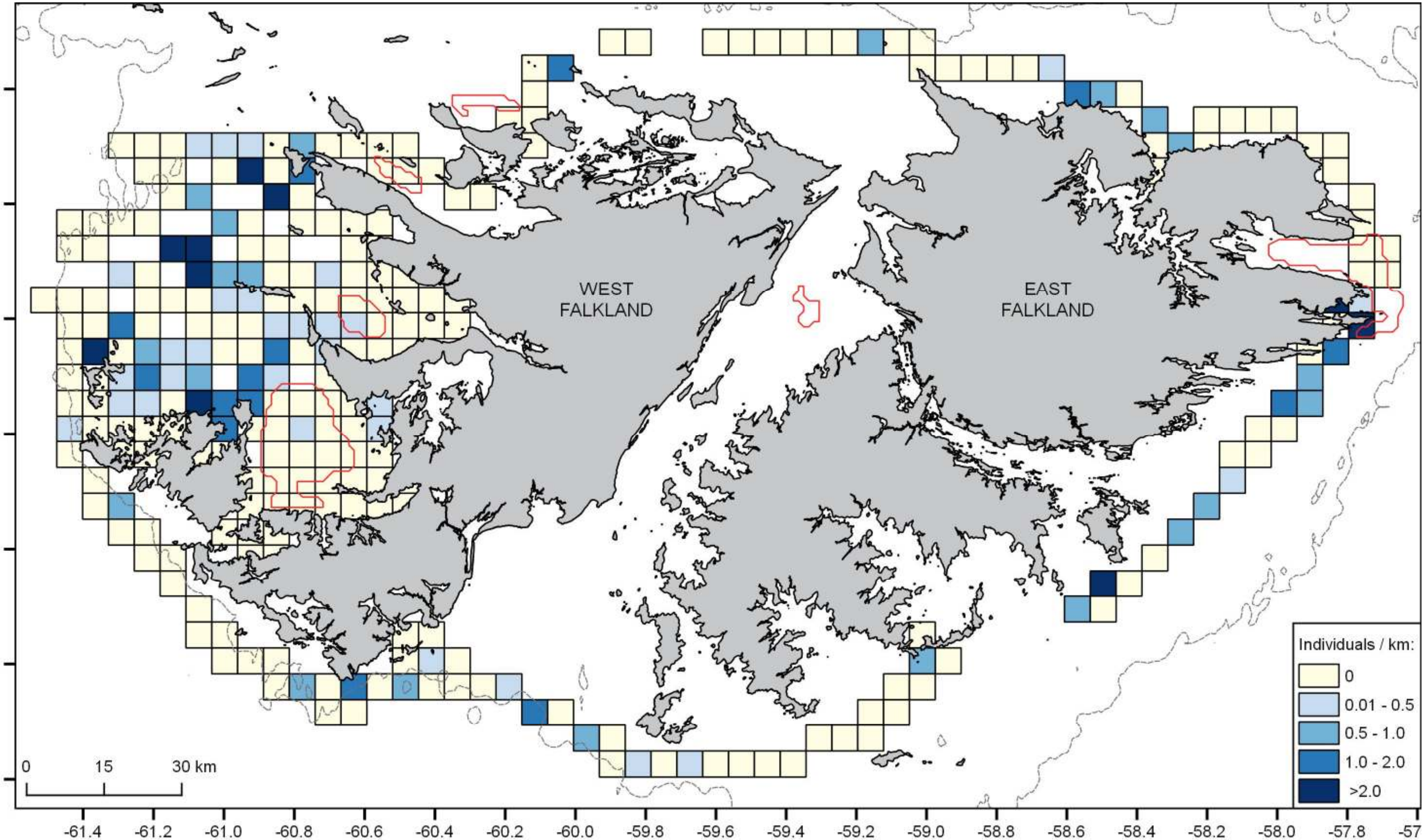


Figure 5.20. The relative abundance of Peale's dolphins in 5 km grid cells, calculated using only search effort collected in favourable weather conditions (171.8 hr / 2,168.3 km). Only grid cells in which ≥1 km survey coverage was achieved are shown.

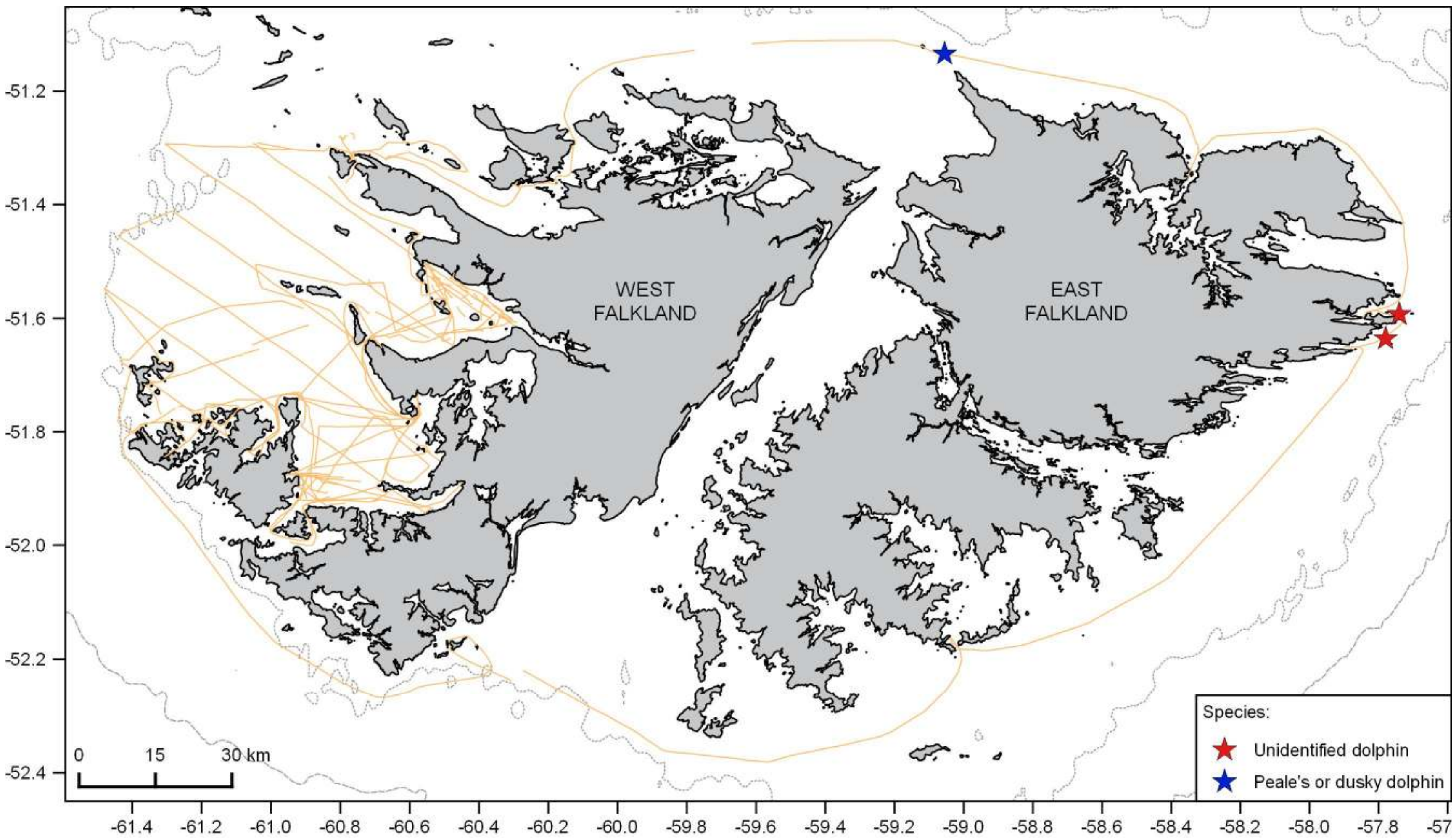


Figure 5.21. The spatial distribution of unidentified dolphin sightings in relation to the cetacean search effort (orange) during the West Falkland 2018 survey.

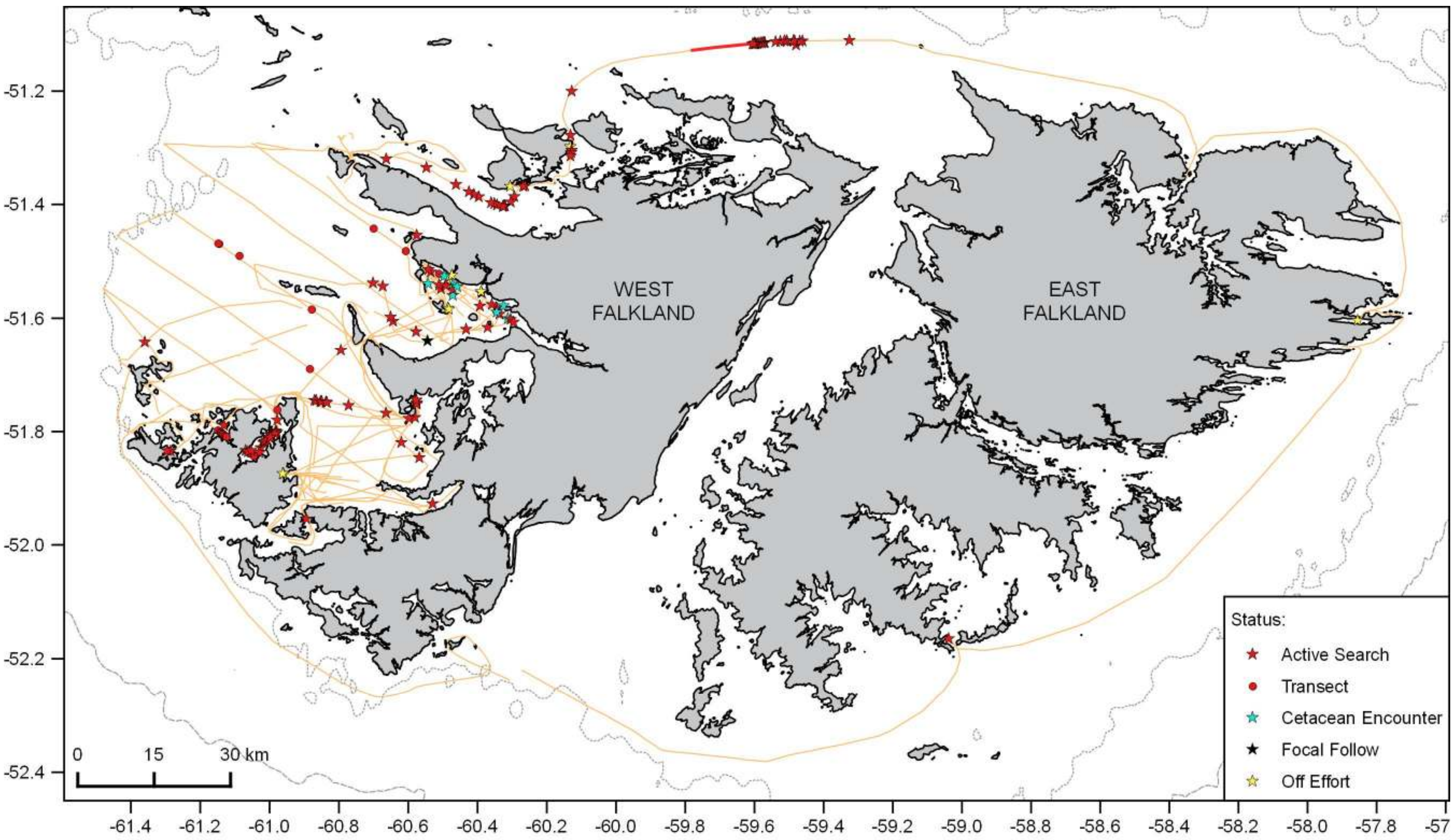


Figure 5.22. The spatial distribution of Commerson's dolphin sightings and encounter effort (red) in relation to the cetacean search effort (orange) during the West Falkland 2018 survey.

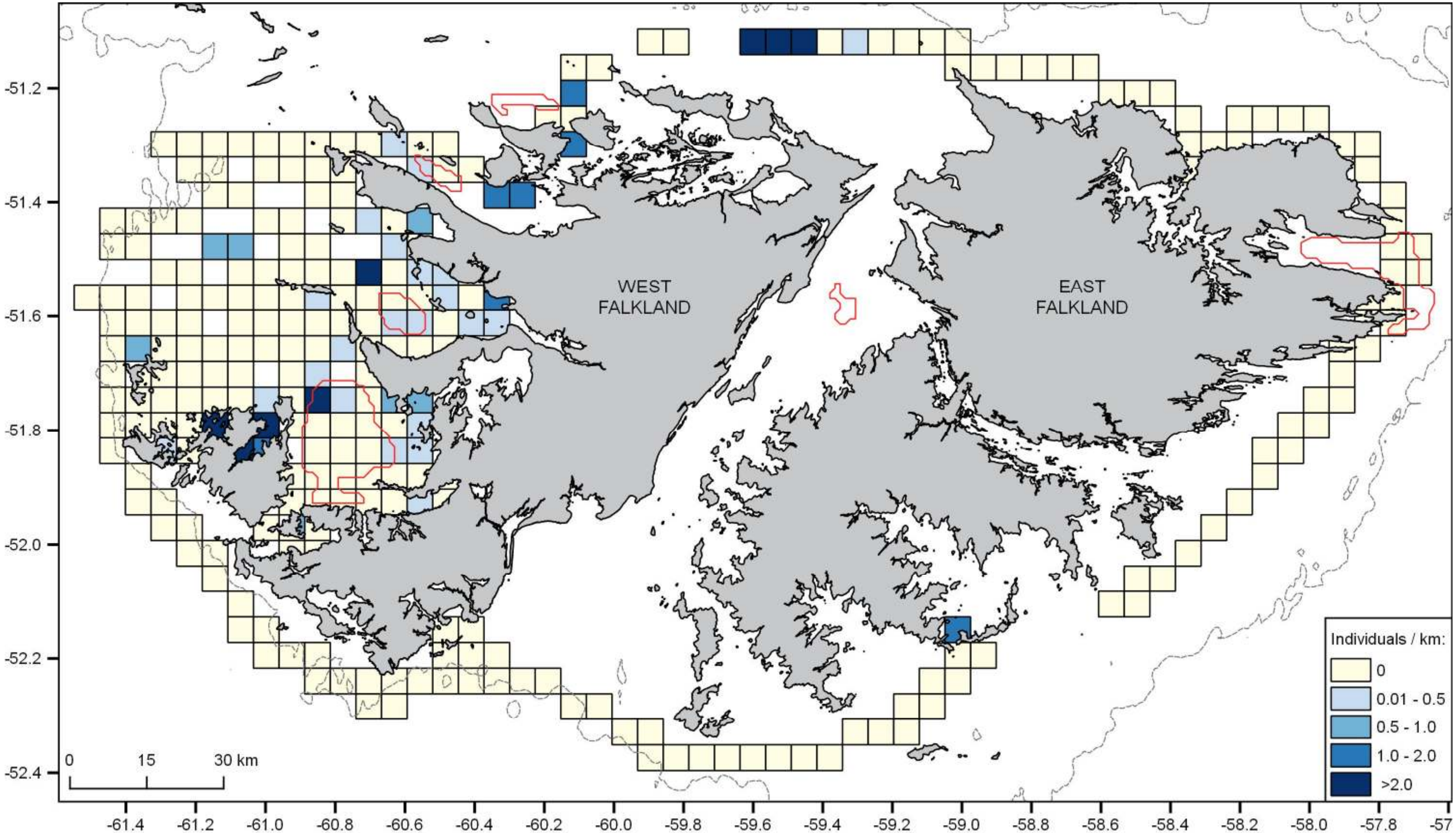


Figure 5.23. The relative abundance of Commerson's dolphins in 5 km grid cells, calculated using only search effort collected in favourable weather conditions (171.8 hr / 2,168.3 km). Only grid cells in which ≥1 km survey coverage was achieved are shown.

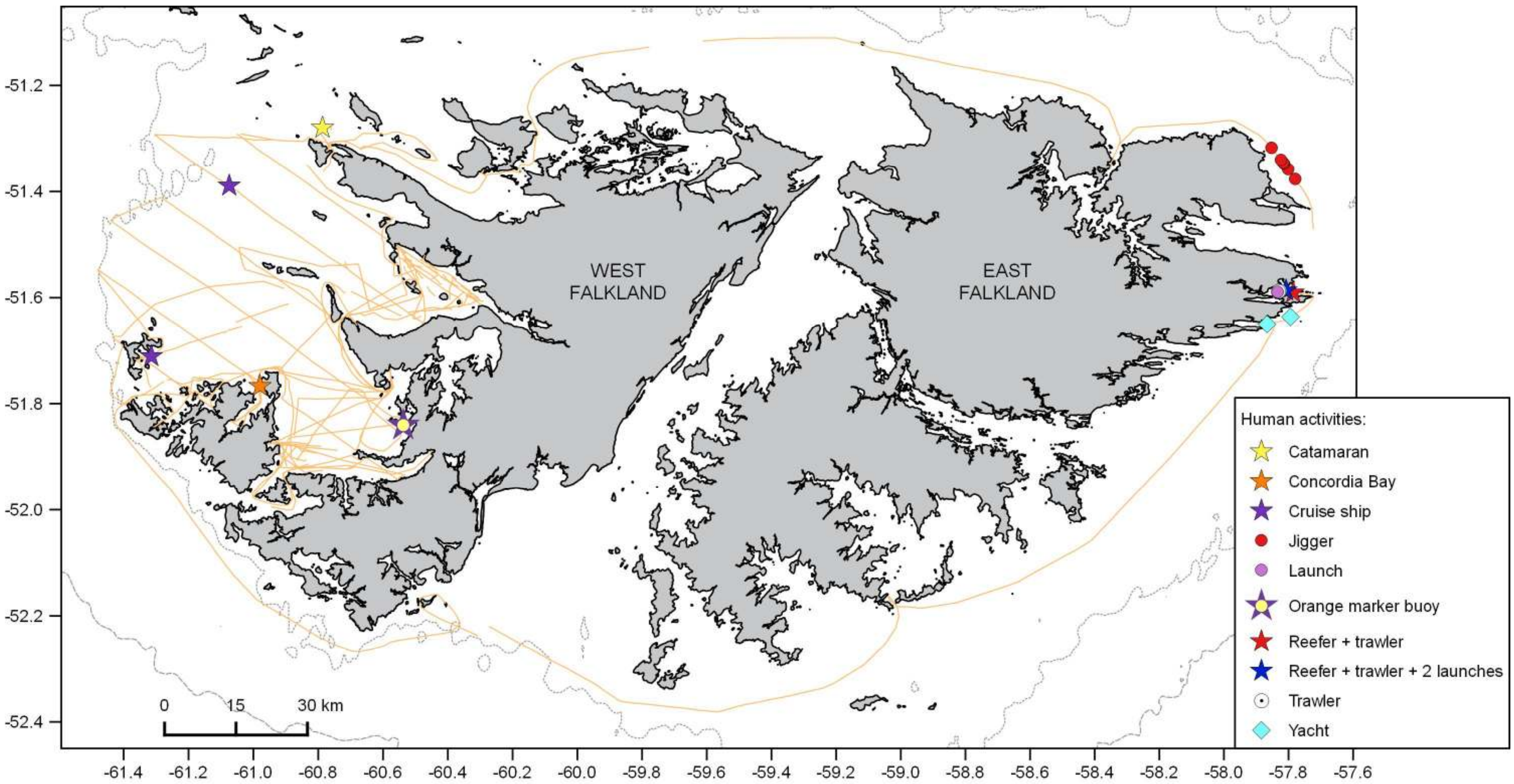


Figure 5.24. The locations of human activities recorded during the West Falkland survey.

Table 5.10. Human activities recorded during the West Falkland survey.

Type	No. of observations
Cruise / expedition ship	2
Jigger	6
Launch	1
Reefer + trawler alongside	1
Reefer + trawler alongside + 2 launches	1
Fishing marker buoy	1
Supply boat (*Concordia Bay*)	1
Trawler	2
Catamaran (motor)	1
Yacht	2
Total	*18*

No human activities were recorded along the entire coast of south-west to south-east Falkland, with vessel traffic increasing only in the vicinity of Cape Pembroke when two yachts were recorded travelling towards Stanley. Inside Port William a variety of reefers, trawlers and launches were recorded (Figure 5.24), consistent with the use of that area as a key mooring location for Stanley.

Although no interactions between sei whales and other vessel platforms were observed during the survey, there was one interaction involving physical contact between a whale and the research platform itself. A report was produced on this event and is provided in Appendix 3.

5.5. Discussion

The visual sighting survey reported here, was developed to address some of the current data gaps with regard to whale occurrence in the Queen Charlotte Bay and King George Bay cKBAs, via systematic scientific survey work on whale distribution, movements, abundance and behaviour. The use of a large yacht as the primary platform facilitated the collection of sighting survey data in less favourable weather conditions than would have been possible from a rigid-hulled inflatable boat (RIB) or similar smaller-sized boat, and in this respect the visual sighting survey was considered to represent the most successful component of the West Falkland survey.

The sighting survey achieved all of its stated aims (Section 5.1), recording four species of cetacean and collecting data over a wide geographic area including in the two cKBAs. The only baleen whale species confirmed during the survey work was the sei whale, with no fin whales being recorded in any of the areas. Although a large number of baleen whale sightings remained unidentified to species level (due to swell and distance), it was not considered likely that there were significant numbers of any other species in the area; rather, all animals that were approached were positively-identified as sei whales, and none of the unidentified whales were suspected to be anything other than sei whales based on the characteristics of their blows and other features. It was emphasised to the observation team that sightings should only be identified to species level when the key characteristics of the species were observed with absolute certainty, and hence animals with sei-like blows were only logged as definite sei whales if their dorsal profile was observed and the identification was without doubt. Similarly, all Peale's dolphins observed during the survey were carefully checked to confirm features and ensure that no dusky dolphins were present (see Weir and Black, 2018). Killer whales and Commerson's dolphins did not present any identification uncertainties within the study area, due to the very unique striking colouration and morphological characteristics of those species.

The core West Falkland study area comprised a substantially larger spatial area than the Berkeley Sound study area of 2017. Consequently, although it was possible to standardise the survey effort in Berkeley Sound by following the same general route on each survey, this was not achievable in West Falkland. The survey effort was therefore not uniformly-distributed over the West Falkland study area (see Figure 5.9). Most of the offshore survey effort was associated with the transect work; outside of the transect survey the search effort was mostly concentrated in coastal, sheltered waters. For these reasons, the coverage achieved during the transect survey and the non-systematic visual survey were assessed separately for this report, as well as being considered together as a single combined "active search" dataset. The transect survey provided a good spatial distribution of survey effort over the wider area and encompassed both nearshore and open habitats, while the distribution of the non-systematic survey effort was largely determined by weather, logistics and the occurrence of whales. The two datasets have different implications, and will be suitable for different additional types of analysis in future (e.g. evaluation of the use of the transect data for estimating abundance).

Regardless of whether the transect survey and the non-systematic survey effort were considered separately, or as a combined "active search" dataset, the results with regard to overall cetacean occurrence were similar. Sei whales, and unidentified baleen whales, were the most frequently-encountered, and the most numerous, cetacean species within the study area. The non-systematic survey effort produced high numbers of sightings in nearshore areas, which was partly the result of greater survey effort in those areas. The transect dataset revealed a more uniform distribution of sei whales across the region, including as far as the 100 m depth isobath at the westernmost limit of the study area. When variation in survey effort was accounted for via the relative abundance maps, it was clear that sei whales and unidentified baleen whales were distributed widely across the core West Falkland study area, and were also encountered during much of the circumnavigation around the Islands. Sei whales are often considered to be a species characteristic of deep, pelagic habitats worldwide (e.g. Horwood, 1987; Prieto et al., 2012), but the West Falkland survey demonstrated an occurrence not only throughout coastal waters around the Islands but also well inside semi-enclosed channels and inlets. Nearshore, shallow waters clearly represent typical habitat for sei whales in the Falklands, suggesting that this species is able to occupy a range of habitats as long as sufficient prey are available. Although nearshore sightings are regularly reported by local inhabitants (Frans and Augé, 2016), the results presented here also indicated a regular occurrence further from the coast and in water depths of up to at least 100 m, and suggest that the species may be using the shelf rather than strictly coastal waters. It remains uncertain how much further into offshore, deeper waters, the documented concentration of sei whale occurrence around the Falklands typically extends, and whether the relative abundances recorded on the shelf continue out to the 200 m depth isobath, or beyond.

The brief assessment of human activities recorded during the sighting survey indicated that cetaceans in the West Falkland study area occupy a habitat that is largely free of conspicuous human activities. A very minimal amount of vessel traffic was observed on the west coast of West Falkland, and there was also little evidence of fishing activity. This may partly be due to the temporal duration of the survey, since fishing boats associated with the Falkland squid fisheries are known to use the area from Queen Charlotte Bay to New Island to shelter from storms at some times of year. However, the bulk of the vessel traffic recorded during the sighting survey was located along the east coast of East Falkland in the Cape Pembroke and Port William areas, close to Stanley. Sei whales are therefore likely to be considerably less exposed to potential interactions with vessels (e.g. disturbance from noise, vessel strikes, or whale-watching activities) in the West Falkland cKBAs than they might be in the Berkeley Sound cKBA (Weir, 2017a). However, the relative abundance of whales in the West Falkland study area was sufficiently high that there is still potential for collisions even with a relatively low amount of vessel traffic. Therefore open reporting (see Appendix 3) and adherence to a voluntary code of conduct (adopted by the FIG Environment Committee and available from Falklands Conservation) is encouraged for vessels operating in the area.

6. PHOTO-IDENTIFICATION

6.1. Introduction and aims

Cetacean photo-identification studies rely on the acquisition of high-quality images of the body, tail flukes, or dorsal fins of cetacean species, so that naturally-occurring markings can be used to recognise individuals (Würsig and Jefferson, 1990). Depending on the species, these markings can comprise scars, nicks, notches or pigmentation patterns, each of which is unique to individuals. Over the long-term, the recognition of individuals can provide valuable information including population size, movements, habitat use, social affiliations, survivorship and life history parameters.

While certain cetacean species have been studied for decades using photo-identification, the technique has seldom been applied to sei whales (e.g. Schilling et al., 1992; Acevedo et al., 2017). The first intensive and targeted photo-identification study of sei whales across a full season anywhere worldwide was carried out in Berkeley Sound during 2017 (Weir, 2017a,b), and individuals were found to be recognisable using nicks and notches along the edges of the dorsal fin, pigmentation and scars on the fin, and the pattern of cookie-cutter shark (*Isistius brasiliensis*), scarring on the flanks. The method produced a minimum population size of 87 sei whales in Berkeley Sound (Weir, 2017a) and also provided useful information on the duration of occurrence within the Sound and on spatial movements.

The use of photo-identification during the West Falkland study, had the primary objectives of:

- Providing a minimum estimate of how many sei whale individuals were present in the West Falkland study area at the time of the survey;
- Providing information on the movements, social affiliations and residency of individual whales within the study period;
- Examining the dataset for any re-sightings of distinctive sei whales between Queen Charlotte and King George Bays in 2018, and Berkeley Sound during 2017 that would indicate movements of sei whales around the Falkland Islands.

6.2. Methods

6.2.1. Field methods

Images of sei whales were taken when opportunity arose, depending on the prevailing weather conditions and the activity of the survey. The acquisition of suitable high-quality images was dependent on being able to approach the whales to a sufficiently-close distance, and consequently no photo-identification was conducted when the vessel was transiting between Stanley and the West Falkland study area, or while dedicated transect work was being undertaken. Photo-identification effort therefore primarily occurred on days when non-systematic visual survey work was being carried out within the two cKBAs, and in conjunction with behavioural focal follows and faecal sampling.

Prior to the survey it had been anticipated that zodiac launches would be routinely-undertaken for the purposes of photo-identification work. However, due to logistical constraints this proved not to be the case (see Section 6.4) and almost all photo-identification effort was carried out from the yacht. During concerted photo-identification attempts a "closing mode" was adopted and the vessel skipper was asked to carefully manoeuvre the vessel to position the photographers parallel with the animal(s) and to travel slowly alongside. Since sei whales were rarely encountered travelling in straight lines, this approach often had to be adaptive and involved continual re-positioning of the vessel. The SL monitored whales for signs of disturbance throughout approaches, and requested that the approach was aborted if repeated avoidance was observed or as soon as it was felt that sufficient images had been obtained of each individual.

During the early stages of the survey the SL provided the RAs with training on adjusting the ISO, exposure compensation and aperture in order to achieve sharp and well-exposed images, and all team members were subsequently involved with the acquisition of photo-identification images. Usually, a single team member took images with a Canon 7D Mark II digital SLR fitted with a Canon 100–400 mm zoom lens. However, during encounters with multiple animals or when opportunity allowed (i.e. outside of behavioural focal follow attempts) then a second photographer also took images with a Canon 5D Mark III and a 100–400 mm lens. The clocks on all camera bodies were synchronised with the GPS at the start of the survey, and regularly throughout the survey, to ensure that images could be cross-referenced with particular sightings. During the final 10 days of the survey, additional volunteers from the local community participated in photo-identification work, resulting in up to three people on deck with cameras. At the end of each survey day, all images were downloaded and filed by sighting reference number.

6.2.2. Catalogue compilation

The production of the photo-identification catalogue for sei whales followed standardised methods for cetaceans (Würsig and Jefferson, 1990; Falcone et al., 2011). The images from each encounter were visually-assessed and allocated to sub-folders for particular individuals whenever possible, based on distinctive dorsal fin markings or flank scarring.

The target area (TA) for the photo-identification work was the dorsal fin and the region of upper flank located forward of, behind and below the dorsal fin (Figure 6.1). This area was most-consistently available on surfacing sei whales (although many animals surfaced without showing any flank at all), whereas the head, lower flank, and tailstock were not always visible at the surface due to the relatively low profile of this species. On occasions when whales arched their backs and revealed more of their lower flank, those images were used in the catalogue as long as the features in the TA remained clearly visible.

Figure 6.1. Image showing the Target Area (TA) of the whale used for photo-identification work.

The best-quality images of the left and right sides of the dorsal fins and flanks of each distinctive individual were selected, cropped, and entered into a catalogue (Figure 6.2). Individuals photographed during subsequent encounters were either matched to animals in the existing catalogue as "photographic recaptures" or were allocated a new unique code and entered into the catalogue as a new animal. Where better-quality images were obtained for particular individuals over the survey duration, the catalogue was updated accordingly. Some initial sorting of photo-identification images taken during the early stages of the survey was carried out by team members onboard the yacht during bad weather days, while the remainder were sorted by the SL after survey completion.

Figure 6.2. Example page from the sei whale photo-identification catalogue (Weir, 2018a).

On completion of the West Falkland survey, the entire photo-identification database and catalogue was cross-checked by the SL using the following methods:

- The images assigned to each individual in every encounter were examined again to ensure that they were correct, and all recaptures of individuals between dates were double-checked;
- A cross-check was carried out for false positives (i.e. matching images to the same animal that actually originate from two separate individuals), which can be reduced by using only good-quality images and applying sufficient care to the matching process;
- A cross-check was carried out for false negatives (i.e. allocating images from the same animal to two different individuals), which are more common in cetacean studies than false positives and can result from: (1) matching images of insufficient quality (including different light conditions that might affect the visibility of scarring); (2) attempting to match individuals that

are very poorly-marked; and (3) changes in the natural markings between encounters caused by acquisition or healing of scars or nicks; and

- Any images that had been initially filed as "uncertain" or "poor" were re-visited in the context of the completed catalogue, to check that no individuals could be further matched.

Each catalogued individual was assigned a Distinctiveness Value (DV) based on: (1) permanent marks along the edges of the fin or posterior to the fin on the tailstock, or (2) scar patterns in the TA (Table 6.1 and Figure 6.3). The lowest applicable value was used; i.e. if an animal had both moderate nicks in the dorsal fin and heavy scarring it was allocated to DV2 rather than DV6A.

Table 6.1. Definitions of Distinctiveness Value (DV) allocated to individual sei whales.

DV	Criteria
1	Conspicuous large nick(s), hole through the dorsal fin or fin deformity/injury.
2	Moderate-sized nick(s), hole through the dorsal fin or fin deformity/injury.
3	Subtle/shallow nick(s) in fin edge or holes through the dorsal fin.
4	Uniquely-distinctive fin shape, such as wavy indents in edges of dorsal fin.
5	One or more dorsal notch on the surface of the tailstock, in the area posterior to the dorsal fin.
6	No evidence of nicks, notches or other permanent marks. Classified from scarring in the target area as:
	6A Extensively scarred/lesioned, including conspicuous marks suitable for identification.
	6B Moderately scarred/lesioned.
	6C Animal only very lightly scarred/lesioned/pigmented and generally poorly-marked.

DV was assigned according to the following considerations:

- DV1–3: Permanent features on the dorsal fin that are likely to remain stable over time, although new additional features may be acquired. The features used to assign DV1–3 were visible on both sides of an animal, and therefore aided the matching of left and right sides to the same individual.
- DV4: As above, but noting that overall fin shape of Falkland sei whales appears to vary along a continuum and its perceived appearance alters markedly with small alterations in angle (see discussion by Weir, 2017a). Consequently, the use of shape as the core method of recognising individuals was limited to a small number of individuals where it was considered to be particularly unique (Figure 6.3). Shape was used only as an additional supporting feature for recognising other individuals.
- DV5: Permanent markings on the tailstock that should be stable over time and be equally visible from either side. Due to the target area selected for sei whale photo-identification (Figure 6.1), which in turn was based on typical sei whale surfacing behaviour where the tailstock is often not visible, only notches in the part of the tailstock closest to the dorsal fin were likely to be consistently available for matching.
- DV6: Individuals assigned as DV6 were catalogued via the presence of distinctive scar patterns or lesioning, including cookie cutter shark bite scars, raised lumps on the dorsal fin presumed to originate from parasites, killer whale tooth rakes, areas of lesioning or pigmentation and other scars. These markings are likely to heal over with time, and the duration of their persistence on sei whales is unknown. Three subcategories (A–C) were used for DV6 animals based on subjective assessment of the amount (extensiveness and intensity) of scarring. Because temporary features were not visible from both sides of an animal, separate DV6 subcategories were allocated to the left and right sides of each individual.

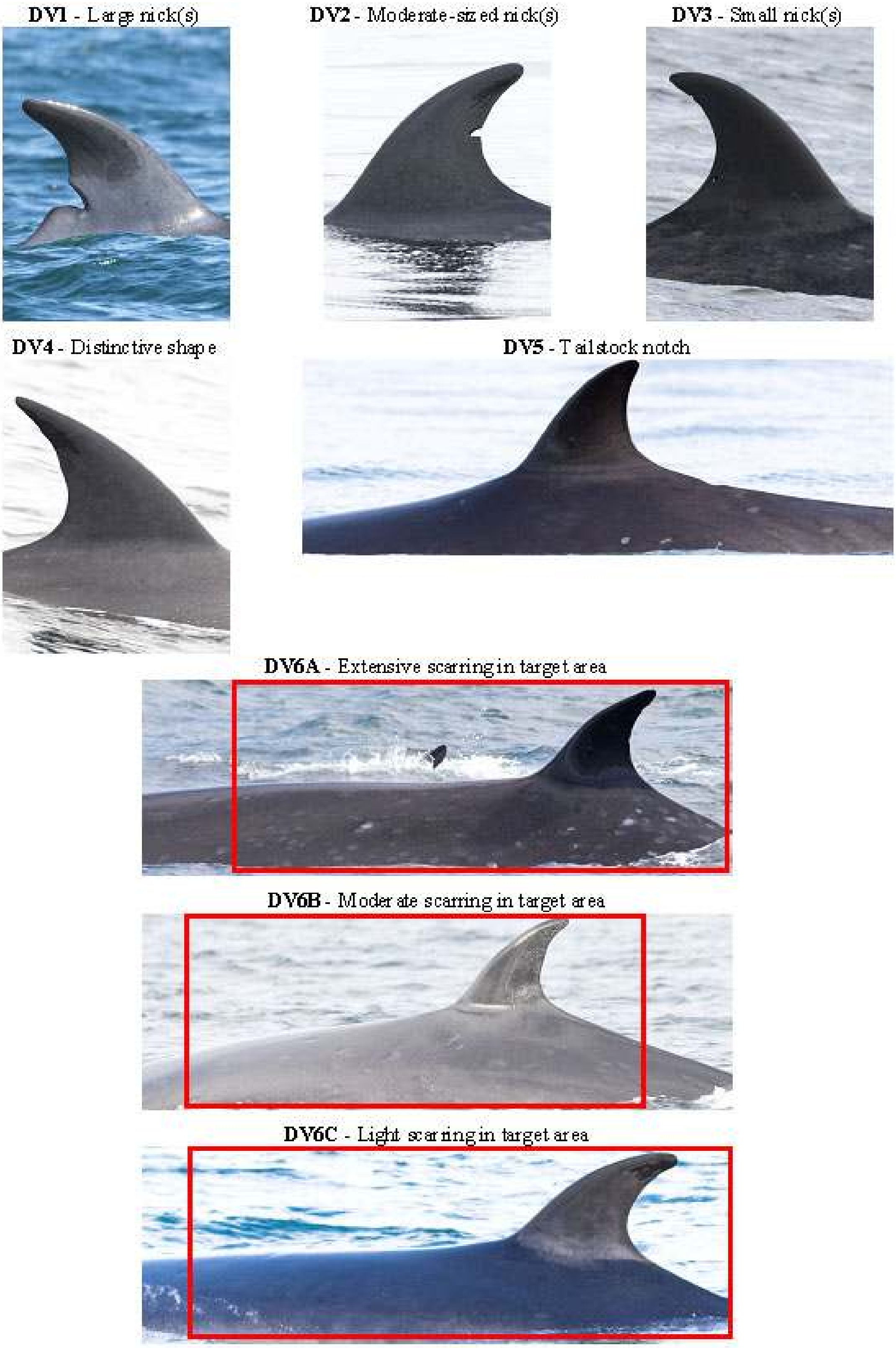


Figure 6.3. Illustrative examples of Distinctiveness Value (DV) allocated to individual sei whales. Red boxes show the defined target area (TA) for scar-based photo-identification.

Using the same method as for the Berkeley Sound 2017 data (Weir, 2017a), a basic Photographic Quality (PQ) rating of 1–4 (excellent, good, fair or poor: Appendix 6) was allocated to the best-available left and right side images of each catalogued animal, according to the focus, camera angle, exposure and size of the dorsal fin/flank region relative to the frame (e.g. Gendron and Ugalde de la Cruz, 2012; Tezanos-Pinto et al., 2017). Photographs rated PQ4 contained features that were useful to identify an individual, but were of insufficient quality for population parameter estimations (Gendron and Ugalde de la Cruz, 2012). To maximise consistency, images were rated relative to one another via a single person (the SL) allocating PQ values to the entire catalogue on a single date.

6.2.3. Data analysis

The minimum population size (MPS) was calculated for the West Falkland study area, and was defined as the total number of distinctive sei whales that were photographically-captured in the study area over the duration of the study (i.e. with no genetic or absolute abundance implications). The MPS for the West Falkland 2018 study was calculated using a slightly-different method from the Berkeley Sound 2017 analysis (Weir, 2017a), and comprised the sum of: (1) all permanently-marked animals (DV1–5; which should be identifiable from both sides), and (2) all animals identified from scar patterns (DV6) on one side (left or right, depending which was highest). Calculations of MPS were made using only a subset of animals for which images of PQ1–3 were available for at least one side.

6.3. Results

6.3.1. Overview

Over 13,300 images were taken during West Falkland sei whale photo-identification encounters. The vast majority of images were acquired from the yacht; only 324 images were taken from the zodiac, during two whale encounters on 25 February and 6 March. Images potentially-suitable for identifying individual sei whales were taken on 17 of the 32 days that the yacht spent time at sea, with between 1 and 26 individual whales being photographed per date.

There was a strong positive relationship between the total combined amount of sei whale encounter and focal follow effort carried out on each survey date, and the total number of individual sei whales photo-identified on that date (Figure 6.4). Dates where the survey effort was concentrated on conducting transects, where the vessel was in transit, or where the weather conditions were sufficiently poor that close approaches to sei whales weren't attempted, resulted in no, or few, whales being photo-identified. The majority of sei whale photo-identification attempts occurred in the north-eastern part of King George Bay (Figure 6.5), with smaller amounts of photo-identification effort scattered across the remainder of the study area. A small number of images were also taken during the preliminary survey with the *Saoirse* in January 2018 (see Section 4), and three distinctive animals from that survey were included in the West Falkland catalogue.

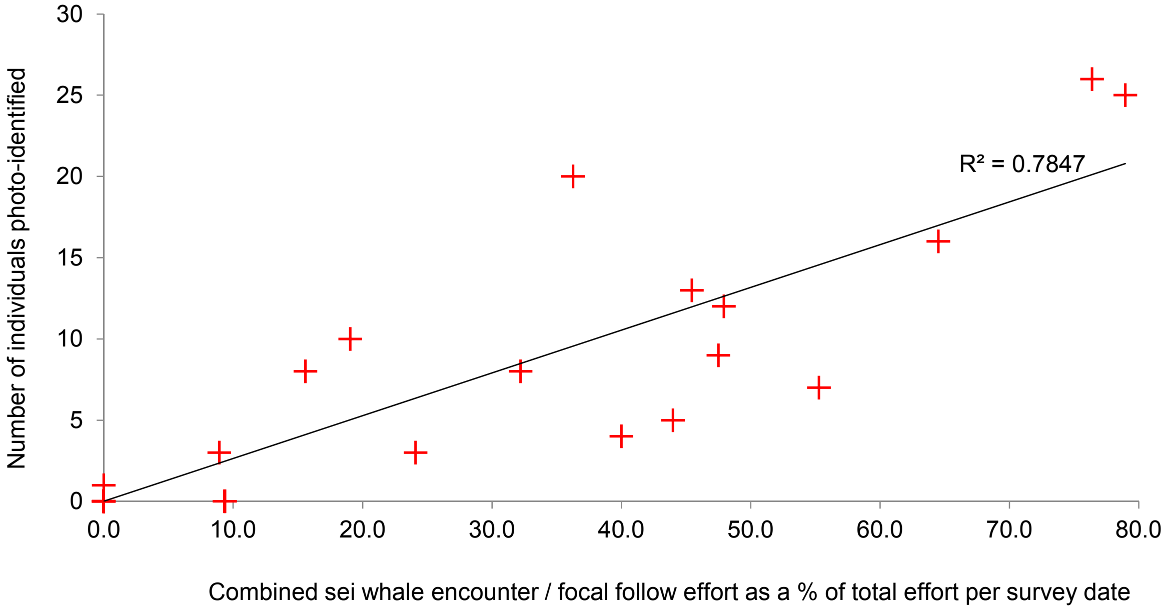


Figure 6.4. The total combined amount of sei whale encounter effort and focal follow effort carried out on each survey date, and the total number of individual sei whales photo-identified on that date. A linear trendline is fitted.

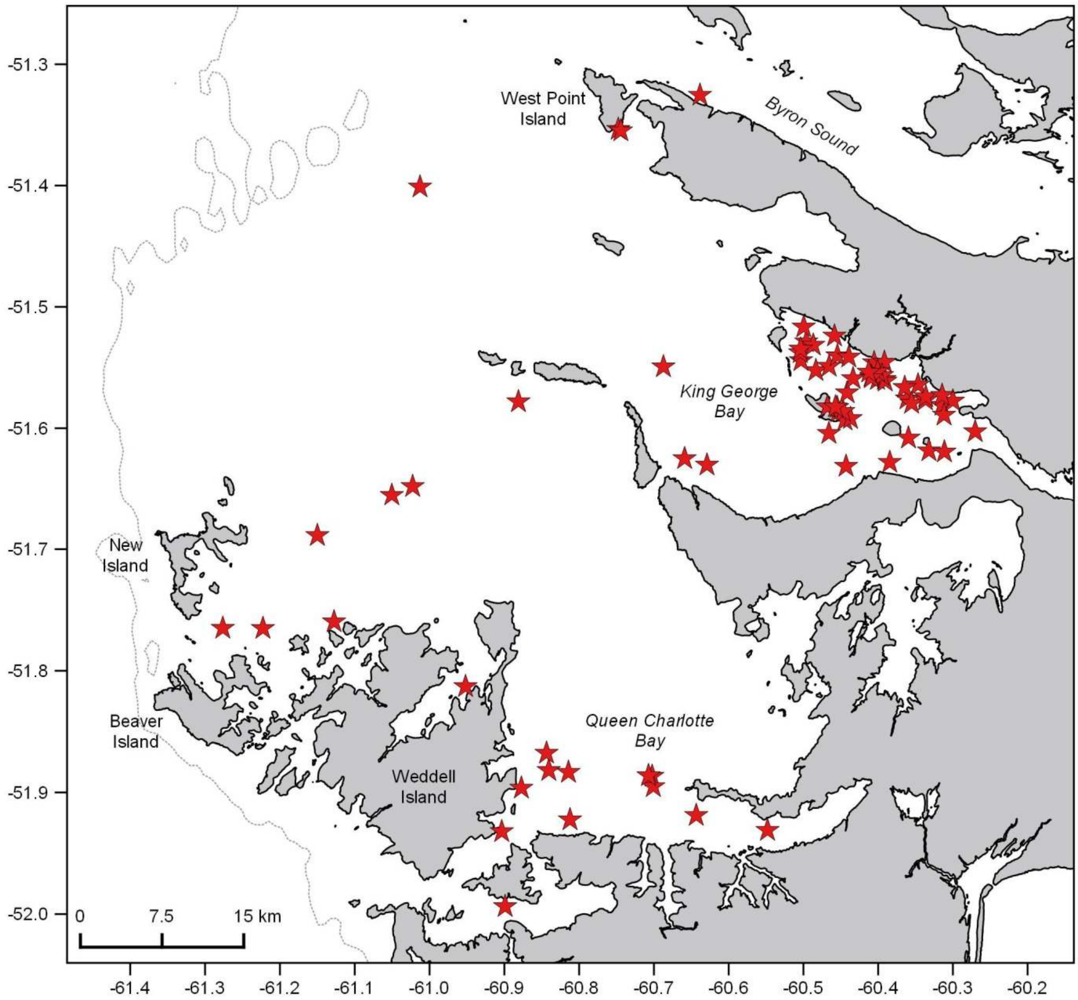


Figure 6.5 The initial sighting locations in the West Falkland study area of sei whale encounters during which photographs were taken.

6.3.2. West Falkland study

A total of 147 animals were initially entered into the West Falkland photo-identification catalogue (Weir, 2018a), of which three were photographed during the *Saoirse* survey in January and the remainder were photographed during the main West Falkland survey in February and March 2018. Of those 147 animals, there were eight individuals for which only images of PQ4 (poor quality) were available. Those animals were retained and catalogued solely in case better images of them were obtained in the future, but were not considered to be of sufficient quality to be certain of their uniqueness or to include in further analyses at this stage.

The remaining 138 animals had images of PQ1 to PQ3 available for at least one side of their body. For 93 individuals, images of both the left and right sides were acquired; however, for 14 of those animals then only PQ4 images were available for one of the sides. Only left side images were available for 25 individuals and only the right side for 20 individuals. A total of 81.2% of the 138 individuals were of DV1–5, and had permanent markings (Table 6.2). Animals lacking permanent markings that were catalogued from scar patterns (DV6) comprised 18.8% of the total (Table 6.2).

The MPS for the West Falkland study area was 133 animals, comprising 112 permanently-marked animals (DV1–5) and 21 DV6 animals for which right-side images were available.

Table 6.2. Summary of the distinctiveness values (DVs) of 138 West Falkland sei whales catalogued from images of fair to good photographic quality (PQ1–3).

DV value	No. of animals	% of total animals
DV1	10	7.2
DV2	46	33.3
DV3	42	30.4
DV4	5	3.6
DV5	9	6.5
DV6	26	18.8

A total of 22 individual sei whales were photographically-captured on more than one survey date, comprising 17 animals that were captured on two dates, four animals that were captured on three dates, and a single animal that was captured on five dates (Table 6.3). Six of the individuals that were photographically-captured on only two dates, were observed on successive dates. All of the animals captured on successive dates were recorded within King George Bay on both dates, although one animal (WF-8) moved a 27 km straight-line distance from the western limit of King George Bay (north of First Island) to the north-eastern part of the Bay (off Brown Point). The remaining animals with two photographic captures were recorded 3 to 27 days apart and at distances of 3.9 to 62.1 km between sightings. Three individuals (WF-15, WF-40 and WF-70; Table 6.3) had capture locations located within 5 km of one another, despite being recorded 11 to 18 days apart. Conversely, the three whales with the largest spatial movements between their two photographic captures (WF-4, WF-26 and WF-65; Table 6.3) travelled distances of at least 62, 29 and 32 km over periods of 27, 17 and 19 days respectively. These three animals moved from Byron Sound to south-west Queen Charlotte Bay (WF-4), from Hummock Island in King George Bay to the Passage Islands (WF-26), and from West Point Island to King George Bay (WF-65). All of the whales with more than two photographic captures were recorded in relatively small spatial areas inside King George Bay, and there were two particular results of note:

1. Whale WF-9 was captured on five survey dates between the 3 and 27 March. All five capture locations were located eastwards of the southern end of Hummock Island in King George Bay, with a maximum distance between the furthest-most capture locations of only 10.8 km (Table 6.3).

Table 6.3. Summary of photographic recaptures of 22 sei whales that were photographed more than once during the West Falkland survey.

Animal	Photographic captures			Days between first and last capture	Maximum straight-line distance between captures (km)	Capture areas
	N	First date	Last date			
WF-4	2	25/02/2018	24/03/2018	27	62.1	Byron Sound to Queen Charlotte Bay
WF-7	2	02/03/2018	15/03/2018	13	19.1	King George Bay
WF-8	2	02/03/2018	03/03/2018	1	26.8	King George Bay
WF-9	5	03/03/2018	27/03/2018	24	10.8	King George Bay
WF-15	2	06/03/2018	24/03/2018	18	3.9	Queen Charlotte Bay
WF-26	2	10/03/2018	27/03/2018	17	29.1	King George Bay to Passage Islands
WF-39	2	15/03/2018	16/03/2018	1	9.9	King George Bay
WF-40	2	15/03/2018	28/03/2018	13	4.3	King George Bay
WF-46	3	15/03/2018	28/03/2018	13	6.6	King George Bay
WF-53	2	15/03/2018	16/03/2018	1	7.0	King George Bay
WF-57	2	16/03/2018	17/03/2018	1	11.4	King George Bay
WF-61	3	16/03/2018	20/03/2018	4	9.3	King George Bay
WF-65	2	25/02/2018	16/03/2018	19	32.1	West Point to King George Bay
WF-66	2	16/03/2018	20/03/2018	4	8.6	King George Bay
WF-67	2	16/03/2018	17/03/2018	1	5.0	King George Bay
WF-70	2	16/03/2018	27/03/2018	11	4.3	King George Bay
WF-73	3	15/03/2018	17/03/2018	2	5.0	King George Bay
WF-75	3	11/01/2018*	28/03/2018	76*	7.4	King George Bay
WF-81	2	17/03/2018	28/03/2018	11	12.1	King George Bay
WF-86	2	16/03/2018	17/03/2018	1	6.2	King George Bay
WF-87	2	17/03/2018	20/03/2018	3	5.4	King George Bay
WF-88	2	15/03/2018	19/03/2018	4	8.6	King George Bay

*Includes a photographic capture from the *Saoirse* survey (see Section 4 of this report) on 11 January 2018. The number of days between captures decreases to 12 if only the two captures from the main West Falkland survey in February–April 2018 are considered.

2. Whale WF-75 was captured twice in King George Bay during the West Falkland survey in March. However, this individual was also photographed during the *Saoirse* survey in January 2018 (Figure 6.6), resulting in a total of 76 days between the first and final capture. All three captures were located in northern King George Bay between Hummock Island and Rabbit Island, separated by maximum straight-line distances of only 7.4 km (Table 6.3).

(A)

(B)

Figure 6.6. Photographic matches of individual WF-75 between: (A) the *Saoirse* January 2018 survey; and (B) the main West Falkland survey during March 2018. The pattern of small nicks near the tip of the dorsal fin, the presence of a shallow tailstock notch, and some distinctive scars on the flank of the whale, were used in combination to confirm the match.

The correlation between the straight-line distances between the furthest-most captures of each individual versus the number of days between the first and final captures, is shown in Figure 6.7. There was a cluster of animals for which there were fewer than five days between captures and for which the spatial distances between the captures was generally small at <10 km. Although it might be expected that the documented spatial distances between captures would increase in direct relation to the number of days between captures, the observed relationship was weak (Figure 6.7). This was due to the tendency for many of the recaptures of individual sei whales to occur within a relatively small distance of their initial captures even over periods of two to three weeks (Figure 6.7). However, it should also be noted that many whales were captured only once during the survey, which also suggests that some individuals may have moved considerable distances from their original capture locations.

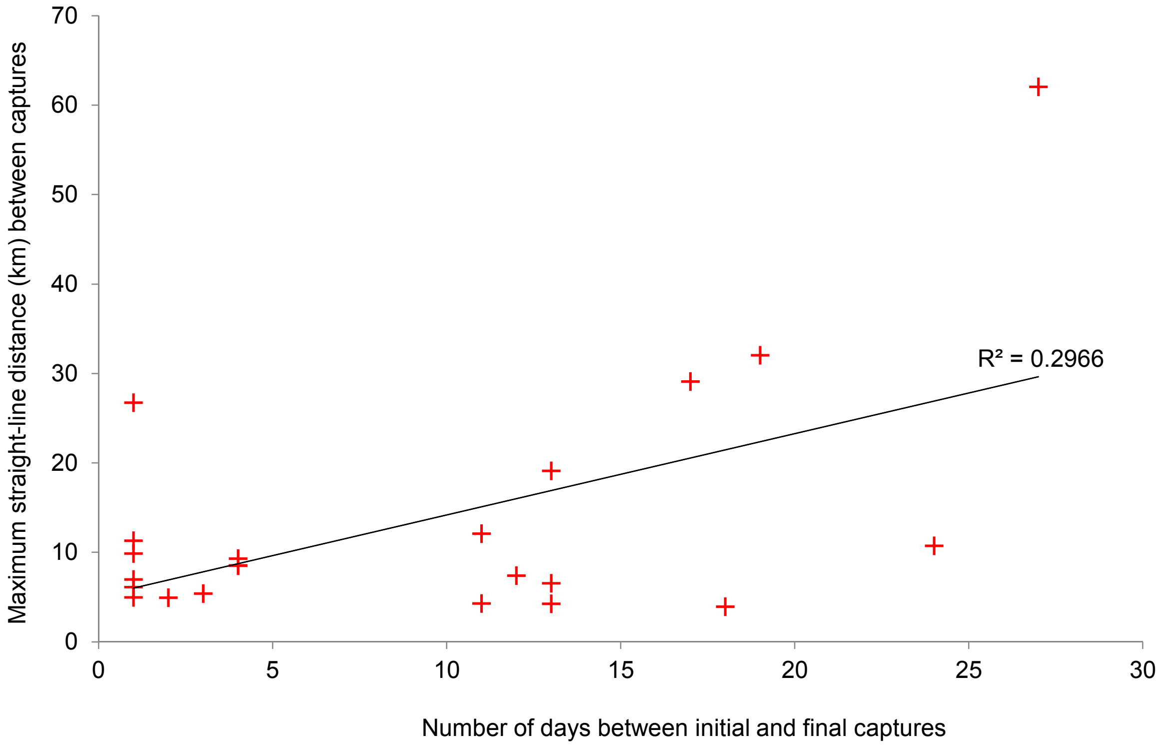


Figure 6.7. Relationship between the number of days between photographic captures of sei whales and the maximum straight-line distance recorded between the two most distant captures for each individual. Note that for consistency, only the captures recorded during the main West Falkland survey are shown for animal WF-75.

6.3.3. Comparison with Berkeley Sound

An initial comparison was carried out between the 2017 Berkeley Sound photo-identification catalogue (Weir, 2017a), and that produced for sei whales for the 2018 West Falkland survey (Weir, 2018a). Two photographic recaptures were found between the catalogues:

1. WF-31 (north of Weddell Island, March 2018) was matched with BS-80 (Berkeley Sound, April 2017; Figure 6.8); and
2. WF-115 (King George Bay, March 2018) was matched with BS-100 (Berkeley Sound, May 2017; Figure 6.9).

Both of the recaptures occurred on opposite sides of the Falklands, with two whales identified inside the Berkeley Sound cKBA being recaptured on the west coast of West Falkland (Figure 6.10). Both captures occurred in separate years (2017 and 2018) and therefore provide the first firm evidence for the inter-annual use of Falkland waters by individual sei whales. It should be noted that this represents a preliminary result from the initial comparison; the two catalogues will be cross-referenced again in future to double-check for additional matches.

Examination of the recaptures indicated some changes in the occurrence of natural features between years. Individual WF-31/BS-80 had acquired new scars on its flanks between the two years, while individual WF-115/BS-100 appeared to have acquired a small new nick in the trailing edge of its dorsal fin (Figure 6.11).

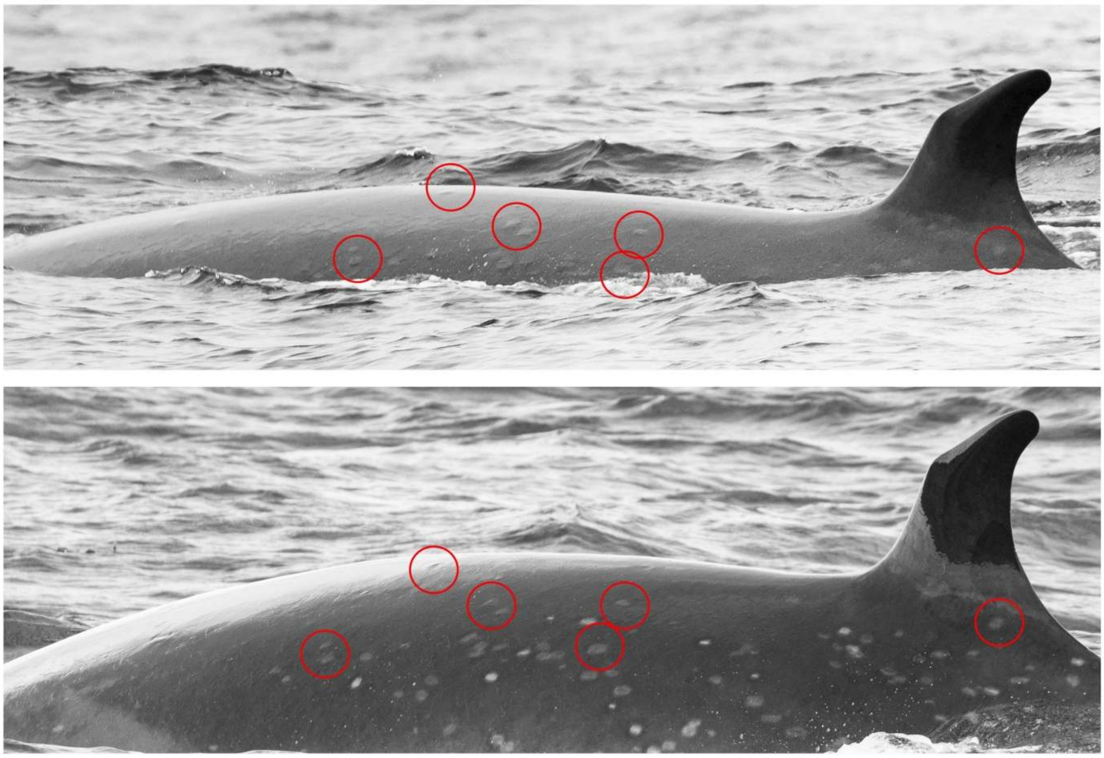


Figure 6.8. Photographic recapture of BS-80 (top image: Berkeley Sound, April 2017) and WF-31 (lower image: north of Weddell Island, March 2018). Some of the scars that are evident in both images are circled in red.

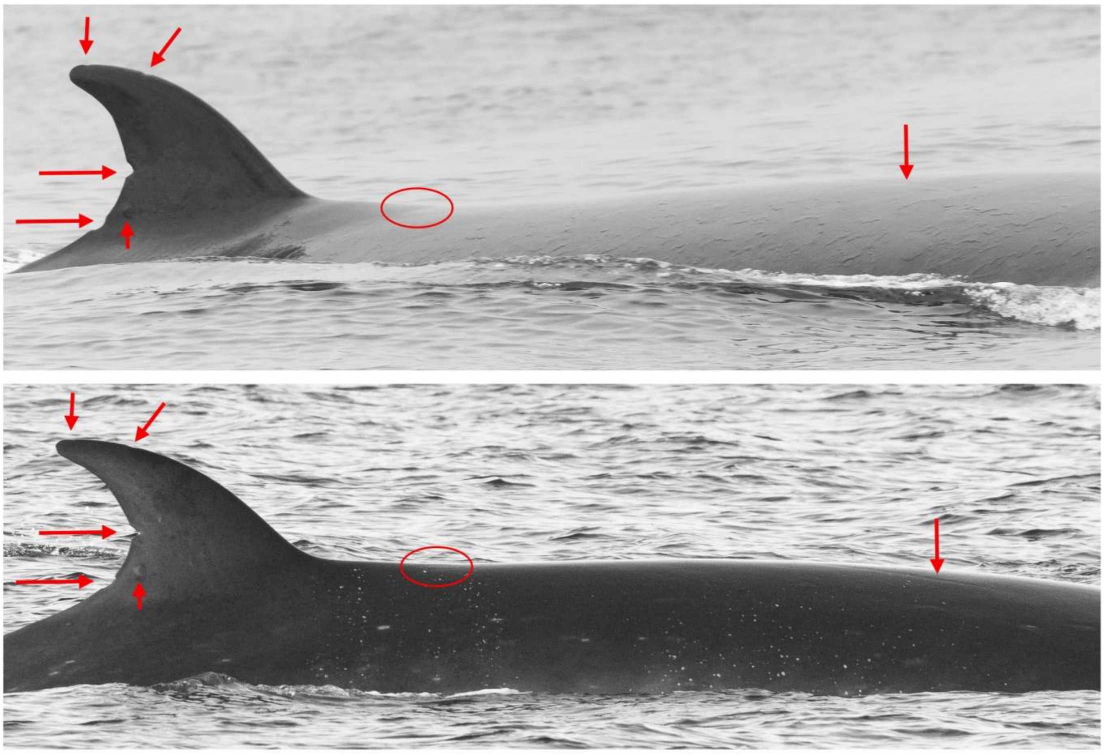


Figure 6.9. Photographic recapture of BS-100 (top image: Berkeley Sound, May 2017) and WF-115 (lower image: King George Bay, March 2018). Markings that are apparent in both years are indicated with red arrows and circles. Note that the overall appearance of the fin shape and nicks is affected by the slight variation in angle of the animal relative to the photographer, and by variation in the surfacing behaviour and therefore the relative curvature of the back. See also Figure 6.11.

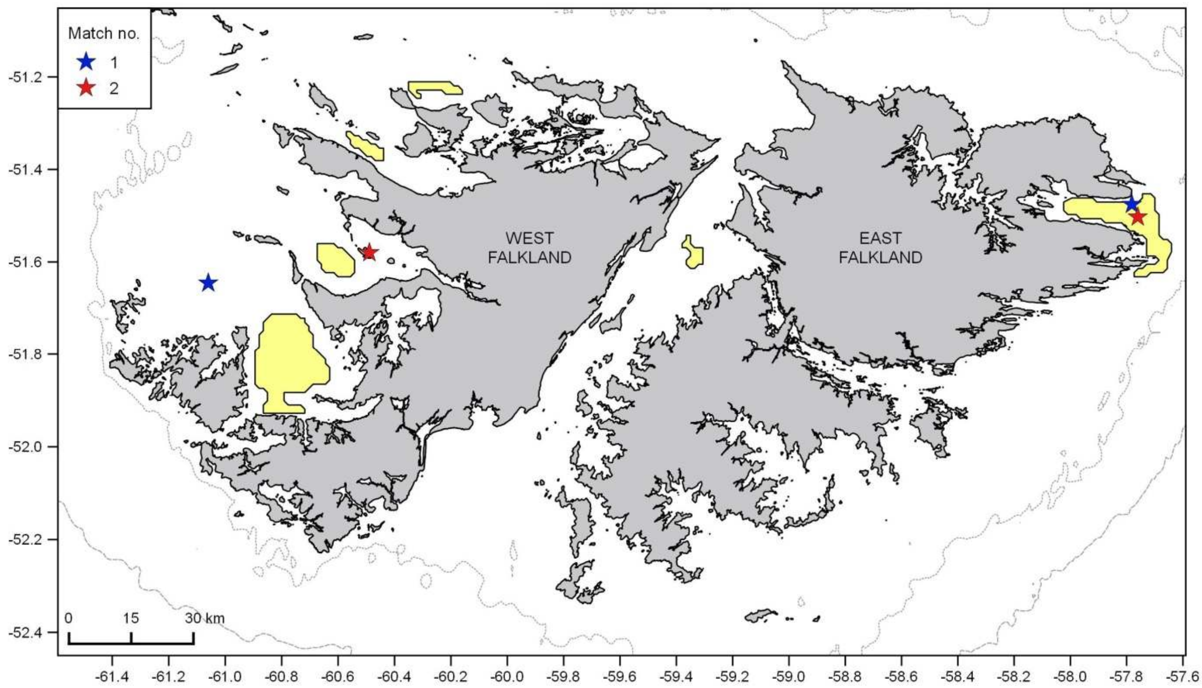


Figure 6.10. Locations of the sightings of two sei whale individuals that were photographically-captured in both the Berkeley Sound (2017) and the West Falkland (2018) study areas. The locations of the six whale cKBAs are shown in yellow (see Figure 1.1).

Figure 6.11. Cropped views of the dorsal fin of the photographic recapture of BS-100 (left image: 2017) and WF-115 (right image: 2018), showing the apparent acquisition by 2018 of a small new nick on the trailing edge at the tip of the fin.

6.4. Discussion

The photo-identification work in West Falkland was successful in acquiring images of sei whales that were suitable for individual recognition. However, a number of limitations were experienced while implementing the method during the survey, which are briefly outlined here:

- As experienced in Berkeley Sound (Weir, 2017a), sei whales did not have a high abundance of overt natural markings, and the prevalence of animals identified from subtle features such as small nicks and scar patterns meant that obtaining images of high quality was fundamental to animal recognition and recapture rate. To achieve the necessary image-quality, photographers need to have a good working knowledge of adjusting camera ISO, exposure compensation, and depth of field, to ensure that image quality is continuously maximised during whale encounters to allow small features to be observed. This is particularly the case in poor light associated with overcast conditions, as often experienced in the Falklands. Ongoing training in camera use for participants in sei whale photo-identification work should therefore be prioritised.
- Also consistent with the Berkeley Sound findings was the challenging behaviour of sei whales in the field with regard to achieving close approaches for photo-identification. The species was found to be fast-swimming, often surfaced without revealing the entirety of the dorsal fin, and frequently changed direction between surfacings in an unpredictable manner (the latter was probably associated with foraging behaviour in the study area). Additionally, sei whales regularly surfaced just ahead of, and at a slight angle away from, the boat, which reduced the usability of the images for identification. It was again noted this season that sei whales were often only cooperative in allowing approaches on one of their sides, and would avoid the boat approaching on their other side (for unknown reasons). Consequently, only one side of some animals was photographed, despite concerted effort to acquire both sides in some of the encounters. Similar responses from sei whales to vessel approaches were noted from the RIB used in Berkeley Sound, and from the small zodiac and the yacht used in the West Falkland survey, and greater tolerance towards certain platform types (which may have been useful in guiding future choice of platform for this work) was therefore not evident.
- The zodiac originally proposed for the photo-identification work during the West Falkland study was only 4.5 m in length, and was completely exposed to the elements. Unfortunately this platform did not prove usable for photo-identification work, having the following limitations: (1) its instability, even in small waves, limited the photographers ability to hold the camera steady and achieve focus, and a high proportion of images were therefore out of focus or omitted parts of the dorsal fin due to the photographer being jostled around in the boat; (2) its openness and low sides restricted the photographer from being able to quickly (and safely) move around to switch the camera from one side of the boat to another when a whale surfaced, and it was difficult to obtain a clear view of whales due to obstruction from the other researcher present in the boat; (3) there was spray coming over the bow of the boat even in small waves, which both obscured the front of the lens and presented a hazard to the camera itself; (4) there was no structure (e.g. steering console or purpose-built person hoop for support) in the boat against which personnel could brace to hold equipment steady; (5) there were communication challenges with implementing the approaches; and (6) there were relatively few survey days where wind, swell and wave conditions were suitable for working from the zodiac. As a result, the zodiac was not found to be a viable platform for the photo-identification of sei whales (even on the calm days from which it was attempted), and subsequent effort was restricted to the yacht.
- The yacht provided a good stable platform and the ability for the photographer to move quickly between sides of the vessel to focus on surfacing whales. There were also structures available (e.g. masts and railings) against which the photographer(s) could brace to ensure the camera could be held steadily to achieve focus. Although the yacht deck was higher above the water than the RIB used in Berkeley Sound, the higher elevation did not negatively-affect the

acquisition of images, and most whale dorsal fins still appeared perpendicular with the nicks fully visible. In fact the higher deck height provided some advantages in providing a better view of animals swimming subsurface, which allowing the photographer to track them and be in the correct position when they surfaced. However, there were also some limitations to the use of the yacht, most notably the lower manoeuvrability and speed of the vessel which often meant that whales were too distant and consequently their dorsal fins were too small in the frame. There was also a lot of structure on the main deck of the vessel (e.g. masts, zodiac storage and ropes) which necessitated the photographer(s) standing right at the front of the bow to obtain a clear view of the whales, and this exposed them to spray coming over the bow and to significant movement of the platform when travelling directly into the swell. The most notable challenge experienced from the yacht was the lack of direct communication between the photographers (located on the bow) and the helmsman (located inside an enclosed wheelhouse), which greatly affected success with regard to manoeuvring the vessel to achieve the necessary close approaches to the whales and resulted in some missed opportunities.

This brief synopsis of the advantages and disadvantages of the platforms for sei whale photo-identification work is intended as feedback on the importance of vessel selection for maximising the outputs of future planned work.

The sei whale photo-identification study achieved all of the aims stated in Section 6.1. It provided a MPS for the study area, information on sei whale movements in the study area, and documented movements between different geographic areas that supports connectivity between the cKBAs. Although photo-identification was carried out on fewer days in the West Falkland 2018 study (17 days) than it was in the Berkeley Sound 2017 study (23 days), a greater number of sei whale individuals was recorded. The MPS for Berkeley Sound was 87 animals (Weir, 2017a), compared with 133 animals in West Falkland. While slightly different methods were used to calculate the MPS in the two studies, this does not explain the variation; the Berkeley Sound dataset was re-analysed using the same method of calculating MPS as used in the West Falkland study, and produced an MPS of 85 animals. Consequently, the photo-identification work suggests that the number of individuals within the West Falkland study area was substantially larger than in Berkeley Sound. This result is unsurprising, since the spatial extent of the West Falkland study area was an order of magnitude larger than Berkeley Sound. The two studies also varied in temporal scale, with almost all of the West Falkland photo-identification effort occurring within a single month (March 2018), whereas the Berkeley Sound effort spanned several months (February to May 2017). The longer timeframe of the Berkeley Sound work potentially provided greater opportunity to encounter new individuals if animals were moving widely around the Islands in search of feeding locations. The results of the two studies were not therefore directly comparable due to these differences in spatial extent of the study area, timeframe and platform type.

The photo-identification dataset provided useful information on the movements of some sei whale individuals in the study area. The fact that most whales were photographically-captured on only a single occasion supports high mobility and suggests that some animals had a relatively transitory occurrence in the study area. However, they may simply have moved into the more open and exposed parts of the study area, where photo-identification effort was largely absent. Since the photographic effort was not evenly distributed and was strongly biased towards the north-eastern part of King George Bay, the potential for recapturing animals between different geographic regions of the study area was small. Nevertheless, several longer distance recaptures were achieved, most notably the confirmed movement of one whale between Byron Sound and south-west Queen Charlotte Bay.

The weak relationship between the number of days between photographic captures and the maximum straight-line distance recorded between the two most distant captures for each individual, was testimony to the varied movements by individual whales revealed by the photo-identification data. Some individuals were repeatedly captured in the same small area over periods of 2 or 3 weeks. This is not necessarily indicative of an absence of spatial movements by those individuals, since they may have swum elsewhere between captures and then returned back to the same area. However, this information does suggest that those areas were sufficiently important to individual whales for them to either remain within them for several days, or to leave but choose to return to them again. Both possibilities are indicative of site fidelity over the timeframe of the survey. The primary driver for the prolonged presence of individual sei whales in these small areas (all of which occurred in the north-eastern part of King George Bay) is likely to be the availability of prey, but other factors, such as social interactions, may also be influential. Conversely, other whales exhibited very different spatial capture patterns, most notably WF-8 which moved a straight-line distance of 27 km in one day. The movements documented from the West Falkland photo-identification study expand on the results from Berkeley Sound in 2017 (Weir, 2017a). Both studies found very variable levels of site fidelity by individuals, with many seen only once while others remained for periods of weeks. However, the much larger spatial size of the West Falkland study area provided more possibility to recapture sei whales across wider areas and examine linkage between the multiple cKBA sites within West Falkland.

Unsurprisingly, the number of individual sei whales photo-identified on a given survey date was positively related to the amount of time spent in proximity to the animals (i.e. during encounter effort or focal follow effort). On days when whales were not purposefully approached for photo-identification work (e.g. during transits or while on transects), few or no whales were photographed. Conversely, the highest numbers of animals photo-identified were on dates where significant amounts of time were spent approaching or following whales. This result clearly indicates that the success of sei whale photo-identification work in the Falklands is reliant on investing sufficient time in targeted close approach work, and that opportunistic photo-identification carried out in conjunction with other non-approach methods is less likely to be successful. Adequate time also needs to be spent with whale individuals or groups to ensure that images of sufficient quality are obtained, and of both sides of the animals whenever possible, in order to ensure that any potential disturbance to the animals is offset by achieving the optimal use of the data. Experience to date with sei whales in Berkeley Sound and West Falkland suggests that patience and the removal of time constraints are critical to this process, particularly when whales are available at the surface only infrequently between long dives. It can be concluded from the results that more sei whales would have been catalogued in the West Falkland study area had more time been invested in approaching whales for the purposes of photo-identification. However, the West Falkland survey was multi-faceted and consequently photo-identification work could not be prioritised on every day.

One interesting difference between the photo-identification datasets from Berkeley Sound and West Falkland was the variation in the proportions of the DV of individuals. In Berkeley Sound only approximately 20% of sei whales were considered to be well-marked (DV1 or DV2) with respect to photographic recapture, while this proportion was 41% in West Falkland. Conversely, approximately 35% of sei whales were identified from their scar patterns only (DV6) in Berkeley Sound, while this proportion decreased to 19% in the West Falkland whales. The reasons for these differences are currently unclear, particularly since the photographic recapture of two sei whales between Berkeley Sound and the west coast of West Falkland supports the mixing of whales between different areas around the Islands. The longevity of sei whale scar patterns with regard to the long-term recognition of individuals remains unknown (Schilling et al., 1992; Weir, 2017a), and continued photographic effort over additional years should facilitate some evaluation of the healing rates of old scars and the acquisition rate of new scars. The two inter-annual recaptures presented in this report, suggest that new scars will appear between years but that older scars remain visible for at least one year.

A basic-level allocation of photographic quality (PQ) ratings was carried out for the provisional analysis of the 2018 photo-identification data presented in this report (see Appendix 6), in order to maintain consistency with that conducted on the Berkeley Sound 2017 photo-identification dataset (Weir, 2017a). However, it is recognised that the future application of mark-recapture analysis techniques to the 2017 and 2018 sei whale datasets will require both a more rigorous PQ scoring method and a more robust assessment of what constitutes 'marked' versus 'non-marked' animals. This is because the PQ grading and requirements for inclusion in analysis will be different depending on whether a 'marked' animal is defined as: (1) those individuals with nicks/notches in the dorsal fin or other permanent markings; or (2) widened to also include individuals with sufficient natural scar patterns (primarily the cookie-cutter shark scar marks on the flanks). In most cases Definition 1 would require only having high-quality images of the dorsal fin itself, whereas Definition 2 would require high-quality images of the entire target area (TA) of the flank. The provisional PQ assessment carried out on the 2017 and 2018 datasets did not distinguish between these different parts of the body, but rather comprised a single overall combined value based on the available images of both the fin and flank. This approach is suboptimal, since different images were usually used to show the dorsal fin and the flank and sometimes may have warranted different PQ scores. Therefore, this approach would need to be refined prior to a robust mark-recapture analysis. Image exposure is also significantly more critical for PQ assessments using Definition 2 for 'marked' animals than it is for Definition 1, and consequently the PQ coding process itself may need to be revised and separate codes allocated for parameters such as angle, exposure, sharpness and visibility of the target area (e.g. Falcone et al., 2011). It is anticipated that these processes will be discussed and refined over the next year, with the aim of conducting a more formal mark-recapture analysis on the datasets in future.

7. BEHAVIOURAL STUDY

The content of this chapter, together with data collected in Berkeley Sound (Weir, 2017a), has already been accepted for publication in the scientific journal Cetacean Research and Management:

Weir, C.R., Taylor, M., Jelbes, P.A.Q. and Stanworth, A. Cue rates and surfacing characteristics of sei whales (*Balaenoptera borealis*) in the Falkland Islands. In Press, Journal of Cetacean Research and Management.

A copy of this paper will be available from FC on request following final publication. A summarised version of the West Falkland component of the published dataset is presented in this chapter.

7.1. Introduction and aims

The collection of data on cetacean dive duration and surfacing behaviour is relevant to several aspects of their management and conservation including assessing energetic costs (Sumich, 1983; Acevedo-Gutiérrez et al., 2002), investigating responses to anthropogenic disturbance (Ljungblad et al., 1988; Argüelles et al., 2016), and producing estimates of the amount of time that animals are at the surface and thus available for visual detection during abundance or cue-counting surveys (Øien et al., 1990; Hiby, 1992; Heide-Jørgensen and Simon, 2007). In addition, knowledge of the breath frequency, dive interval, surfacing behaviour and swim speed of whales is important for understanding the conditions in which whale encounters can lead to vessel strikes (Nowacek et al., 2001; Argüelles et al., 2016). Consequently, the dive behaviour of most large baleen whale species has been studied worldwide. However, the diving and surfacing behaviour of the sei whale has been little studied to date, comprising small amounts of (non-systematic) information provided for encounters in Chile (Avecedo et al., 2017) and the Gulf of Maine (Schilling et al., 1992), and a recently-published tagging study of two sei whales off Japan (Ishii et al., 2017).

FC initiated the collection of systematic dive behaviour data on sei whales in the Falklands during survey work in Berkeley Sound during 2017 (Weir, 2017a; Weir et al., In Press), with the primary aim of producing correction factors for the abundance estimates resulting from aerial survey work. However, it was also desirable to collect similar datasets from other areas around the Falklands in order to: (1) increase sample size; and (2) provide a comparison with other spatial areas to determine whether sei whale dive behaviour varies according to site or habitat. Consequently, the West Falkland sei whale survey also aimed to collect data on sei whale dive and surfacing behaviour.

The overall aims of the West Falkland behavioural study were to produce a baseline dataset of the undisturbed behaviour of sei whales, and to examine the use of the cKBAs by sei whales for foraging (indicated by repeated long duration dives within an area) and feeding (evidenced by observations of faecal events, skim-feeding and lunge-feeding) behaviour. Specific objectives were:

1. To collect quantitative information on behavioural events to provide information on why sei whales are using Falkland waters;
2. To collect data on dive duration, surfacing bouts and "cue rates" (i.e. blows per whale per hour) that can be used to correct abundance estimates and potentially to inform collision risk assessments; and
3. To conduct an initial comparison of the behavioural data collected with and without the immediate proximity of a motorised boat, in order to assess the potential impacts of vessel disturbance on whale behaviour.

7.2. Methods

7.2.1. Data collection

Behavioural focal follows (FFs) were carried out on sei whales on selected occasions when the following conditions were met: (1) the sighting occurred outside of a line transect survey and at least a 1 hr window was available to follow animals; (2) when weather conditions were such that the vessel could be stopped or slowed to work with the animals; and (3) when other survey priorities allowed (for example it was not possible to do focal follows alongside repeated close approaches for photo-identification, or the natural behaviour of the animals may be disrupted). Standardised information on location, group size and environmental conditions were logged at the start of every sighting as part of the general visual sighting survey, and a GPS recorded the vessel's position at 1-min intervals throughout every focal follow.

Focal follows were carried out on both individuals and groups, and commenced when the following criteria were met so that respiration and critical behavioural events were not missed: (1) the sighting was at sufficient proximity that the observer was confident of detecting all blows; (2) the group size and spacing were stable so that the target animal(s) could be confidently tracked over time; and (3) prevailing light and sea conditions were favourable for detecting blows. Each FF ceased either: (1) after at least one hour of data had been collected; (2) if the focal animal or group was lost; or (3) immediately that group composition changed. At the onset of each FF, a dedicated team member was nominated as the core observer for visually tracking the focal whale(s) with the naked eye. However, in the majority of FFs at least two observers scanned around the vessel for whale cues. The survey vessel was slowly manoeuvred throughout each FF to maintain a suitable detection distance to the whales while minimising potential impacts on natural behaviour (usually around 200 to 500 m distance).

During a FF the onset of each whale surfacing event or "cue" was called out by the core observer, and was either logged directly into a laptop by a second person using a custom-designed Excel spreadsheet with an automatic timestamp (1 sec accuracy), or recorded verbally by the core observer into a time-calibrated digital voice recorder (DVR). A cue was defined as any appearance of the whale at the surface; this predominantly comprised the blow, but could also include a head, back or dorsal fin breaking the surface without a visible blow. The primary surfacing event was therefore recorded as either "blow" or "no blow", and a secondary behavioural state was entered whenever applicable which comprised one of the categories in Table 7.1. No specific secondary behavioural event was logged for the default behaviour of a "typical roll" of the back and fin at the surface.

Table 7.1. Specific behavioural states logged during behavioural focal follows of sei whales in West Falkland.

Behavioural state	Description
DIVE	Whale arches its back steeply signalling the onset of a longer or deeper dive
LUNGE	Engulfing prey at the surface
SKIM	Swimming along the surface skimming food
FAECAL	Faecal event associated with the surfacing
OTHER	Any other behaviour (stated)

7.2.2. Data analysis

A number of FFs were commenced but then aborted after relatively short periods due to groups splitting or merging with other animals. Consequently, FFs of <20 min duration were omitted from the analysis to reduce potential bias from long dives being under-recorded.

For FFs recorded on the DVR, the time to the nearest second of every whale cue was extracted using the software Audacity 2.1.2 (www.audacityteam.org/). The Cue Rate (CR), defined as the number of cues per whale per hour, was calculated for each FF as: CR = (B / D)*60 / G. Where, B is the total number of cues during D, minus 1; D is the total duration (min) of the FF, from the time of the first cue recorded to that of the last; and G is the number of individuals in the FF.

Since it was not possible to assess accurate dive duration of individual whales within each group (due to a lack of overt natural markings to enable individuals to be recognisable at distance), a Minimum Dive Duration (MDD) was produced for each FF. The MDD was defined as the maximum amount of time when all individuals within a focal group were submerged, and provides an indication of the minimum dive duration of any single animal within the focal group. A minimum average swim speed was calculated for boat-based FFs, by calculating the distance travelled by the boat during each FF using a QGIS script. This definition produced a straight-line horizontal swim speed across the surface and does not account for vertical movements or finer-scale spatial movements.

Only FF data collected from solitary sei whales were used for detailed investigation of dive types and cycles. Inter-breath intervals (IBIs) were calculated as the time elapsed between two consecutive surfacings by an individual. Only data from complete dive cycles were used in the analysis to ensure adequate representation of longer dives. A complete dive cycle was defined as a long, deep dive (i.e. true dive) followed by a full surfacing bout, or vice versa (depending on where in the dive cycle the FF had commenced). Initial examination of IBIs against dive sequence number for each whale revealed obvious inter-individual differences in sei whale dive pattern. Consequently, a combined approach was developed to define dive types that allowed for inter-individual variation in dive pattern and dive type duration. Details of the combined approach are described fully by Weir et al. (In Press).

7.3. Results

7.3.1. Overview

The West Falkland behavioural study was originally designed to fulfil three specific objectives (Section 7.1). However, due to the logistical and weather challenges described elsewhere in this report, only one of the three objectives could be addressed during the fieldwork.

The first objective, to collect quantitative behavioural information on surface feeding and deep diving, was thwarted by the lack of overt behaviour displayed by sei whales in the study area. In practice, only a single observation of surface feeding (which occurred outside of a FF) was recorded during the entire West Falkland survey (Figure 7.1). Additionally, Objective 3 regarding the comparison of sei whale behaviour with, and without, the close proximity of a motorised boat could not be achieved, since the original plan to use the zodiac to approach whales for photo-identification work was aborted early in the project due to the unsuitable small size of the zodiac for photographic work (see Section 6.4). Consequently, only Objective 2, regarding the collection of data on dive behaviour and cue rates, could practically be addressed during the fieldwork. The remainder of the Results section therefore relates to that objective.

Figure 7.1. Only one observation of surface feeding was recorded during the West Falkland survey, on 17 March 2018. The image shows a sei whale lunging on its side at the surface, with the left flipper visible along with the throat grooves.

A total of 24 behavioural FFs were initiated on sei whales during the West Falkland survey. However, seven of those were aborted after durations of <20 min due to the whale(s) merging with other whale groups or simply becoming difficult to track with confidence due to the presence of other animals in the same area. Seventeen of the West Falkland FFs had duration of at least 20 min and were suitable for analysis, occurring between 25 February and 26 March 2018 (Table 7.2). These FFs included solitary animals (n = 6), groups of 2 or 3 animals (n = 9), and two groups of five animals (Table 7.2). The average linear swim speed recorded during the West Falkland FFs was 5.3 km h^{-1} (Table 7.2; n = 15, SD = 1.3, median = 4.8, range = 3.6–8.3 km h^{-1}).

Table 7.2. Sei whale cue rates (cues / whale / hr) recorded during the West Falkland study.

FF No.	Date	Photo-ID no.	FF durn. (min)	Group size	Average speed (km / hr)	Total no. of blows	Cue rate
WF–1	25 Feb 18	WF–2, 3, 5	84.7	3	5.4	137	32.1
WF–2	3 Mar 18	–	90.0	1	–	44	28.7
WF–3	3 Mar 18	WF–9, n/a	96.8	2	6.0	104	31.9
WF–4	3 Mar 18	WF–12, n/a	53.5	2	4.8	55	30.3
WF–5	3 Mar 18	WF–12	38.2	1	4.6	15	22.0
WF–6	5 Mar 18	–	22.2	3	8.3	37	32.4
WF–7	6 Mar 18	WF–15, n/a	109.2	3	4.1	165	30.0
WF–8	6 Mar 18	WF–16, 17, 18	61.4	3	4.3	90	29.0
WF–9	6 Mar 18	WF–19, 20, 21	23.8	3	3.7	40	32.7
WF–10	10 Mar 18	WF–24, 25, 26, 27, 28	66.4	5	4.6	171	30.7
WF–11	15 Mar 18	–	24.6	1	4.8	14	31.7
WF–12	15 Mar 18	WF–39	72.2	1	3.6	37	29.9
WF–13	16 Mar 18	WF–55, 56, 57, 58, 59	38.1	5	5.3	111	34.7
WF–14	19 Mar 18	WF–61, 88	34.3	2	–	41	35.0
WF–15	24 Mar 18	WF–15, 97, 98	62.1	3	6.0	105	33.5
WF–16	25 Mar 18	WF–100	85.7	1	7.7	43	29.4
WF–17	26 Mar 18	–	54.1	1	5.9	25	26.6

The locations of the 17 FFs spanned different areas of the West Falkland study area, and included Byron Sound, south of the Passage Islands, Dyke Island, and multiple locations in King George Bay and the south-west of Queen Charlotte Bay (Figure 7.2).

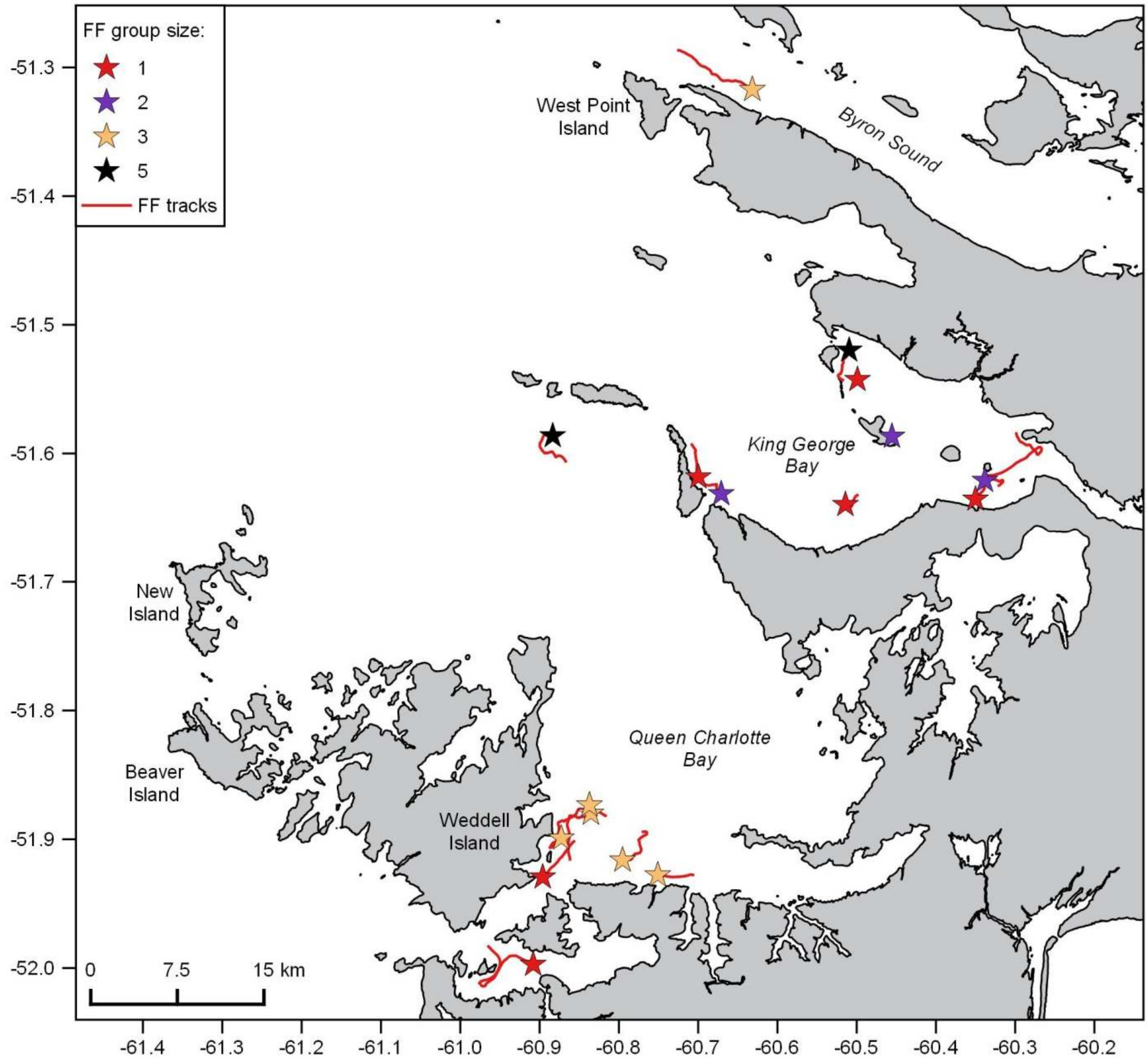


Figure 7.2. The locations of 17 sei whale focal follows carried out during the West Falkland study.

7.3.2. Cue rates

The CRs of sei whales in West Falkland ranged from 22.0 to 35.0 (Table 7.2), with an overall mean of 30.6 (SD = 3.1) and a median of 30.7. The mean CR for each of the recorded group sizes was 28.1 (n = 6, SD = 3.4, median = 29.0) for single animals, 32.4 (n = 3, SD = 2.4, median = 31.9) for pairs, 31.6 (n = 6, SD = 1.7, median = 32.2) for groups of three whales, and 32.7 (n = 2, SD = 2.8, median = 32.7) for groups of five whales.

7.3.3. Dive duration

There were 19 occurrences of submergences that exceeded 300 s (5.0 min), including 14 accurate dive times recorded from individuals and five MDDs recorded from groups of 2 or 3 whales. These long dives occurred over nine different FFs and therefore were undertaken by multiple individuals. The longest submergences recorded in West Falkland were 574 s (9.6 min) by an individual and 363 s (6.1 min) as a group MDD.

7.3.4. Dive types

Accurate dive cycle timings were available for six solitary sei whales. Photo-identification images were available for three of the animals, and indicated that each was a unique individual (Table 7.2). The mean IBIs for the six whales ranged from 119.5 to 163.7 s (Table 7.3), producing an overall combined mean IBI of 129.6 s (n = 161, SD = 104.6). Four of the West Falkland whales were considered to have differentiated dive patterns, while two animals exhibited more variable dive patterns (Table 7.3; Figure 7.3). Using the combined-method approach, a total of 121 (75.2%) IBIs were assigned to a dive type, while the other 40 (24.8%) dives remained unclassified (Table 7.3). The majority of IBIs (37.9%) comprised surface dives with a mean IBI of 49.3 s and a median of 48.0 s (Table 7.4). True dives had a mean IBI of 299.5 s and a median of 288 s, and comprised 21.7% of the total IBIs. A relatively small number of dives (15.5%) were categorised as intermediate dives, with a mean IBI of 118.8 s and a median of 120.0 s. The remaining dives were unclassified, but their mean and median IBIs of 110.0 s and 103.0 s respectively indicated that they would be most-appropriately categorised as intermediate dives (Table 7.4).

The four individuals with differentiated dive patterns were, in most cases, characterised by a high proportion (>48%) of surface dives, a low proportion (<15%) of unclassified dives, and median IBIs of <85.0s (Table 7.3). The exception was the whale in FF WF–12 (Figure 7.3D), which was considered to have a differentiated dive pattern but had a far higher proportion (44.1%) of intermediate dives and a lower proportion of surface dives (26.5%) compared with the other three individuals. One whale (FF WF–11) exhibited a strikingly-differentiated dive pattern characterised by 100% of its dives comprising either surface or true dives (Figure 7.3C). The dive patterns of FF WF–5 and WF–16 were mostly clearly differentiated but included approximately 22% of intermediate or unclassified dive types (Figure 7.3B and E). The whales in FF WF–12 and WF–16 appeared to alter their dive patterns over the durations of the FFs, changing from defined sequences of true and surface dives to a more variable pattern of intermediate dives (Figure 7.3D and E).

The two whales with undifferentiated dive patterns were characterised by high proportions (35.7–68.2%) of unclassified dive types, low proportions (9.1–38.1%) of surface dives, and median IBIs of >97 s (Table 7.3). The mean IBIs of true dives for those whales were <300 s. Both animals exhibited periods of successive intermediate or unclassified dive types (Figure 7.3A and F), with the majority (77.3%) of dives by FF WF–17 comprising those types.

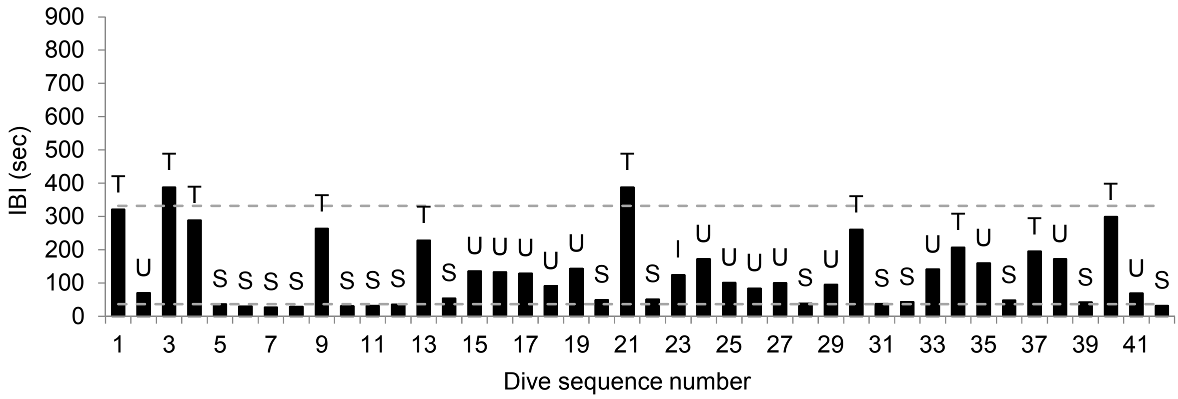
7.4. Discussion

The dive data collected in West Falkland provide a valuable site comparison with those collected in Berkeley Sound in 2017, and the two datasets have already been analysed together for a scientific publication (Weir et al., In Press). The mean CR recorded for West Falkland sei whales (30.6) was lower than that recorded for other similar baleen whale species such as minke (46.1), fin (52.0) and humpback (71.0) whales in Greenland (Heide-Jørgensen and Simon, 2007), fin whales in the Gulf of Maine (48.0 without boats and 51.0 with boats present; Stone et al., 1992), and minke whales in Norway (44.0; Øien et al., 1990). The lower CR indicates that sei whales in the Falkland Islands surface less often than those species, for reasons that could potentially be related to differences in habitat, behaviour or energetics. The surfacing patterns revealed in this study suggest a substantial amount of shallow diving behaviour by sei whales, and determining the proportion of feeding occurring during this time would help shed light on the ecological interactions between sei whales and their prey around the Falkland Islands.

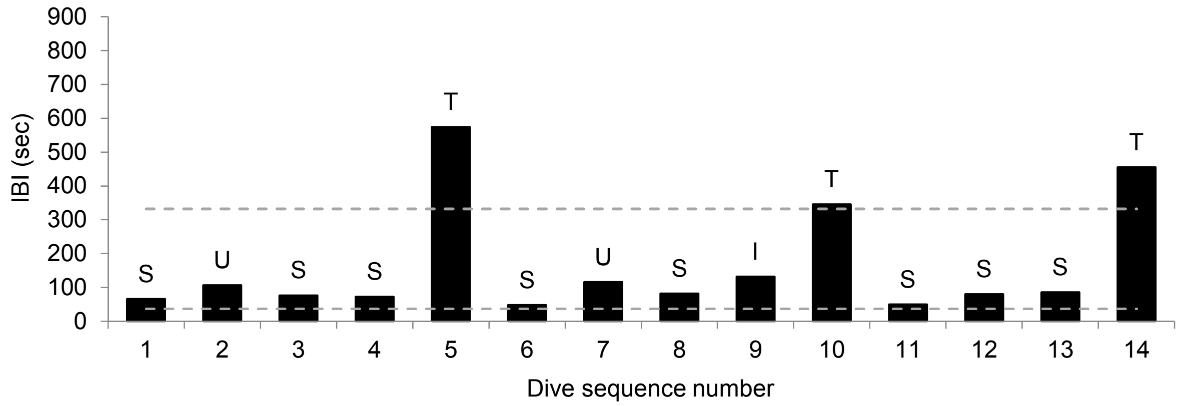
Table 7.3. The inter-breath intervals recorded during the full dive cycles of six sei whale focal follows (FF) in West Falkland.

FF No.	Dive pattern type	All dives combined (s)						Surface dives (s)			Intermediate dives (s)			True dives (s)			Unclassified dives (s)		
		n	Min	Max	Mean	SD	Median	*n*	%	Mean IBI	*n*	%	Mean IBI	*n*	%	Mean IBI	*n*	%	Mean IBI
WF–2	Undiff.	42	27.0	388.0	128	102.6	97.5	16	38.1	38.6	1	2.4	124	10	23.8	284	15	35.7	119.7
WF–5	Diff.	14	48.0	574.0	163.7	167.4	84	8	57.1	70.3	1	7.1	132	3	21.4	458.3	2	14.3	111.5
WF–11	Diff.	10	38.0	391.0	124.6	132.4	48.5	7	70.0	45.7	0	0	–	3	30.0	308.7	0	0	–
WF–12	Diff.	34	32.0	458.0	119.5	95.5	93	9	26.5	48.7	15	44.1	108.5	5	14.7	325.4	5	14.7	74.2
WF–16	Diff.	39	31.0	347.0	125.4	93.7	81	19	48.7	51.3	6	15.4	140.3	11	28.2	256.1	3	7.7	85.3
WF–17	Undiff.	22	45.0	419.0	136	81.6	126.5	2	9.1	46.5	2	9.1	123	3	13.6	299.7	15	68.2	116.9

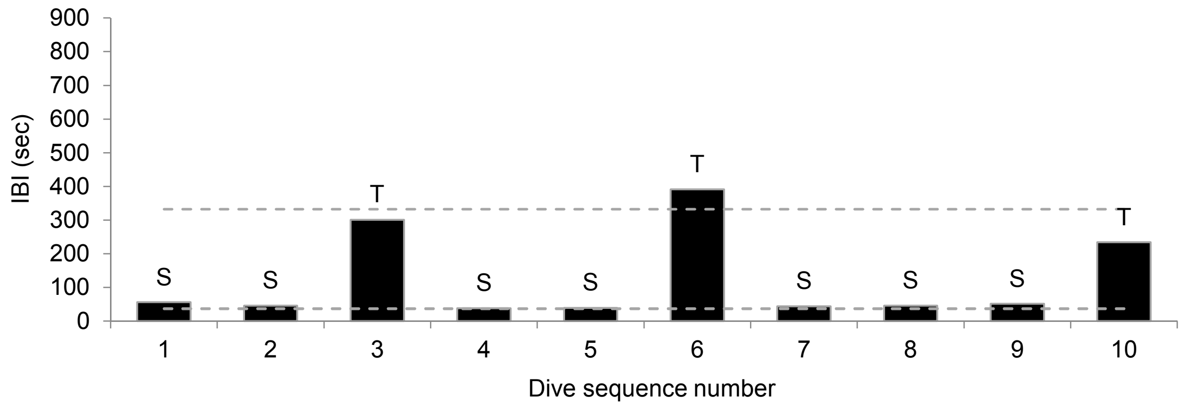
(A) FF WF–2



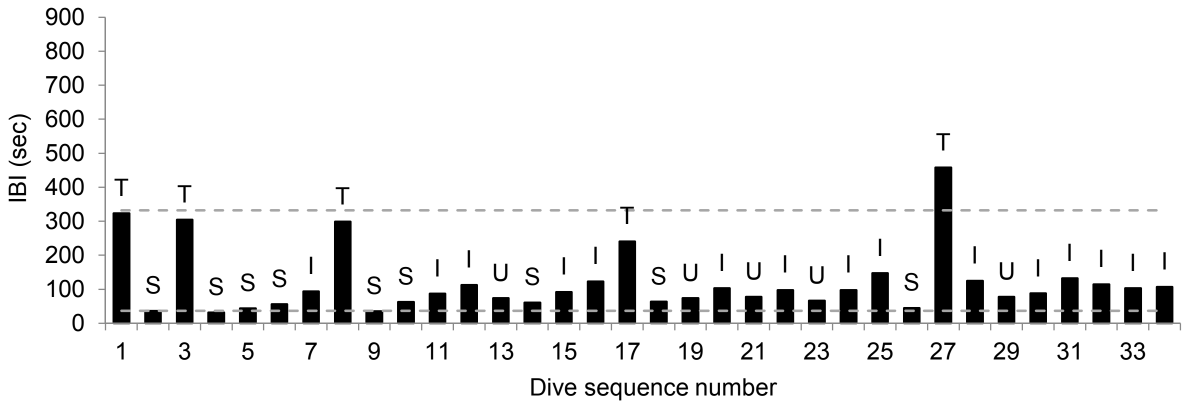
(B) FF WF–5



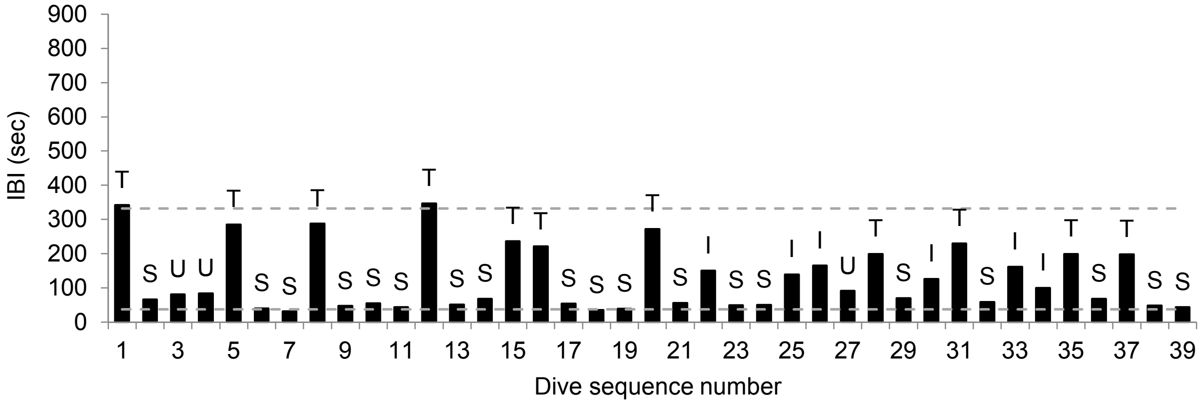
(C) FF WF–11



(D) FF WF–12



(E) FF WF–16



(F) FF WF–17

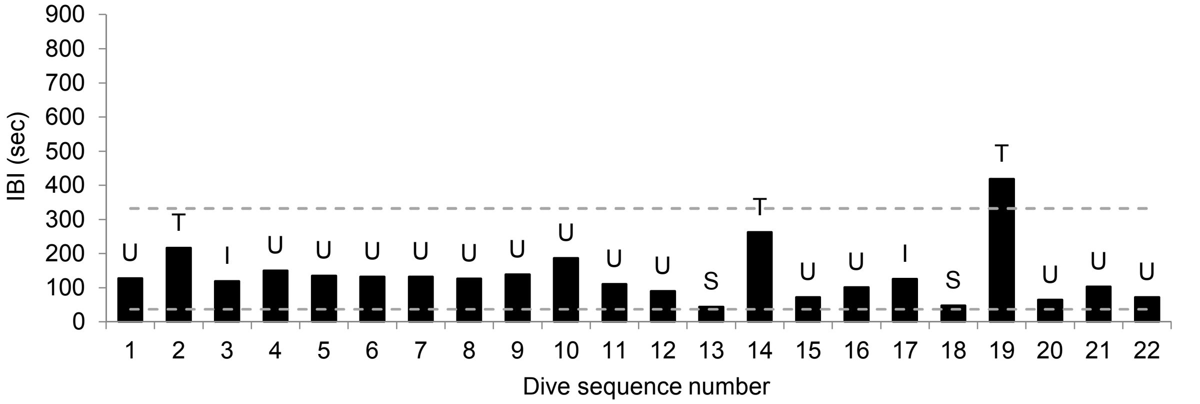


Figure 7.3. Inter-breath intervals (IBIs) for complete dive cycles recorded during West Falkland focal follows (FF) of six individual sei whales (A–F). Dashed lines show the mean IBI for surface and true dives for the combined dataset of dive types from Berkeley Sound and West Falkland (see Weir et al., In Press). Dive types assigned during the analysis are labelled: S–Surface, I–Intermediate, T–True, U–Unclassified.

Table 7.4. Inter-breath Interval (IBI) durations measured for sei whale dive types in West Falkland.

Dive type	IBI (s)				
	n	%	Mean	Range	Median
Surface	61	37.9	49.3	27.0 – 86.0	48.0
Intermediate	25	15.5	118.8	87.0 – 165.0	120.0
True	35	21.7	299.5	195.0 – 574.0	288.0
Unclassified	40	24.8	110.0	65.0 – 187.0	103.0
TOTAL	161	100.0	129.6	27.0 – 574.0	94.0

The surfacing behaviour described here for Falkland sei whales broadly overlaps with the limited information available for the species elsewhere. For example, the maximum dive times recorded for sei whales in the Gulf of Maine (11 min; Schilling et al., 1992) and off Japan (12.2 min; Ishii et al., 2017) are similar to those recorded in the Falklands (13.6 min), despite being recorded in different habitats including open shelf waters (Gulf of Maine), nearshore shallow waters (Falklands), and open ocean of around 5,000 m depth (Japan). These likely reflect longer foraging dives since all three of these regions are considered to represent sei whale feeding areas. The shorter dive times (≤90 s) recorded regularly by Schilling et al. (1992) were correlated with numerous observations of surface-feeding during that study, whereas the whales monitored in the Falklands and Japan were predominantly feeding sub-surface (Ishii et al., 2017; Weir, 2017a; this report).

The average swim speeds recorded for Falkland sei whales were inherently limited by methods, since the GPS positions reflect the locality of the boat rather than the movements of the whales themselves. These estimates are therefore very much a minimum indication of average swim speeds. The Falkland results (3.5–8.3 km h^{-1}) are lower than those recorded during two boat-based focal follows in Japan (8.1 and 10.0 km h^{-1}; Ishii et al., 2017), but comparable to the mean speeds of 6.2 and 7.4 km h^{-1} (for migration and non-migration) reported by Prieto et al. (2014) from satellite-tracking in the Azores. It is likely that different methods, varying focal follow duration, and behaviour of the animals in different studies will affect the results.

The combined study (Berkeley Sound and West Falkland) of Falkland sei whale cue rates and surfacing behaviour provides novel systematic information that will be useful to inform abundance estimates and to better understand differences in behaviour between habitats around the Islands. Other baleen whale species vary their diving behaviour according to factors including prey type, group size, time of day, geographic area, season, behaviour and habitat (Würsig et al., 1985; Stone et al., 1992; Kopelman and Sadove, 1995; Stockin et al., 2001; Alves et al., 2010), and consequently the most appropriate datasets for correcting whale abundance estimates are those collected on the same species, in the same geographic area, and at the same time of year, as the abundance survey is carried out (Heide-Jørgensen and Simon, 2007). In addition, understanding the natural surfacing behaviour of sei whales is an integral component of vessel strike modelling, assessing potential disturbance from human activities, and maximising fieldwork approaches for photo-identification, tagging and biopsy sampling. While visual methods have produced useful initial data, they are restricted to daylight hours and periods of favourable weather. The collection of full diurnal datasets (i.e. including the hours of darkness) and information on the underwater behaviour of sei whales via the use of tags would be useful for monitoring behaviour over spatio-temporal scales relevant to the whales around the Falklands to better inform future management decisions.

8. FAECAL SAMPLING

8.1. Introduction and aims

The collection of whale faecal material potentially supports a variety of studies including feeding ecology, assessment of reproductive status, genetic profiling of whales, health and parasitology. This method is also advantageous in being a benign and non-invasive technique. Initial work in Berkeley Sound during 2017 demonstrated that sei whales sometimes defecated at the surface and that the collection of faecal material using a standard fine-mesh dip net was possible (Weir, 2017a). A faecal sampling component was therefore included in the West Falkland survey, with the following aims:

- To investigate whale diet in West Falkland (which could be compared with that from whales sampled in Berkeley Sound during 2017) through a collaboration with the BAS;
- To potentially extract whale DNA to contribute to the ongoing sei whale genetic study with the BAS; and
- To collect parasites to investigate sei whale helminth infections and health through collaboration with the Natural History Museum (NHM) in London.

8.2. Methods

Whale faecal sampling was limited to use of the zodiac, since it was not practical to carry it out from the yacht due to the lower manoeuvrability of that platform and the high deck height relative to the length of the handle for the sampling equipment. Since faecal events were not predictable, sampling was limited either to periods when the zodiac was already in the water in proximity to whales, or to periods when defecation events occurred close to the yacht and in sufficient time to launch the zodiac specifically for sampling. During sampling a sterilised long-handled 150µm mesh dipnet was used to collect as much faecal material as possible from the water, via repeated side-to-side sweeps through the water column (Figure 8.1). The net was deployed as deep as possible during the initial period of collection, since most faecal material rapidly sinks. Some prey body hard parts and parasites sank more slowly, and those could still be collected in the surface waters some time after the bulk of the faeces had dissipated.

On completion of sampling, each faecal sample was removed from the net using disposable gloves (to reduce contamination) and stored in a sterile sample pot. On return to the yacht the sample was processed as follows:

- Material was initially inspected for obvious parasites, and any present were removed with sterile forceps and placed into a 2 mL vial of 96% ethanol (EtOH);
- The remaining faecal sample was subdivided as follows:
    - Part A, stored in EtoH and then frozen (-20ºC) - Genetic analysis;
    - Part B, frozen (-20ºC) - Isotope analysis;
    - Part C, stored in EtoH and then frozen (-20ºC) - Parasitology analysis; and
    - Part D, frozen (-20ºC) - Any remaining material for unspecified future use.

To limit cross-contamination between samples while out in the field, any residue left in the net was rinsed out using seawater. The net was then sprayed with 10% bleach solution to sterilise it before the next sample. Between zodiac launches, the net was thoroughly washed with fresh water and soaked in 10% bleach solution for 10 min before being rinsed again in fresh water and air-dried.

(A)

(B)

Figure 8.1. Collection of sei whale faecal material from the zodiac: (A) showing rapid dispersion of the faecal cloud in a choppy sea on 16 March 2018 (sample FS-WF-4); and (B) screengrab from video showing faecal sampling on 26 March 2018 (sample FS-WF-7). The faecal material appears as a reddish-brown cloud in the water.

8.3. Results

A total of 48 sei whale faecal events were recorded during the survey; these observations represent a minimum indication of defecation rates, since faeces were only visible at reasonably close range and rapidly dissipated in the sea. All whale defecations had a similar orange-brown appearance (Figure 8.2). Faecal events were observed throughout the study area, including Byron Sound, King George Bay and Queen Charlotte Bay, as well as in the outer areas south of West Point Island, and between the Passage Islands and New Island (Figure 8.3). They were also recorded over the full extent of the West Falkland survey duration, on at least 11 dates between 25 February and 29 March 2018.

Figure 8.2. Examples of sei whale faecal events photographed during the 2018 survey: (A) 25 February; (B) 3 March; (C) 10 March; (D) 16 March; (E) 26 March; and (F) 28 March. In these images the faecal material is notably more concentrated compared with Figure 8.1, since the photographs were taken immediately following the defecations.

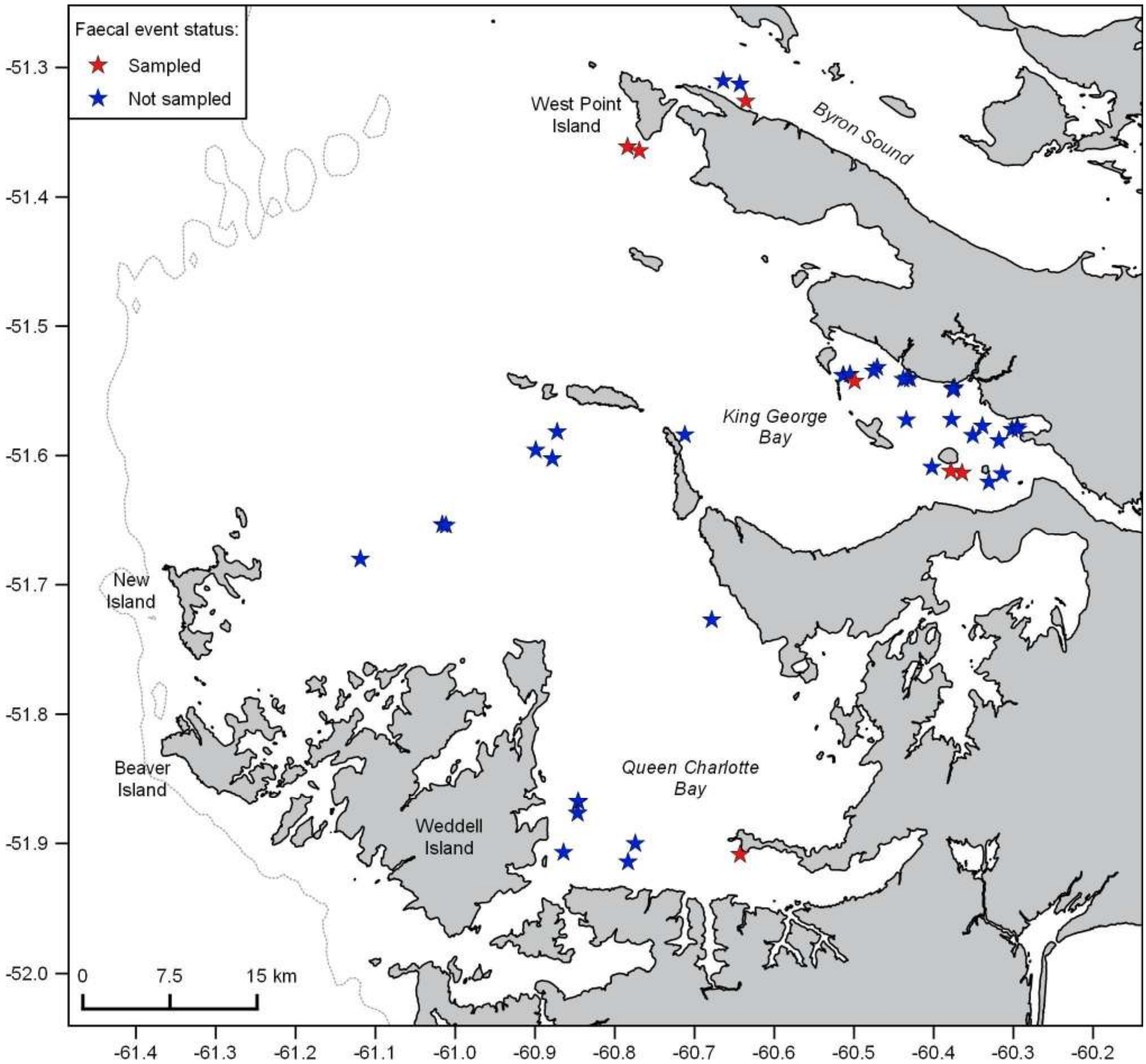


Figure 8.3. Spatial distribution of 48 sei whale faecal events observed during the West Falkland survey.

Seven faecal samples were collected using the zodiac (Table 8.1), including one from Byron Sound, two from south of West Point, three in King George Bay, and a single sample from Port Richards at the southern end of Queen Charlotte Bay (Figure 8.3). An initial basic visual inspection indicated that all of the samples contained the hard parts (e.g. pincers, carapaces and eyeballs) of squat lobster krill (*Munida gregaria*).

8.4. Discussion

The detection of faecal events was limited to when whales defecated at the surface (as opposed to underwater), when the yacht was sufficiently close to the whales, and when weather conditions permitted (they were easier to observe in good light conditions). Consequently, the 48 events reported here should be considered a minimal indication of sei whale defecation occurrence in the study area. Given that defecation is indicative of recent feeding, the good number of faecal events recorded during the study supports the use of the West Falkland study area as a sei whale feeding ground. The observations spanned the complete timeframe of the study, which also indicates that feeding behaviour was sustained over the entire February–March period.

Table 8.1. Details of the seven sei whale faecal samples collected during the survey.

Sample No.	Date	Location	Part A	Part B	Part C	Part D	Parasites
WF–1	25 Feb	Byron Sound	✓	✓	✓		✓
WF–2	25 Feb	West Point	✓	✓	✓	✓	
WF–3	25 Feb	West Point	✓	✓	✓	✓	✓
WF–4	16 Mar	King George Bay	✓				✓
WF–5	16 Mar	King George Bay	✓	✓	✓		
WF–6	16 Mar	King George Bay	✓	✓	✓	✓	✓
WF–7	26 Mar	Port Richards	✓	✓	✓	✓	✓

Unfortunately only seven faecal samples were collected. This was the consequence of logistical constraints with the platforms available, and the prevailing weather conditions experienced during the survey. The persistent Beaufort 4 and 5 winds and associated choppy seas in which many of the faecal events were observed (Figure 8.2), greatly limited the scope for small boat launches due to health and safety considerations and the small size of the available zodiac. The 2017 sei whale surveys in Berkeley Sound used a 6.5 m RIB and only occurred on favourable weather days for all of the survey work, which meant that whale faecal events could be very rapidly approached and immediately sampled as soon as they were observed. Lessons learnt from this survey therefore included the importance of platform type for maximising the effectiveness of sampling when defecations are observed. The development of a sampling net with a much longer handle that might be usable from a higher deck platform could be investigated for future surveys from larger vessels.

The seven faecal samples collected during the survey were exported (with relevant permits) by vessel to BAS in the UK during June, and were received in early August. They will be incorporated into a genetic (whale and prey DNA) and isotope analysis that is being funded by the RSPB and is due for completion in the first quarter of 2019. Although visual inspection of the samples suggested that faecal samples contained lobster krill, the prey DNA analysis will confirm whether that is the case and whether any other species have been consumed that do not persist in the sample as obviously as krill (which have hard body parts such as carapaces, pincers and eyeballs that are poorly-digested). The parasites and a set of faecal subsamples are being exported to the NHM in London for the parasitology assessment, from which results should be forthcoming in the future.

9. BONE SAMPLING

9.1. Introduction and aims

During 2017, FC supplemented their sei whale biopsy and faecal sampling programme with the use of skeletal material, in order to increase the sample size of genetic material available for a collaborative project with the BAS. During that season, nine samples were obtained from whale bones located in Stanley, on Carcass Island, and on Sea Lion Island.

Although not an original stated aim of the West Falkland survey, the collection of additional skeletal material was carried out opportunistically on some of the islands that were visited on bad weather days. Additionally, in anticipation of being anchored at New Island during bad weather at some point during the West Falkland survey, the New Island Conservation Trust (NICT) was contacted prior to the survey and permission was granted to sample whale bones at the island including those inside the New Island museum and on the shoreline at the former whaling station. New Island provides a unique opportunity to acquire bone samples, since it was the location of the only shore-based whaling station in the Falkland Islands and at least 1,730 whales were processed there between 1905 and 1915 (Allison, 2016). Consequently, this location potentially represents the single richest site for baleen whale remains in the Falklands.

The aims of the whale bone sampling were:

- To ascertain species identification;
- To acquire DNA samples to investigate whale population identity, structure and genetic diversity in Falkland waters; and
- To potentially generate trophic information via isotope analysis.

9.2. Methods

The acquisition of skeletal material for the project involved either: (1) the collection of small segments of bone; or (2) drilling into a bone to extract bone shavings (Figure 9.1). The latter method was used when bone pieces were large (e.g. vertebrae, jaw bones, solid ribs or skulls), or when the bones were on public display and could not be removed or damaged (e.g. in peoples' gardens or at the New Island museum).

Prior to drilling bones, the drill site was selected in the most solid, dense and least weathered part of the bone (although weathered porous bones were still drilled in many cases). Where large skeletons (e.g. skulls) were on display then the least-conspicuous part of the bone was drilled when possible. The surface of the bone was scrubbed with bleach solution. A clean, sterile drill bit was used for each sample. The bone was then drilled; in most cases the shavings from the initial surface layer of the bone were discarded due to potential contamination (e.g. algal growth). The clean shavings from inside the bone were then collected into a piece of tinfoil (Figure 9.2), and transferred to fill a 5 mL sample vial.

Where bones were on public display, the drill sites were subsequently repaired using white epoxy resin to seal the hole (Figure 9.3). Usually a small sample of the shavings drilled from the bone were placed onto the surface of the epoxy resin to camouflage the drill site as best possible.

Supporting data were collected for all bone samples, including the sampling date, location, species (if known), bone type (where known) and bone condition.

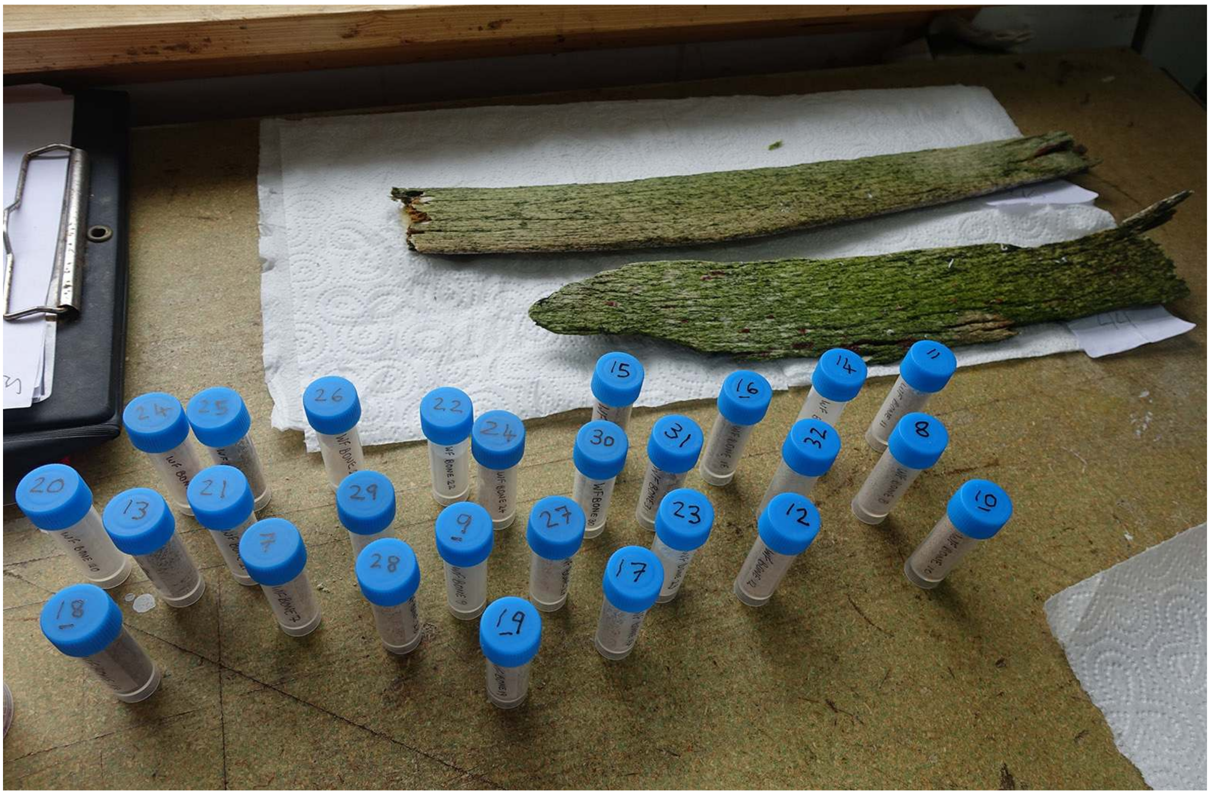


Figure 9.1. Small segments of bone collected from the beach at New Island whaling station, and the vials containing bone shavings from the New Island samples.

Figure 9.2. Drilling a whale vertebrae in the New Island whaling museum, with the shavings falling onto a clean piece of tinfoil.

(A)

(B)

(C)

Figure 9.3. Repair of a whale bone drill site using epoxy resin: (A) the vertebrae after drilling, showing the extent of the drill hole: (B) repair of the drill site with epoxy resin and spare bone shavings; and (C) the final repaired drill site in the centre of the vertebrae.

9.3. Results

A total of 107 bones were sampled during the West Falkland survey, comprising 73 bone segments and 34 bones that were drilled to extract shavings (Table 9.1). The clear majority of these originated from New Island (n = 99), while a small number of samples were also collected from West Point, Weddell and Beaver Islands. All bone sampling occurred on poor weather days when the research platform was unable to conduct at-sea surveys and was at anchor in the lee of the islands. An additional 12 small whale bone segments were provided from Spring Point settlement, Bleaker Island and Pebble Island following completion of the survey (Table 9.1).

Table 9.1. Summary of the bone samples collected during the West Falkland survey.

Sampling date	Location	Unique bone segments collected	Unique bone shaving samples collected
28 February 2018	West Point	0	3
5 March 2018	Weddell	1	0
9 March 2018	Beaver	0	4
11 March 2018	New Island	72	27
30 March 2018[1]	Spring Point	2	0
April 2018[2]	Bleaker	9	0
April 2018[2]	Pebble	1	0
Total		*85*	*34*

[1]Provided by Mike, Donna and Dale Evans following their participation in the survey.
[2]Provided after survey completion by Nick Rendell (old whale strandings on Bleaker Island) and Dot Gould (live sei whale stranding on Pebble Island).

A full report on the whale bone sampling operations on New Island was produced separately for the NICT (Weir, 2018b), and is available from FC on request.

9.4. Discussion

A number of logistical and weather constraints limited the biopsy and faecal sampling of live sei whales during the West Falkland survey. However, the lack of biopsy and faecal samples was compensated for to some extent by the significant success with collecting bone samples at New Island and several other islands, which generated numerous samples for the ongoing FC–BAS study of sei whale genetics and diet (isotopes). The successful application of these techniques to the whale bones will depend on the quality of each bone sample and how degraded the material is from exposure to the weather and, in the case of many of the New Island bones, submersion in seawater. Consequently, not all of the collected bone samples may be usable for the analyses. Additionally, it is likely that some of the bones will have originated from the same individual whales, and some of the smaller fragments from New Island may even potentially originate from animals other than whales. These issues will all be clarified during the analysis process.

All of the bone samples were exported from the Falklands to the UK (with appropriate export/import CITES permits) in June 2018 on the BAS vessel *Ernest Shackleton*, and were received at BAS in Cambridge at the beginning of August. It is currently envisaged that analysis of these samples will continue well into 2019, and the outputs will be distributed when available.

10. ACOUSTIC FEASABILITY STUDY

10.1. Introduction and aims

Cetaceans produce a wide variety of sounds for purposes including navigation, communication, and the localisation of prey and predators. In recent decades Passive Acoustic Monitoring (PAM) technologies have been developed to record these sounds, providing the opportunity for scientists to detect and monitor species using PAM techniques. The latter includes a variety of approaches such as seabed-mounted stationary PAM devices, hydrophone cables towed behind vessels, and free-floating acoustic sonobuoys. For some cetacean species, PAM provides a long-term cost-effective monitoring approach, and it may represent the only viable means of monitoring cetaceans during the hours of darkness or in rough seas where visual methods are limited. However, the usefulness of PAM varies between species, depending on factors such as their vocalisation rates and call parameters. For example, echolocating delphinids are obligate callers and must vocalise frequently in order to navigate and locate their prey, whereas baleen whales vocalise primarily for communicative reasons and their call rates may not be directly related to the abundance of animals in the area (Baumgartner et al., 2008). Consequently, the vocalisation rates of many larger baleen whales may be sporadic, or vary seasonally, making it problematic to collect robust presence or absence data (i.e. animals may be present but not vocalising).

Baleen whale species mostly emit low frequency sounds with peak energy concentrated below 1 kHz (Richardson et al., 1995). The vocal repertoire of the sei whale is still poorly understood, with few acoustic recordings having been corroborated by visual sightings of the species (Calderan et al., 2014). Most studies are consistent in describing sei whale calls as predominantly comprising short (~1.2 s) downsweep vocalisations at mean frequencies of between 20 and 100 Hz (Table 10.1).

A large proportion of baleen whale vocal activity is thought to correspond with communication related to reproductive activities, and has therefore been most-documented from low-latitude winter breeding areas (Rankin and Barlow, 2007). However, whales also vocalise on their feeding grounds. This includes sei whales, the calls of which have now been documented from several summer higher-latitude areas including the Gulf of Maine (Baumgartner et al., 2008) and south of the Auckland Islands (Calderan et al., 2014).

Little acoustic work on cetaceans has been published to date for the Falkland Islands. Several studies have used either towed arrays or moored C-PODs to investigate the acoustic behaviour of the two narrow-band high-frequency (NBHF) coastal dolphin species that occur in the Falklands (e.g. Kyhn et al., 2010; Munro, 2010). Acoustic monitoring of large whales has been limited to mitigation-related work by the oil and gas industry, including the use of towed arrays during seismic exploration surveys and the use of moored devices to collect baseline data on cetacean occurrence in the offshore oil fields (Hipsey et al., 2013). A one year static acoustic monitoring programme was carried out in the Sea Lion Development Area located 230 km north of the Falklands (415 m depth) during 2012 and 2013 using two Autonomous Multichannel Acoustic Recorders (AMARs) and three C-PODs, but did not record any calls attributable to sei whales (Hipsey et al., 2013).

During 2018, two pilot studies were carried out to trial different acoustic methods during yacht surveys aimed at sei whales. This chapter describes the methods and results of the work with regard to logistics, and with respect to developing a future PAM programme for sei whales in the Falklands.

Table 10.1. Summary of mean call parameters recorded from confirmed or presumed sei whales worldwide.

Area	Type	Duration (s)	Mean frequency (Hz)			Source
			Min.	Max.	Peak	
Nova Scotia	2-part pulse	0.5–0.8 (each part)	1500	3500		Knowlton et al. (1991)
Nova Scotia / Newfoundland	2-part pulse	0.7	1500	3000		Thompson et al. (1979)
Antarctica	Broadband	1.5	100	600		McDonald et al. (2005)
Antarctica	Tonal and upsweep	1.3	200	600		McDonald et al. (2005)
Antarctica	Frequency-stepping	–	170	570		Gedamke and Robinson (2010)
Hawaii	Downsweeps	1.2	44.6	100.3		Rankin and Barlow (2007)
Hawaii	Downsweeps	1.2	21.0	39.4		Rankin and Barlow (2007)
Cape Cod	Downsweeps	1.4	34.0	82.3		Baumgartner and Fratantoni (2008); Baumgartner et al. (2008)
New Jersey	Downsweeps	1	40	120		Newhall et al. (2012)
Florida			40	100		Johnson et al. (2010)
Auckland Islands	Downsweeps	0.7	69	78	73.8	Calderan et al. (2014)
Auckland Islands	Upsweep-downsweep	1.2	53.8	83.3	78.3	Calderan et al. (2014)
Auckland Islands	Upsweep	1.2	36.3	66.3	45.8	Calderan et al. (2014)
Azores	Downsweep	1.2	37.0	100.0		Romagosa et al. (2015)
Union Seamount, British Columbia	Downsweep	1.3	39.3	96.6		Ford et al. (2010)
La Perouse Bank, British Columbia	Downsweep	1.6	41.4	76.4		Ford et al. (2010)

10.2. Methods

Acoustic deployments were carried out opportunistically during two sei whale surveys in West Falkland during 2018.

10.2.1. SoundTrap

The first set of acoustic deployments occurred during the preliminary survey using the yacht *Saoirse* in January 2018 (see Section 4). A SoundTrap acoustic device (model ST300HF: http://www.oceaninstruments.co.nz/product/soundtrap-300-hf-high-frequency) was deployed using a variety of techniques including:

- Static mooring close to shore (<10 m depth), with the SoundTrap suspended between a 5 kg dinghy anchor and a surface buoy, at approximately 4–6 m depth below the surface (deployments 1, 6 and 7; Table 10.2);
- From the stern of the *Saoirse* (while the vessel drifted at approximately 1–2 knots) and free-hanging, with the SoundTrap at approximately 5–8 m depth below the surface (deployments 2, 4 and 5; Table 10.2); and
- From the stern of the *Saoirse* (while the vessel was anchored) and free-hanging, with the SoundTrap at approximately 3 m depth below the surface in <10 m water depth (deployments 3 and 8; Table 10.2).

Recordings were made automatically to the internal memory card of the SoundTrap, at sampling rates of 48 or 96 kHz. The recordings were downloaded to PC following recovery of the device.

10.2.2. Dip hydrophone

The second set of acoustic deployments occurred during the dedicated survey of sei whales in West Falkland between February and April 2018 (see Section 5). Recordings were made using a Sensor Technology SQ26-08 hydrophone (Cetacean Research Technology - https://www.cetaceanresearch.com/hydrophones/sq26-08-hydrophone/index.html). The frequency response of the hydrophone element extended to frequencies greater than 50 kHz and was flat (sensitivity variation of +/-3dB) within the 45 Hz to ~33 kHz bandwidth (Joe Olson, pers. comm.). Initially it had been intended to deploy the hydrophone from a zodiac in proximity to sei whales. However, weather conditions during the survey prohibited the use of the zodiac on all but a handful of occasions, and other project components had to be prioritised on those days. Consequently, the acoustic feasibility study was conducted from the yacht.

During deployments the hydrophone was suspended at a depth of 6 m below the surface, using a bungee cord attached to a Norwegian buoy to reduce surface strumming on the cable (Figure 10.1). The hydrophone cable ran to the main deck of the vessel, where the signal was recorded with an M-Audio MicroTrack II solid state digital recorder (sampling rate = 48 kHz). Since the yacht needed to be stationary with the engine switched off in order to make low frequency recordings of baleen whales, opportunities for deploying the hydrophone were limited to when the yacht was drifting or at anchor. Deployment of the hydrophone was also dependent on having suitably calm environmental conditions (Beaufort sea state ≤2, swell ≤1 m) in order to reduce surface water noise.

Table 10.2. Summary of eight SoundTrap acoustic deployments made during the *Saoirse* yacht survey.

No.	Date	Start time (LT)	End time (LT)	Duration (hr)	Sea State	Water depth (m)*	Deployment method	Sample rate (kHz)	Bit rate
1	2 Jan 18	21:28	08:14	10.8	1	<10	Static mooring, suspended between anchor and surface buoy	96000	16
2	3 Jan 18	12:02	13:45	1.8	1	32	Free-hanging from stern of drifting sailboat	96000	16
3	3 Jan 18	21:34	08:01	10.4	2	12	Free-hanging from stern of anchored sailboat	48000	16
4	4 Jan 18	12:41	14:26	1.7	1	54	Free-hanging from stern of drifting sailboat	96000	16
5	4 Jan 18	16:59	17:41	0.8	2	48	Free-hanging from stern of drifting sailboat	96000	16
6	4 Jan 18	19:32	11:19	15.7	1	<10	Static mooring, suspended between anchor and surface buoy	96000	16
7	10 Jan 18	08:04	11:05	3.0	1	<10	Static mooring, suspended between anchor and surface buoy	48000	16
8	10 Jan 18	21:30	09:00	9.3	1	<10	Free-hanging from stern of anchored sailboat	48000	16

*Measured from a 500 m cell size bathymetry grid in QGIS.

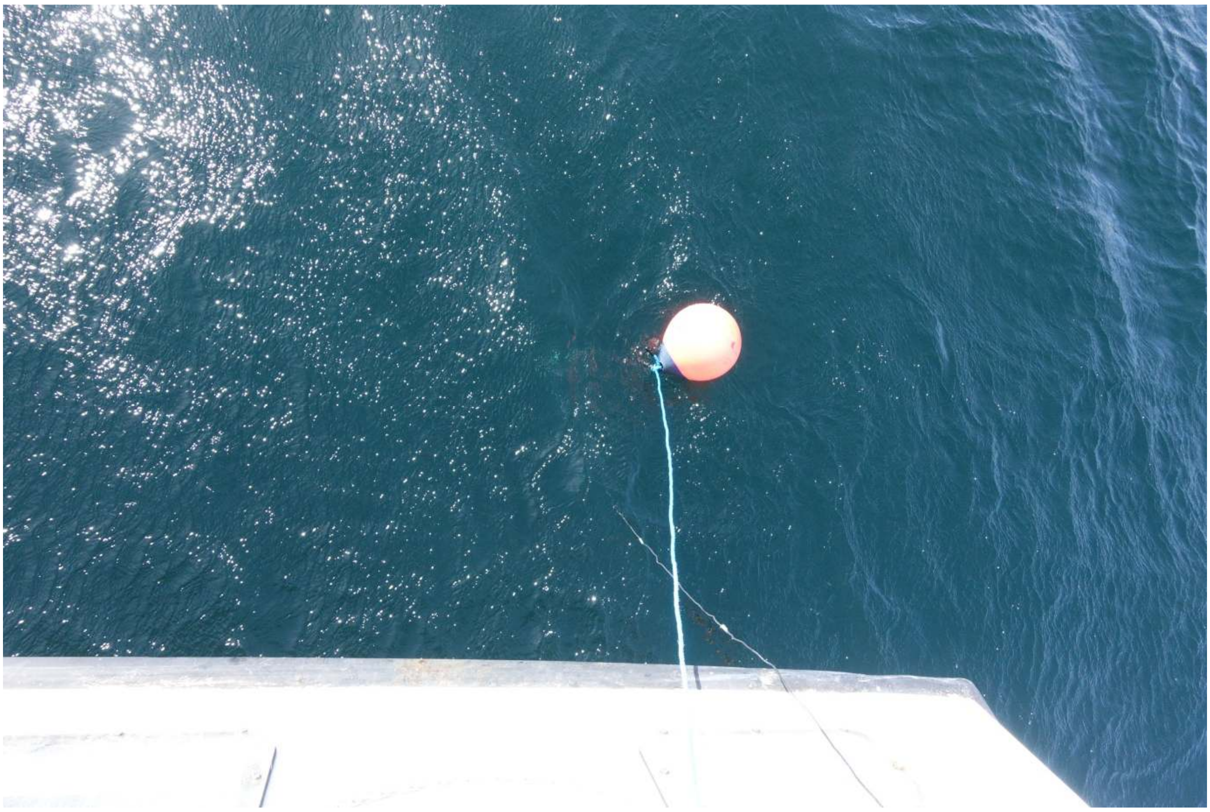


Figure 10.1. Deployment of the dip hydrophone from a Norwegian buoy off the side of the yacht.

10.2.3. Data analysis

All of the acoustic files recorded during the two surveys were visually inspected as spectrograms in Audacity 2.1.0 (http://audacity.sourceforge.net/). A fine-scale examination for the presence of sei whale calls was not carried out at this stage due to time constraints. However, the spectrograms were given a brief assessment for noise content and usability, with regard to the deployment logistics and informing the development of future baleen whale acoustic work in the Falklands.

10.3. Results

The SoundTrap was deployed on eight occasions from 2 to 10 January 2018, producing a total of 53.5 hr of recordings (Table 10.2). The majority of the SoundTrap deployments took place overnight while the vessel was at anchor, and consequently they occurred close to shore in shallow water (≤12 m) and often in semi-enclosed areas (Figure 10.2). However, SoundTrap deployments 2, 4 and 5 occurred in deeper water while the yacht was drifting (Table 10.2), and sei whales had been visually-sighted in the wider area prior to deployments 4 and 5.

The dip hydrophone was deployed on eight occasions on three dates during March 2018, resulting in 19.1 hr of acoustic recordings (Table 10.3). The first deployment on 6 March occurred while the yacht was drifting at sea in Queen Charlotte Bay in proximity to sei whales (Figure 10.2). The remaining deployments occurred at Hummock Island in King George Bay (Figure 10.2), at an anchorage adjacent to an area of high sei whale use (whales were observed from the anchorage).

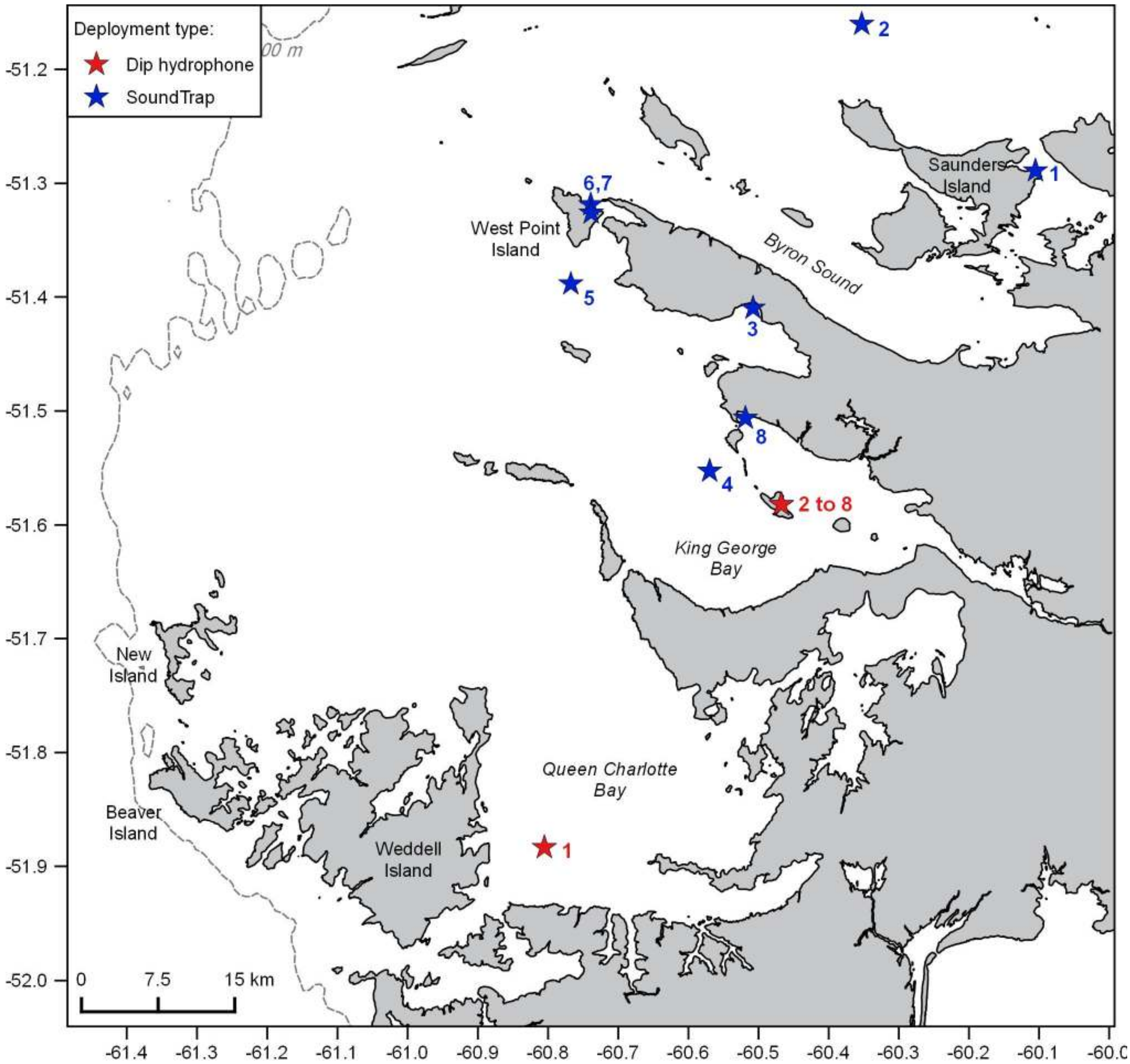


Figure 10.2. The spatial locations of acoustic deployments in West Falkland using the SoundTrap and the dip hydrophone methods.

Table 10.3. Summary of dip hydrophone deployments during the main West Falkland survey.

No.	Date	Start time (UTC)	Duration (hr)	Water depth (m)*	Sea state	Sample rate	Bit rate	Yacht status
1	6 Mar 18	19:21	0.6	20	3	48	16	Drifting
2	18 Mar 18	12:36	1.9	19	3	48	16	Anchored
3	18 Mar 18	16:13	1.8	19	3	48	24	Anchored
4	18 Mar 18	18:04	3.5	19	2	48	24	Anchored
5	18 Mar 18	21:33	1.7	19	1	48	24	Anchored
6	19 Mar 18	09:48	3.4	19	3	48	24	Anchored
7	19 Mar 18	14:43	2.9	19	3	48	24	Anchored
8	19 Mar 18	17:42	3.3	19	2	48	24	Anchored

*Measured on the vessel echosounder.

Some examples of the acoustic data recorded during the survey are shown as spectrograms in Figures 10.3 to 10.8. In general it was apparent that the SoundTrap recordings were quieter than the dip hydrophone recordings over the majority of the bandwidth, but that both methods experienced significant noise at the lowest frequencies (<1 kHz) where baleen whale calls are expected to occur. Much of that noise was clearly the result of deployment methods. For example, in Figure 10.3 there are wide swathes and spikes of noise that correlate with audible rubbing noises in the audio file, and are quite likely to relate to the SoundTrap interacting with kelp or similar. In Figure 10.4 the short vertical spikes in the bottom part of the spectrogram correlate with apparent strumming noise heard in the audio file, while in Figure 10.5 there are loud discrete vertical spikes in the spectrogram that correlate with loud clanging noises in the audio file which sound like a shackle or some other metallic object knocking or moving in the current. Wide areas of noise associated with surface water sounds from waves and swell were apparent in both the SoundTrap (e.g. Figure 10.6) and dip hydrophone (e.g. Figure 10.7) recordings.

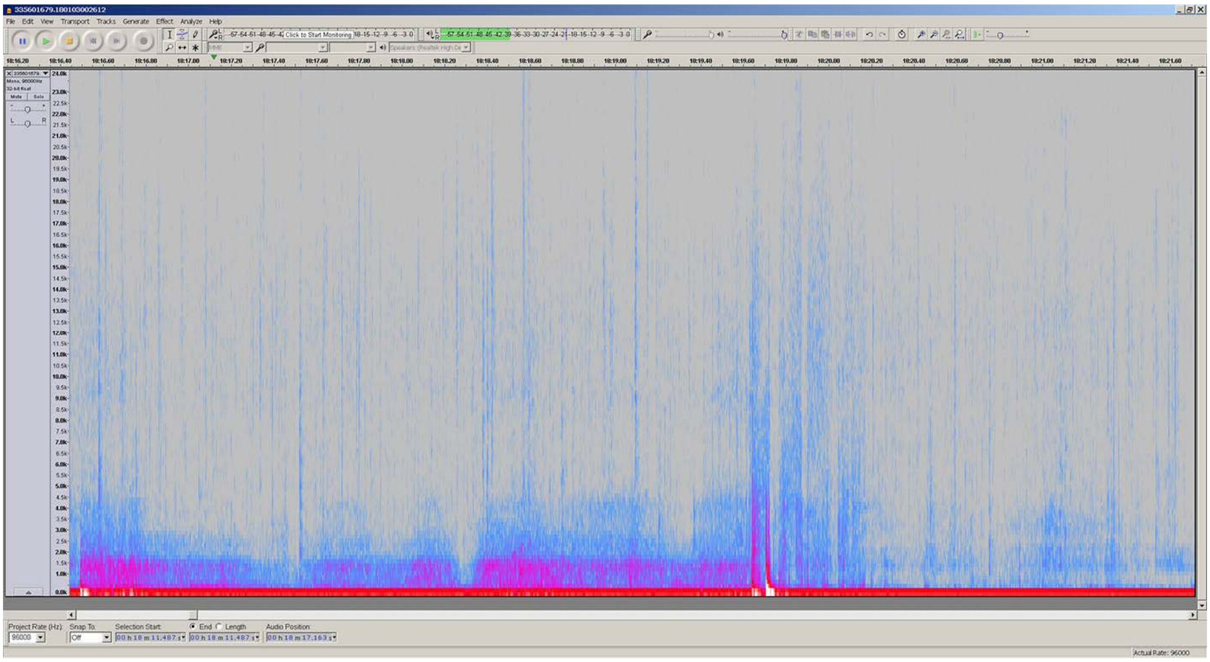


Figure 10.3. Audacity spectrogram (512 point FFT, Hanning window) from a recording made using the SoundTrap ST300 deployed statically between the anchor and the yacht off Saunders Island on 2 January 2018 (No. 1; Table 10.2).

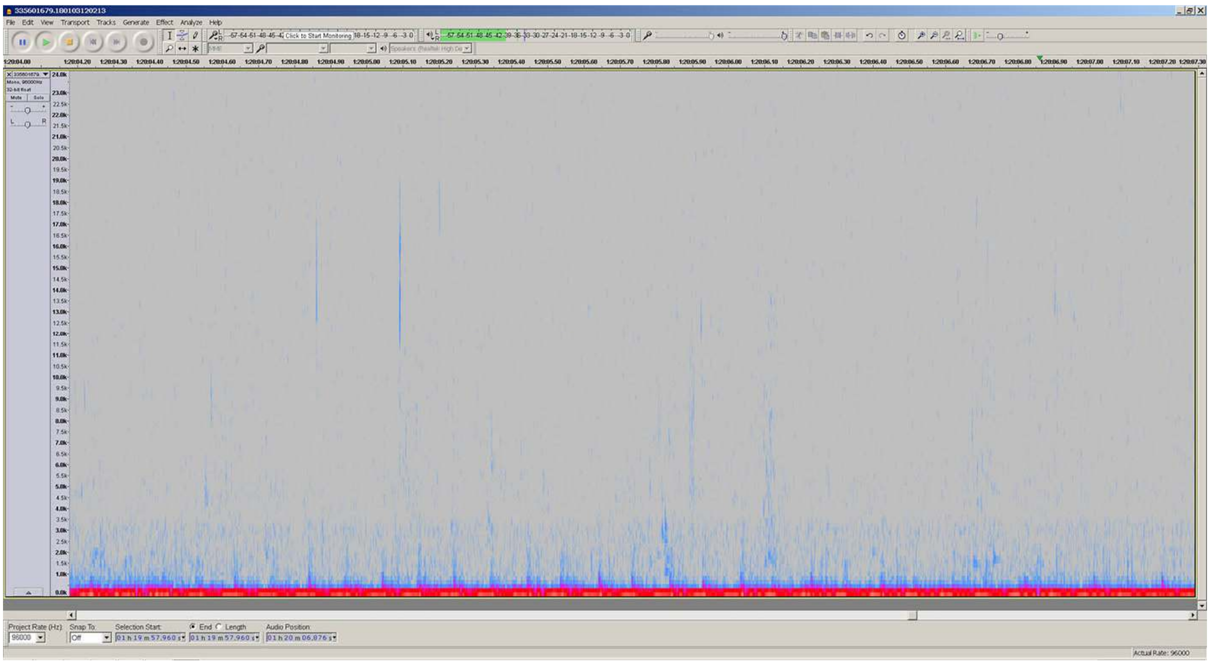


Figure 10.4. Audacity spectrogram (512 point FFT, Hanning window) from a recording made using the SoundTrap ST300 deployed from a drifting yacht north of Saunders Island on 3 January 2018 (No. 2; Table 10.2).

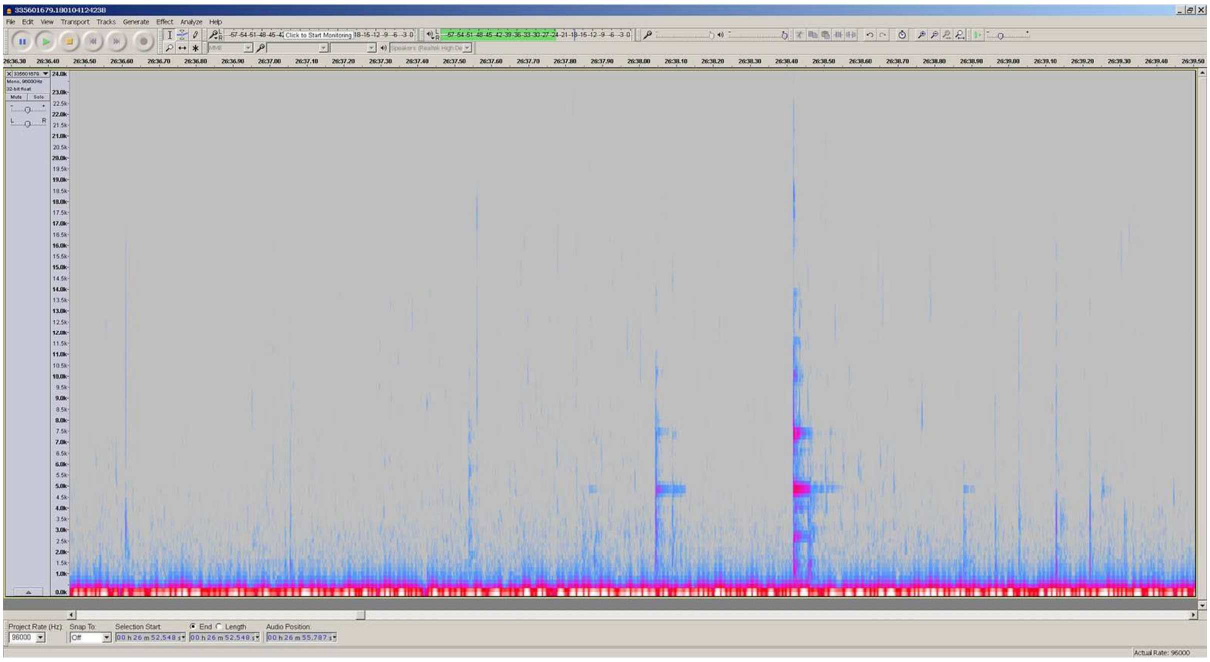


Figure 10.5. Audacity spectrogram (512 point FFT, Hanning window) from a recording made using the SoundTrap ST300 deployed from a drifting yacht south-west of Rabbit Island on 4 January 2018 (No. 4; Table 10.2).

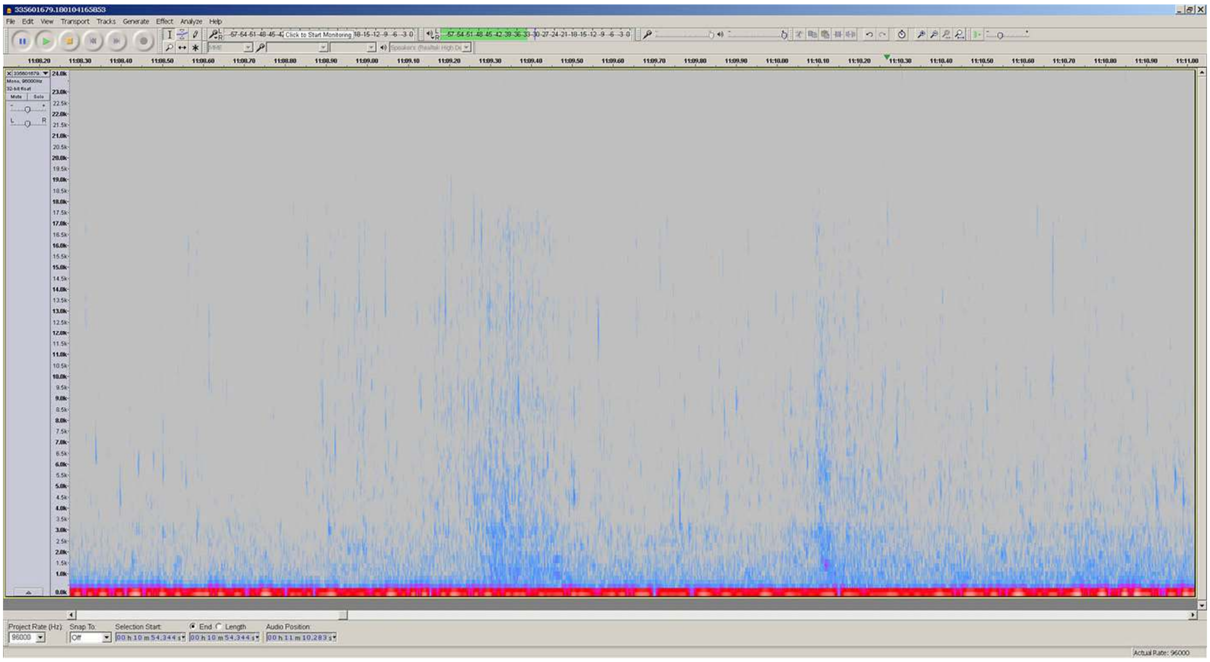


Figure 10.6. Audacity spectrogram (512 point FFT, Hanning window) from a recording made using the SoundTrap ST300 deployed from a drifting yacht south of West Point Island on 4 January 2018 (No. 5; Table 10.2).

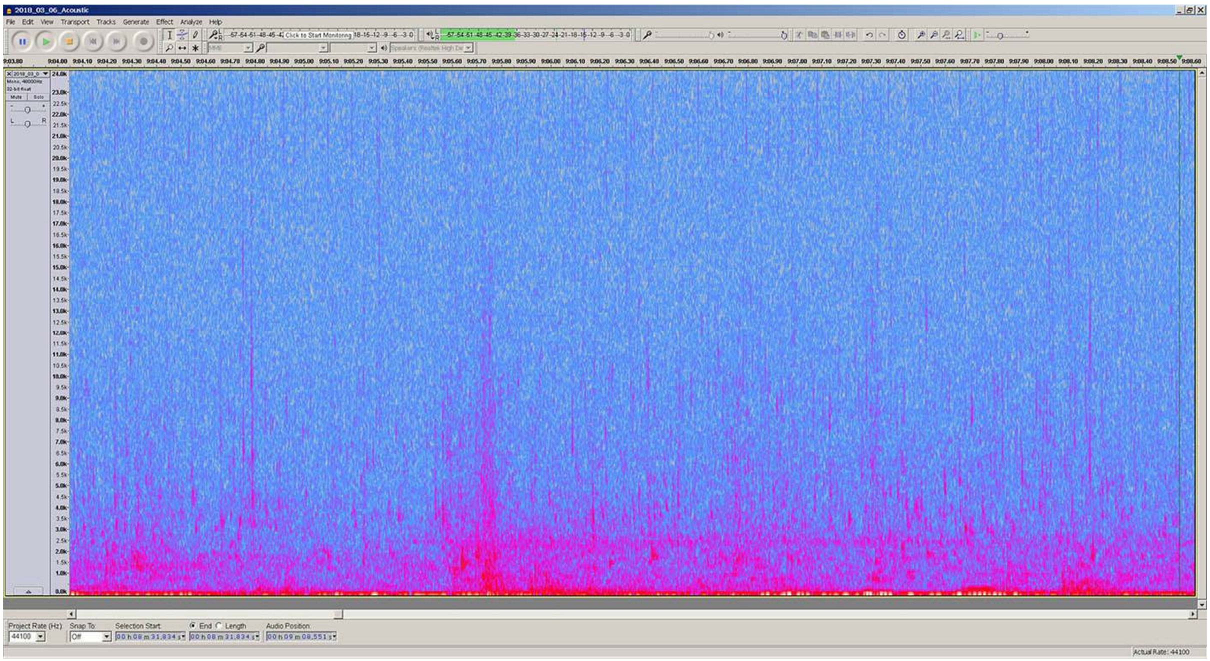


Figure 10.7. Audacity spectrogram (512 point FFT, Hanning window) from a recording made using the dip hydrophone deployed from a drifting yacht in Queen Charlotte Bay on 6 March 2018 (No. 1; Table 10.3).

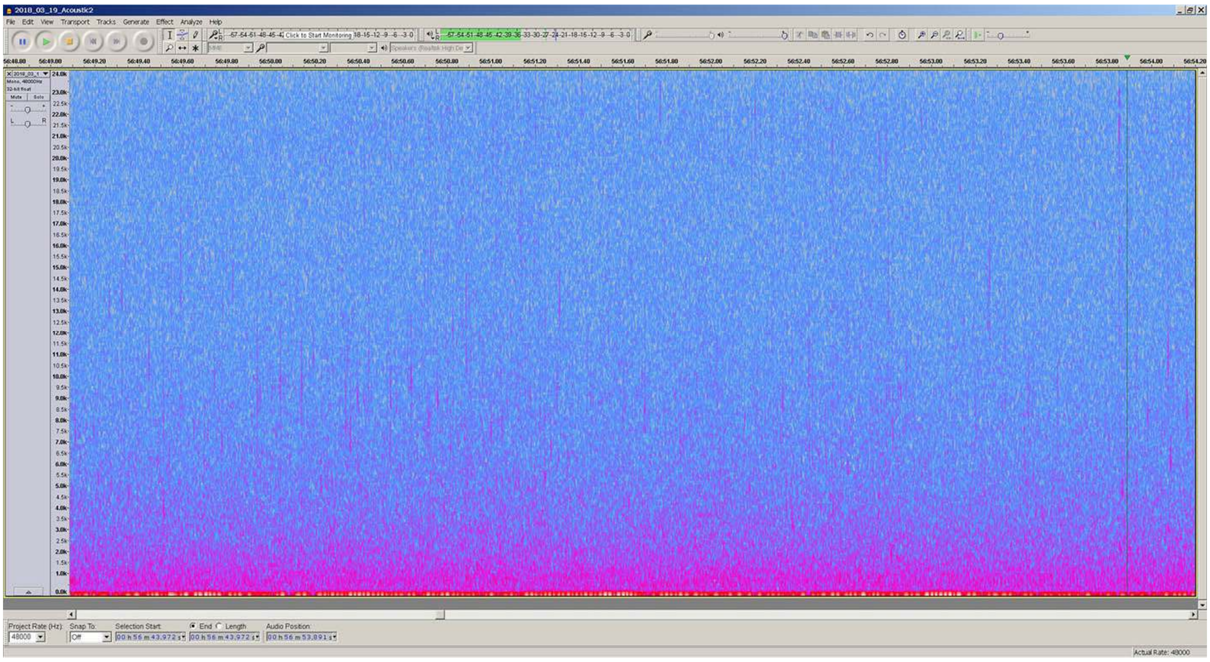


Figure 10.8. Audacity spectrogram (512 point FFT, Hanning window) from a recording made using the dip hydrophone deployed from an anchored yacht at Hummock Island on 19 March 2018 (No. 7; Table 10.3).

10.4. Discussion

While the acoustic files recorded during the two surveys have not yet been thoroughly checked for the presence of whale vocalisations, the acoustic feasibility study should be considered a successful exercise with regard to highlighting a number of logistical considerations that can be addressed during future PAM deployments. High levels of low frequency (<1 kHz) noise were apparent in the spectrograms for all of the recordings, and in many cases that noise extended to also mask the higher frequencies in relation to the equipment rubbing on the mooring or on kelp, strumming of mooring lines, and water noise associated with current, swell, wind and the surf breaking on adjacent shorelines. At best these noise sources make the resulting files suboptimal for monitoring sei whales.

A number of useful lessons were learnt from the feasibility study:

- The site choice for the deployment of static equipment (e.g. a SoundTrap moored to the seabed) needs to avoid the location of kelp beds in order to reduce rubbing and knocking of the equipment;
- The deployment technique should be designed to avoid any loose elements (i.e. ropes or loose shackles) that can potentially move around and cause rubbing;
- Strumming noise needs to be minimised by avoiding ropes to surface buoys where possible, or via the use of a spar buoy or bungee cord component;
- Deploying both the SoundTrap and the dip hydrophone from drifting yachts proved noisy due to flow noise, water sloshing against the platform at the surface, and noise from the platforms and their human occupants themselves. Ideally, the acoustic moorings need to be deployed independently of the platform to minimise these noise sources which can be significant (e.g. Figure 10.7);
- Achieving a suitable water depth for the deployments was problematic due to both the SoundTrap and the dip hydrophone being deployed from platforms rather than independently. The dip hydrophone was limited to 6 m below the water surface, while the SoundTrap was deployed to 10 m depth from the drifting yacht but shallower depths when at anchor. These depths were insufficient to avoid surface water noise from wind and swell, particularly when combined with water flow noise from the current. Future deployments would benefit from methods to locate the recording devices much deeper in the water column;
- While deploying the acoustic devices at sheltered anchorages reduced some of the flow and water noise experienced when deploying from the drifting yachts, the relatively shallow and semi-enclosed nature of most anchorages naturally reduces the likelihood of detecting sei whale calls. Acoustic detections would be maximised by placing devices in areas of more open water where sei whales are more likely to occur, and where propagation of their calls is optimised.

In conclusion, future PAM programmes for sei and other baleen whales in the Falklands are unlikely to be successful using the methods trialled during the feasibility study, due to the high masking of the target low frequencies by a variety of noise sources. It is recommended that long-term acoustic monitoring devices such as SoundTraps are deployed statically, and on their own moorings (i.e. independently of a research platform). Ideally, sites should be selected that are: (1) in, or openly adjacent to, areas used by sei whales; (2) in water depths of at least 20 m, and preferably deeper; (3) away from kelp beds; (4) away from vessel traffic; (5) at a suitable distance from the coast to avoid surf noise; and (6) in areas where currents and swell are as minimal as possible (i.e. avoiding shoals or narrow tidal channels). Using localisation from sonobuoys, Calderan et al. (2014) reported an approximately 20 km range for the detection of sei whale calls south of the Auckland Islands. Baumgartner et al. (2008) also considered detection ranges to be possibly as high as 20 km and realistically in the 10–15 km range. Other studies have noted that calls attributed to sei whales had relatively low estimated source levels and may only be detectable over short ranges of at most a few kilometres (McDonald et al., 2005). However, all of aforementioned studies were in deeper (>100 m), open oceanic waters, and are likely to represent optimal detection ranges. The coastal habitat occupied by sei whales in the Falklands is markedly different, and the increased levels of background noise inherent to coastal environments is likely to greatly reduce the detection ranges to vocalising animals. Consequently, careful deployment of the devices at appropriate sites to maximise potential detections is important. Ultimately, the Falkland Islands are a naturally windy environment and it may need to be accepted that water noise will affect the detection of whales on many days. For example, Hipsey et al.

(2013) reported that wind speed and wave height significantly affected noise levels even when acoustic monitoring devices were placed at 400 m depth to the north of the Falklands.

While this report summarised the characteristics of sei whale calls published for other studies, McDonald et al. (2005) noted that habitat, season, location and specific activity undoubtedly influence the type of sounds produced by sei whales. Therefore sei whales may produce different calls on the shallow feeding ground in the Falklands compared with what has been described in oceanic habitats elsewhere.

Careful interpretation of the results from any acoustic monitoring programme will be required. As noted by Baumgartner et al. (2008), the detection of a vocalisation on a PAM system is certainly conclusive evidence of the presence of a whale, but silence is not always indicative of an absence of whales. In their study, sei whales were visually observed during 29% of hourly periods in which calls were not detected, and there were also occasions when calls were detected but whales were not seen. Consequently, it may be useful to conduct some control visual observations at PAM deployment sites in order to examine the correlation between acoustic and visual detection rates.

11. DRONE FEASABILITY STUDY

11.1. Introduction and aims

Unmanned aerial vehicles (UAVs), commonly referred to as 'drones', are increasingly used in a range of scientific work including wildlife monitoring. UAVs provide advantages to researchers including their relatively low cost and reduced safety issues (i.e. compared with aerial surveys with a plane), their ability to access remote or logistically-difficult areas, and (if used appropriately) their generally lower likelihood of causing disturbance to animals compared with other methods (Hodgson et al., 2010; Smith et al., 2016; Fiori et al., 2017). UAVs have been incorporated into a number of marine mammal research programmes in recent years (Fiori et al., 2017), including abundance surveys, behavioural work, measurement of the individuals through photogrammetry methods, and the collection of whale blows to assess health and collect DNA.

The use of UAVs should be useful for monitoring a range of cetacean species in different geographic areas. However, some initial field trials are required to test their applicability to the particular species and conditions encountered at different study sites worldwide (e.g. Hodgson et al., 2010; Aniceto et al., 2018). This section provides a description of some opportunistic feasibility trials carried out with a UAV in the West Falkland study area. The main objectives of the feasibility study were to:

- Determine whether footage of sei whales could be acquired with a UAV;
- Identify the primary limitations of UAV use for sei whale work through "lessons learnt," with feedback for what improvements might be needed for future, more focussed, applications.

11.2. Methods

The UAV feasibility trials were limited to the period from the 23 to 29 March 2018, when the UAV pilot Andy Stanworth was onboard the vessel in the study area. The UAV comprised a DJI Phantom 4 quadcopter with an inbuilt camera system comprising a 20 mm 12.4 million pixel CMOS sensor. During deployments, the UAV was programmed to record video in .MOV format using Auto settings. Videos were variously initiated either when a whale was first observed on the display screen of the controller or when the flight commenced.

The UAV was launched opportunistically when suitable conditions prevailed including: (1) low wind speed (maximum 15 knots); (2) presence of sei whales (detected by the visual survey team); and (3) sufficient time was available (i.e. when the vessel had paused in an area to work with whales). During trials, a crew member launched and retrieved the UAV by hand from the rear platform of the yacht (away from the rigging and masts), and the pilot operated the UAV via a remote controller connected to an iPad display screen.

The default maximum flight altitude of 120 m was used for locating nearby whales, and also for filming whale groups where a wider field of view was required to observe multiple animals simultaneously. The altitude was reduced to approximately 10 m on occasion when closing in to film individual whales. Since the flights were experimental in nature, the remit was simply to locate and follow whales for as long as was possible and the pilot was otherwise free to adjust altitude and other parameters as he saw fit, depending on the encounter and prevailing conditions. Flight times were limited either by the whales being lost from sight (i.e. when they dove deeper in the water column) or by the 15–20 min maximum duration of the battery power. The UAV was immediately returned to the boat by the pilot when the 25% battery remaining alarm sounded.

11.3. Results

11.3.1. Field trials

The UAV was deployed on three dates in March 2018 (Table 11.1), with the remaining dates being too windy to operate the UAV safely. A total of 58.8 min of video footage was acquired while attempting to fly over six separate sei whale sightings, comprising groups of 1–5 animals (Table 11.1). Two of the UAV–whale encounters were located off Hummock Island in King George Bay, while the remaining four UAV–whale encounters were located in Queen Charlotte Bay (Figure 11.1).

Table 11.1. Summary of the UAV flights over six sei whale sightings off West Falkland, March 2018.

Video no.	Date	Daily sighting ref.	Visual group size	Video durn. (min)	Whales in video	Notes
1	24 Mar	16	3	5.7	0	
2	24 Mar	16	3	2.7	1	
3	24 Mar	16	3	1.6	1	
4	24 Mar	16	3	2.2	0	
5	26 Mar	10	2	6.5	0	Faecal sampling was filmed
6	26 Mar	12	3	3.3	2	
7	26 Mar	12	3	2.4	0	
8	26 Mar	13	4	8.4	4	
9	27 Mar	48	1	8.2	0	
10	27 Mar	49	5	9.4	4	
11	27 Mar	49	5	8.6	5	

Video footage of sei whales was obtained during flights over four of the sightings (Table 11.1; Figures 11.2 to 11.5). The UAV deployments were successful in acquiring both close approaches to single animals and wider-views of sei whale groups (Figures 11.2 to 11.5), providing insights on the group sizes of submerged animals, their group formations, and their behaviour.

11.3.2. Lessons learnt

A number of limitations were encountered during the feasibility study, and the main lessons with regard to future UAV work were:

- Much of the footage, especially the closer shots of whales, were over-exposed due to the strong daylight reflecting off their bodies and blows (Figures 11.4 and 11.5). Additionally, glare from the surface of the sea also obstructed the acquisition of clear images of submerged animals (Figures 11.3 and 11.4). Exposure had been set to auto-adjust on the UAV camera, and it was clear that this setting was unsatisfactory and would need to be revised during future work. Either the exposure would need to be stopped down, or the use of a polarising filter or similar equipment could be trialled to address the sun glare issue.
- The limited battery power of the UAV meant that the pilot sometimes had to return the device to the yacht in the middle of whale follows, causing the animals to be lost. Since significant time was required to initially locate whales with the UAV, the short battery life affected the amount of footage that was obtained. This was especially the case since sei whales are able to dive for periods of several minutes and occasionally up to 13 min (Weir et al., In Press), and consequently their availability at the surface was relatively low. It is recommended that options for extending battery power should be investigated ahead of future work.
- The UAV could not be launched or landed reliably from the deck of the yacht due to obstructions (e.g. rigging, masts, wheelhouse etc). Consequently, it was launched and

retrieved by an assistant, who leaned over the railings near the stern of the yacht to reduce chances of collision. Safety considerations included the use of glasses by the assistant for launch and retrieval, and the use of propeller guards on the UAV to minimise injury from the blades. A standard automated launch was used with the assistant releasing the UAV by hand once lift was detected. Landing to the hands was done manually, with engine shutdown implemented once the UAV had been received by the assistant. Careful consideration of the launch and recovery procedures will be required for future operation from vessels, with appropriate training and safety procedures implemented to minimise injury to crew and damage or loss of the UAV.

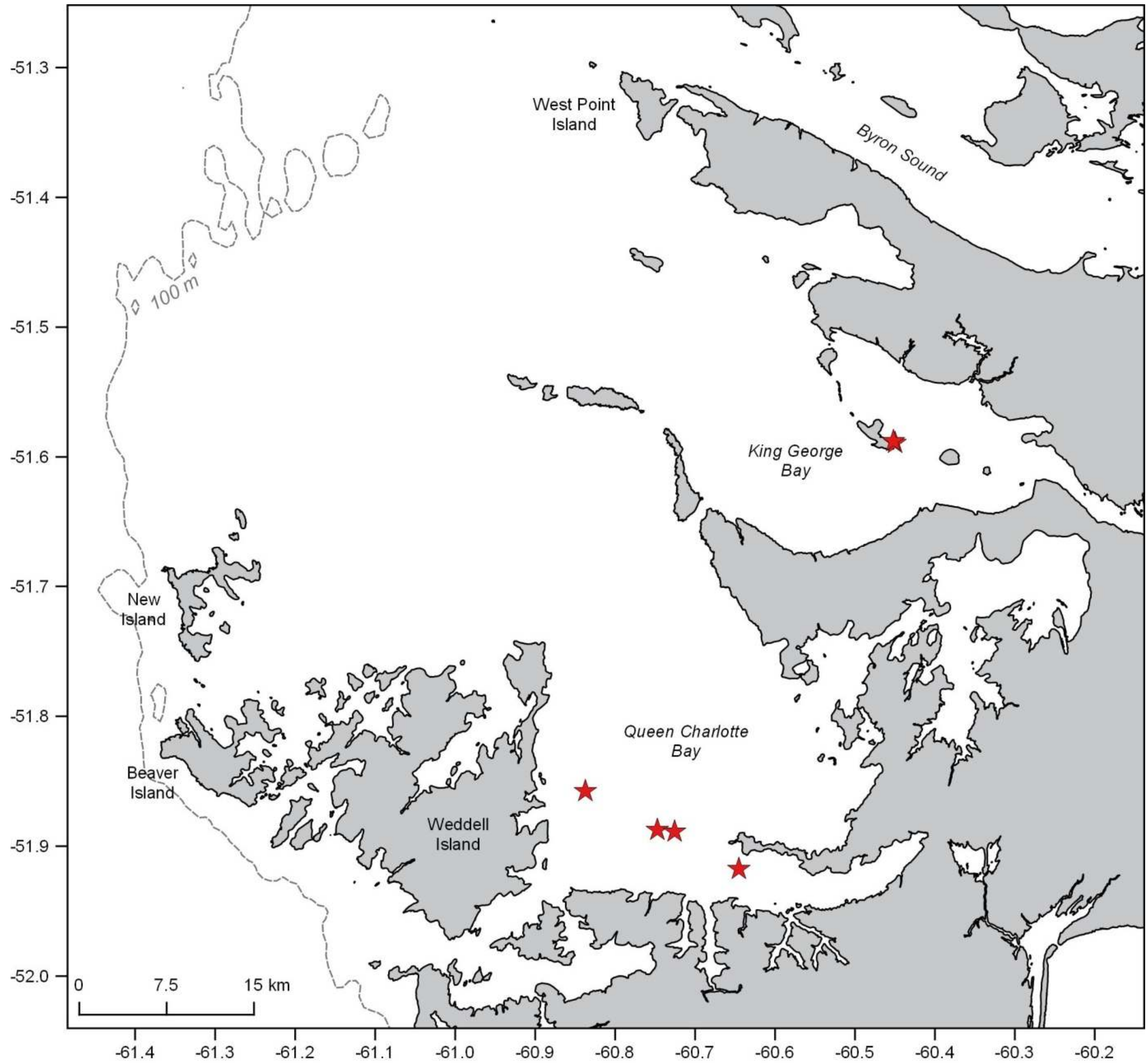


Figure 11.1. Initial locations of the six sei whale sightings over which UAV flights were attempted.

Figure 11.2. Screengrab from UAV video taken of sighting reference 16 on 24 March 2018.

Figure 11.3. Screengrab from UAV video taken of sighting reference 12 on 26 March 2018.

(A)

(B)

Figure 11.4. Screengrabs from UAV video taken of sighting reference 13 on 26 March 2018: (A) showing a wide-angle view of the group of four; and (B) close approach to one individual.

(A)

(B)

(C)

(D)

Figure 11.5. Screengrabs from UAV video taken of sighting reference 49 on 27 March 2018: (A) one individual blowing at the surface; (B) close overhead view of one individual; (C) wide-angle view of five animals; (D) presumed subsurface defecation by one whale.

11.4. Discussion

Although some challenges were encountered with the use of the UAV with regard to glare and battery life, the feasibility study was successful in obtaining aerial footage of sei whales and highlighting areas for improvement. Difficulties with obtaining images of whales due to constraints including sun glare and flight time constraints have been reported by other researchers during trials (e.g. Hodgson et al., 2010), and identifying these limitations is the first step towards addressing them and improving the technique.

The footage acquired from the UAV in West Falkland has already been incorporated into a scientific publication on sei whale dive and surfacing behaviour (Weir et al., In Press). Additionally, the footage provides optimism that future, more-focussed, work on sei whales using a UAV would be achievable. For example, the overhead approaches of individual whales during the field trial indicated that, with a more specialised type of UAV, it should be possible to fly overhead of sei whales for the purposes of photogrammetry. This would provide body measurements (length and girth) from aerial photographs, and represents a method of monitoring growth rates, body condition and individual health (Durban et al., 2016). Another possibility is the biological sampling of whale blows using UAV-mounted petri dishes, which potentially allows the collection of respiratory bacteria, lipids, proteins, DNA and hormones (e.g. Hogg et al., 2009; Hunt et al., 2014; Pirotta et al., 2017), that can be used in a wide range of health assessment contexts. Furthermore, UAVs may provide additional information on whale behaviour that cannot easily be acquired from boats, for example subsurface mating or feeding behaviour, or the presence of subsurface defecations (Figure 11.5). While it is unlikely that individual sei whales could be routinely recognised from aerial images using their body markings, the use of UAVs to obtain aerial images of southern right whales (*Eubalaena australis*) may provide useful data on the occurrence of individuals based on the pattern of callosities (hardened skin) on their heads. Initial UAV footage obtained from Port William in East Falkland during 2017 suggests that this method will be applicable to southern right whales in the Falklands and may facilitate matching of individuals with catalogues of callosity patterns from other geographic areas.

There should be consideration during future marine mammal UAV work in the Falklands of the potential for disturbance to the target animals (and other wildlife in the area) from either noise, or from visual cues from the UAV or its shadow (Smith et al., 2016). Relatively few studies have systematically monitored the behaviour of marine mammals in response to a UAV to assess disturbance (Smith et al., 2016), but it is recommended that this be incorporated into whale monitoring programmes (especially where UAV are flown at lower altitudes) in order to identify and limit any potential impacts.

12. CONCLUSIONS

This report described the results of the first systematic survey targeting the distribution, abundance and ecology of baleen whales on the west coast of West Falkland. A discussion of each survey component was provided at the end of each section, but some key overall conclusions of the fieldwork with regard to sei whale occurrence and the applicability of the cKBAs are summarised below.

12.1. West Falkland survey

12.1.1. Survey aims and constraints

With the exception of the biopsy sampling component, the West Falkland survey achieved most of its original stated aims. The visual sighting survey was particularly successful, with the yacht platform facilitating the collection of robust amounts of survey coverage even in open offshore areas. Additionally, good amounts of data were collected for the photo-identification and behavioural analyses, and the acoustic and UAV feasibility studies both provided useful information that is applicable to the future development of these techniques for sei whale research.

The multifaceted nature of the survey maximised the opportunities for collecting a diverse range of data to investigate multiple aspects of sei whale occurrence and ecology, and provided flexible options to keep working around the weather conditions. For example, good weather days were prioritised for transect work in the early part of the survey, while much of the photo-identification work in the north-eastern part of King George Bay occurred on days where the weather was unsuitable for working in more open areas. However, the multifaceted approach was in some respects a limiting factor, and inevitably resulted in a reduction of the effort applied to any single technique. For example, as discussed in Section 6.4, a dedicated photo-identification survey would undoubtedly have acquired a lot more images, and resulted in the cataloguing of more individuals and potentially more photographic recaptures. Similar is true of the faecal sampling and biopsy work, with the likelihood that a greater number of samples would have been obtained if those components had been the sole or priority aims of the survey work. The success of the latter techniques would also have been optimised if there had been additional experienced team members available to implement them. For example, if there had been a dedicated arbalester stood with the crossbow on the yacht's bow ready to take advantage of the occasions when a whale surfaced close enough to attempt sampling from the yacht. This was particularly the case since multiple opportunities sometimes presented themselves simultaneously, for example when whale defecations occurred during behavioural focal follows and photo-identification work. The survey lacked sufficient personnel to take full advantage of such occasions.

The importance of acknowledging constraints originating from platform availability was emphasised by Weir (2017a) following the Berkeley Sound survey work. That study found that the use of a 6.5 m RIB yielded the largest and most useful dataset (relative to aerial and shore surveys) on the spatial distribution of sei whales, and additionally produced the best-quality information on behaviour and group sizes due to the closer proximity of the observers to the animals. The West Falkland survey was conducted entirely from boat platforms, comprising a 19.5 m yacht and a 4.5 m zodiac. As described in detail in the photo-identification (Section 6.4) and faecal sampling (Section 8.4) sections of this report, the zodiac proved unsuitable for implementing the original plan for the biopsy sampling, faecal sampling or photo-identification components, particularly in the often choppy sea conditions encountered during the survey. The photo-identification effort was switched to the yacht, which provided the advantages of better eye height and greater stability than smaller platforms, but also the disadvantages of lower manoeuvrability and communication challenges described in Section 6.4. The low number of faecal samples obtained during the survey (seven, out of at least 48 observed), was certainly a consequence of platform type and associated logistics (Section 8.4). In contrast, it was clear that the yacht platform was superior to the smaller platforms for carrying out the visual survey work, offering raised eye height and a stable seated location, and also having an autopilot for effectively following the survey transects. The use of a liveaboard vessel was ultimately the only viable option for the survey, given the aims, spatial scale and remote nature of the survey area. In conclusion, the West Falkland survey results support the findings from the Berkeley Sound survey (Weir, 2017a) that the choice of platform has a large influence on the success of the different types of data collected.

12.1.2. Sei whale occurrence

The spatial dataset produced by the West Falkland survey is the first comprehensive assessment of sei whale distribution along the west coast of the Falklands, and revealed that the species was widely-dispersed from the coast to the 100 m depth contour at the westward limit of the study area, with whales being documented almost everywhere that survey effort occurred. Queen Charlotte and King George Bays represented a conspicuous data gap during previous cetacean and seabird survey work around the Falkland Islands between 1998 and 2001, which otherwise covered the entirety of the Falklands shelf (White et al., 2002). Little robust information has emerged for the region since, although anecdotal support for high numbers of whales in the region has emerged during interviews with local inhabitants and aircraft pilots (Frans and Augé, 2016; Weir, 2017a). Sei whales are known to occur in the Magellan Straits of Chile (Acevedo et al., 2017) and in the Golfo San Jorge in Argentina (Iñiguez et al., 2010), raising the possibility that the species inhabits much of the Patagonian Shelf Large Marine Ecosystem and could potentially have a continuous distribution extending directly westwards of the Falklands towards South America. Surveys would be needed between South America and the Falkland Islands to establish whether that is the case.

Sei whale distribution in the West Falkland study area corresponded well with what was documented for Berkeley Sound in 2017. The latter dataset indicated that whales occurred from the coast to distances of at least 15 km offshore (the furthest distance from the coast that the survey effort covered), with a mean water depth for the initial sighting locations of 40.6 m (Weir, 2017a). In West Falkland the survey coverage extended further from the coast and into deeper waters than was achieved in Berkeley Sound, but very similar mean water depths of 41.7 and 47.0 m were recorded for the sei whale and unidentified large baleen whales respectively. These initial results suggest that sei whales may occupy broadly similar habitats on the east and west sides of the Falklands, which likely reflects the areas favoured by their target prey species. Although only seven faecal samples were collected off the west coast of the Falklands, visual inspection revealed the presence of the pincers and eyeballs of squat lobster krill, as found in all of the samples collected in Berkeley Sound (Weir, 2017a). It can therefore be concluded that sei whales appear to feed on lobster krill on both sides of the Falklands, and the presence of this prey supply this may be one factor driving their spatial and temporal occurrence in the Islands. Better understanding of the ecology and distribution of squat lobster krill around the Falklands would doubtless provide insight on the occurrence of the sei whale and other marine predators.

The relative abundance of sei whales was calculated using different methods for the West Falkland study and the Berkeley Sound study, and the resulting values are therefore not directly comparable between the studies. Slightly more generous environmental conditions were used for the calculations of relative abundance in West Falkland (Beaufort sea state ≤4, swell of ≤2.5 m) than in Berkeley Sound (Beaufort sea state ≤3, combined swell/wave height of ≤1.5 m), in recognition of the higher eye height and greater stability of the survey vessel which was felt to impact less on cetacean detection rates. Additionally, the West Falkland study used kilometres as the unit for calculating relative abundance, whereas the Berkeley Sound study used time as the unit in order to be able to compare the values obtained from the shore, aerial and boat platforms. It is anticipated that a re-analysis of both datasets using comparable, standardised methods will be conducted in the future, to also incorporate additional sites.

The West Falkland survey occurred in February and March, which correlates with what is anecdotally-considered to be the seasonal peak of baleen whales in the Falklands (Frans and Augé, 2016). This is a much shorter timeframe than the suite of Berkeley Sound survey work (January to June: Weir, 2017a), and therefore offers less insight into the temporal occurrence of sei whales in the region. Both the relative abundance and the spatial distribution of the whales may vary seasonally or inter-annually, and additional survey work in other months and/or other years would be necessary to clarify whether the data recorded during the 2018 season are fully representative.

12.2. Candidate Key Biodiversity Areas (cKBAs)

The KBA system is intended to identify priority areas which contribute significantly to the global persistence of biodiversity, including vital habitat for threatened plant and animal species in terrestrial, freshwater and marine ecosystems. The Global Standard for the Identification of Key Biodiversity Areas (IUCN, 2016) sets out globally agreed criteria for the identification of KBAs worldwide.

In the 2016 BEST Ecosystem Profile for the South Atlantic region, six cKBAs were proposed for sei whales, based on areas of high density identified during the Falklands marine spatial planning project (Figure 1.1; Taylor et al., 2016). Since these high-density areas had been largely identified from anecdotal data, Taylor et al. (2016) emphasised that further field studies were required to confirm and understand the species identification, abundance and distribution. Consequently, the six whale cKBAs were highlighted as a priority for research due to their potential to qualify for full KBA status.

This report has described the results of field work carried out in February and March 2018, that provides the first assessment of the King George Bay and Queen Charlotte Bay cKBAs with respect to the species identification, abundance (via photo-identification) and spatial distribution of endangered baleen whales. The following subsections provide some key conclusions of the work with respect to the applicability of the cKBAs for the effective management and conservation of sei whales.

12.2.1. Species occurrence in the cKBAs

Although the King George Bay cKBA was nominated solely for sei whales, the Queen Charlotte Bay cKBA was nominated for the presence of both sei and fin whales (Frans and Augé, 2016; Taylor et al., 2016). The West Falkland survey coverage included both of the cKBAs and wide areas of the surrounding waters, but recorded only sei whales. While many observations of unidentified baleen whales were logged during the survey, there were no sightings that the observers suspected to be anything other than sei whales, and every whale that was closed upon to verify the identification was confirmed as a sei whale. Consequently, it is considered unlikely that there were many, if any, fin whales present in the study area at the time of the survey. A similar result was found for the Berkeley Sound cKBA (which was also nominated for both sei and fin whales) during fieldwork in 2017 (Weir, 2017a). Together, these studies suggest that either previous anecdotal reports indicating the presence of fin whales were a case of misidentification, or else both 2017 and 2018 have been unrepresentative years for fin whales in the study areas. It is notable that extensive survey work around the Falkland Islands from 1998 to 2001 only recorded fin whales close to, or seaward of, the shelf edge (200 m depth), while sei whales were also recorded over the shelf (<200 m depth) including close to land (White et al., 2002). This information strengthens the findings of Weir (2017a) and this report, in supporting a predominance of sei whales over fin whales in nearshore areas of the Falklands shelf. Distinguishing between sei and fin whales can be problematic for inexperienced observers, since both species have similar dorsal profiles (separated by subtle variations in the relative slope and size of the dorsal fin), and the overall body size of animals can be difficult to judge at sea. Furthermore, photography of sei whales in the Falklands has revealed that the species often has a pale chevron marking in the same location as that of the fin whale. Good supporting information (i.e. photographs or video) should therefore be requested for future reports of fin whales in the nearshore cKBAs, to enable the species identification to be independently-verified.

12.2.2. Appropriate of the cKBAs for effective whale conservation

It was apparent from the survey results that sei whales and unidentified large baleen whales were widely-distributed across the entire West Falkland study area, and from the coast out to the 100 m depth isobath. Neither the Queen Charlotte Bay cKBA nor the King George Bay cKBA were found to overlap with areas of sei whale occurrence that were notably higher than those recorded in adjacent waters or elsewhere in the West Falkland study area. Rather, the delimited boundaries of the cKBAs overlapped with relative abundance grid cells of predominantly low or moderate value for sei whales, large baleen whales, and combined sei/large baleen whales, and did not include the grid cells of highest relative abundance. Evaluation of the distribution of sei whale and unidentified baleen whale sightings within the West Falkland study area indicated that the current cKBAs, which are located in the central, most exposed areas of the two bays, do not extend sufficiently far towards the shore to include the areas used by many sei whales. In Queen Charlotte Bay in particular, the highest numbers of sightings were recorded in the southernmost part of the bay, along the north-east coast of Weddell Island, and along the coast between Shallow Harbour and the Passage Islands. These data were collected in February and March 2018, and it is important to acknowledge that the distribution and relative abundance of whales may vary between years or seasons. However, based on the most recent dataset then there is evidence that the current cKBA boundaries should be reconsidered to ensure that the most relevant areas for whales are incorporated, and that those areas remain relevant over meaningful timeframes, i.e. are of a scale sufficient to allow for some finer-scale seasonal and annual variation in whale distribution.

The Queen Charlotte cKBA and the King George Bay cKBA are two of the largest cKBAs that are currently proposed for whales in the Falklands (Table 12.1). However, the areas are still relatively small in the context of conserving large and highly-mobile predators such as sei whales. For example, data from the 17 West Falkland focal follows of sei whales revealed a (minimal) mean linear swim speed of 5.3 km h^{-1}, which suggests that a sei whale could swim across any of the KBAs in less than 5 hr and illustrates well the scale of sei whale movements relative to the spatial dimensions of the cKBAs. Such small cKBAs would only be meaningful for the conservation of sei whales if they were located in particularly critical and persistent hotspots (relative to surrounding waters) for key activities such as feeding or breeding.

Table 12.1. Spatial dimensions of the six candidate Key Biodiversity Areas (cKBAs) proposed for whales in the Falkland Islands.

cKBA	Area (km^2)	Maximum dimensions (km)	
		N–S	E–W
King George Bay	54.8	7	11
Berkeley Sound	181.1	20	22
Queen Charlotte Bay	295.3	24	18
Saunders Island Waters (North)	30.6	4	13
Byron Sound	27.4	4	11
Falkland Sound	20.9	8	5

The photo-identification re-sighting data indicated that while one individual (WF-9) was encountered five times within a relatively small spatial area of 24.6 km^2 (located outside of either of the cKBAs) over 24 days, three other individuals were recaptured at distances of at least 62, 29 and 32 km from their original capture locations over similar time periods (27, 17 and 19 days respectively). Unfortunately, due to prevailing weather conditions, no photo-identification encounters were initiated inside the King George Bay cKBA and there was therefore no available evidence for the persistent use of that cKBA over time. Similar was true for the Queen Charlotte Bay cKBA, where only four photo-identification encounters were initiated within the cKBA. However, individual WF-15 was encountered on 6 March close to Weddell Island (outside of the cKBA), but was subsequently recaptured approximately 4 km from the original sighting and inside the south-western part of the Queen Charlotte Bay cKBA on the 24 March. This suggests that some individuals were remaining within the broader area of Queen Charlotte Bay, even if not consistently within the cKBA boundaries. The movements of individual WF-4 from Byron Sound to the Queen Charlotte Bay cKBA, and of individual WF-26 from Hummock Island to the Passage Islands (and therefore very likely through the King George Bay cKBA), suggests that whales transit in and out of the relatively small cKBA areas.

Considered in combination, the spatial distribution, relative abundance and photo-identification results therefore support replacing the current Queen Charlotte and King George Bay cKBAs with a single larger KBA that would comprise much of the wider West Falkland study area. However, if the desired (from a practical perspective) management approach in future was to continue with the designation of small-scale cKBAs for Falklands whale conservation, then the north-eastern part of King George Bay (north and east of Rabbit Island, Hummock Island, Middle Island and Gid's Island) would certainly warrant consideration as an addition to, replacement for, or expansion of, the current King George Bay cKBA. This area was consistently-important for sei whales over the duration of the survey, as evidenced by all methods (photo-identification, transect survey, and relative abundance analysis).

12.2.3. Connectivity between cKBAs

The photo-identification results provided good evidence for connectivity between the cKBAs, suggesting that the proposed areas are not discrete. One whale (WF-4) travelled from Byron Sound to the Queen Charlotte Bay cKBA, and highlighted the linkage between those areas (and presumably King George Bay, located between those two sites). In total, five individuals were documented to have made minimum straight-line movements of ≥19 km, which is greater than the swimming distance between the King George Bay and Queen Charlotte Bay cKBAs and clearly illustrates the potential for linkage between those sites. Given the relatively low potential for recapture between sites during the survey (due to the low photographic effort within any of the cKBAs, and strong bias towards one part of King George Bay), these results should be interpreted as only a minimum indication of the scale and frequency of movement of individual sei whales.

Additional strong evidence for connectivity between the cKBAs was presented by the two photographic recaptures of individual sei whales between the Berkeley Sound cKBA in 2017 and the West Falkland study area (King George Bay and north of Weddell Island) in 2018. These recaptures demonstrate movements of animals between the opposite coasts of the Falkland Islands, and provide a strong indication that individual sei whales utilise large expanses of the Falklands shelf including multiple cKBAs and the areas in between them. The latter areas cannot reasonably be described as 'corridors' at this time, since it may be the case that the waters located between the cKBAs are just as important for foraging sei whales as the cKBAs themselves. For example, the high relative abundance of sei whales recorded along the north coast of the Falklands (north of Falkland Sound) during this survey, suggests that this area was important in its own right (at least at the time of the survey) rather than simply comprising a transit area for whales.

12.2.4. Status of the cKBAs

The combined information presented in the preceding sections is suggestive that the currently-proposed network of small, discrete cKBAs may not represent the optimal approach to achieving effective whale conservation in the Falklands, since the small areas identified as cKBAs are not of a scale appropriate to the documented whale movements. Given that situation, a discussion of whether the status of the Queen Charlotte cKBA or the King George Bay cKBA warrant upgrading to full status may be inconsequential. However, they are briefly discussed here for completeness.

Sei whales are currently classified as a globally endangered species by the International Union on the Conservation of Nature (IUCN) Red List (Reilly et al., 2008a). Therefore, a site would qualify as a full KBA for the species if it regularly supported:

1. ≥0.5% of the global population size AND ≥5 reproductive units; or
2. ≥0.1% of the global population size AND ≥5 reproductive units of a species assessed as endangered due only to population size reduction in the past or present.

The endangered status of the sei whale is a direct result of population reduction caused by commercial whaling in the 20th century (Reilly et al., 2008a), and the species was therefore globally-assessed under the Red List criterion A1 (IUCN, 2012). Consequently, full KBA status for a sei whale site would be warranted by the presence of 0.1% of the global population and ≥5 reproductive units of the species. In the context of the KBA process, reproductive units are defined as the minimum number and combination of mature individuals necessary to trigger a successful reproductive event at a site (IUCN, 2016). A 50:50 sex ratio has been assumed in global sei whale population assessments (Reilly et al., 2008a). The current global population size of the sei whale is very poorly understood due to a lack of systematic abundance surveys targeting the species. The latest IUCN assessment for sei whales indicated an estimated global mature population size of approximately 30,000 individuals in 2007 (Reilly et al., 2008a). Based on that information, 0.1% of the mature global population would equate to the presence of around 30 adults.

There are several lines of evidence available to examine the number of animals occurring in each of the two cKBAs:

- <u>Sighting data</u>: Of the 1,012 sightings of sei whales or unidentified large baleen whales recorded during the survey, 86 (122 individuals) occurred within the boundaries of the Queen Charlotte Bay cKBA and 22 (25 individuals) occurred within the King George Bay cKBA. Since these sightings occurred over a range of dates and mostly lacked associated photo-identification data then the number of re-sightings of the same individuals is unknown.
- <u>Abundance</u>: Absolute abundance and density data are not yet available, but analysis is underway that should allow an estimate of the number of animals within both cKBAs.
- <u>Photo-identification data</u>: No sei whales were photo-identified within the King George Bay cKBA. Four sightings were photo-identified at the southern end of Queen Charlotte Bay cKBA, resulting in a total of 12 catalogued individuals.

While these datasets do not absolutely support either the King George Bay or Queen Charlotte Bay cKBA qualifying for full status, they provide a convincing argument that with additional survey effort the qualifying number of 30 animals would be reached in both sites. In particular, very low amounts of photo-identification effort occurred in the open waters of the sites (including the entirety of the King George Bay cKBA), due to weather conditions. The KBA Standard (IUCN, 2016) makes allowances for such cases, stating that sites that are inferred, with justification, to meet global KBA criteria and thresholds, but for which the data have not yet been compiled to demonstrate the case, will be treated as global KBAs for an 8–12 year re-evaluation period and flagged as ‘priority for update.’

While the KBA process provides guidance on the quantitative thresholds for which a site qualifies for full KBA status (IUCN, 2016), it does not provide specific guidance on the temporal scale over which those quantitative thresholds apply. Given that sei whales are migratory species, and evidence suggests that they use Falkland waters as a seasonal feeding ground, a reasonable interpretation might be that the quantitative thresholds would apply to a feeding season (i.e. the austral summer and autumn months spanning at least December to early June for sei whales in the Falklands). The temporal extent of the survey work conducted at the King George Bay and Queen Charlotte Bay cKBAs was short (five weeks) relative to the six-month duration of the whale feeding season. The Berkeley Sound dataset showed a continual influx of newly-identified individuals to that site between February and May (Weir, 2017a), and new animals continued to be photo-identified throughout the

West Falkland survey duration. Consequently, it seems reasonable to infer that a significant number of additional whales would have been photo-identified if the survey had been carried out over the full season.

It is also clear that the evidence of whale numbers generated from the visual sighting dataset, was much more supportive of full KBA status for the larger site (Queen Charlotte Bay; 122 sightings) compared to the smaller site (King George Bay; 22 sightings), which further demonstrates the effect of scale. Clearly, if whale densities are similar across a large area, then designating a larger site will include more animals than a smaller site. Therefore, both the qualifying status and the applicability of the cKBAs for the management and conservation of whales, will be directly affected by the choice of site size.

It is emphasised that while full KBA status of the small-scale King George Bay and Queen Charlotte Bay cKBAs was not categorically demonstrated by the data, the wider West Falkland study area would undoubtedly qualify as a full status KBA based on the MPS from the photo-identification data of 133 animals at the time of the survey. An absolute abundance estimate from the transect data is forthcoming, and early indications are that it will considerably exceed the MPS generated from the photo-identification data.

12.2.5. Conclusions

The results of this report indicate that, given additional survey effort, the two current cKBAs in Queen Charlotte Bay and King George Bay would very likely meet the criteria to qualify for full KBA status. The Global Standard on KBA designation (IUCN, 2016) indicated that the boundaries for a KBA should be based on ecological considerations that include mapping the local spatial distribution of the species and also estimating extent using models or knowledge of habitat requirements combined with maps of remaining habitat. It also notes the need to consider connectivity with other areas, concluding that the size of the KBA will depend on the ecological requirements of the biodiversity elements triggering the criteria and the actual or potential manageability of the area (IUCN, 2016). The various datasets presented in this report demonstrated that: (1) movements of whales occur between areas, including between cKBAs; (2) the current cKBAs did not overlap with the areas of highest relative abundance; (3) the current cKBAs were sufficiently small in scale that whales could potentially transit across them in only a few hours; (4) whales were widely-distributed across the entire area; and (5) the numbers of whales in the West Falkland study site would certainly qualify the wider area for full KBA status. Consequently, there is increasing evidence that if marine KBAs are to be designated in the Falklands with the core aim of conserving and managing sei whale populations, then their spatial scale needs to be revised (with appropriate stakeholder consultation) to ensure that they correlate with the scales appropriate to the movements and ecology of sei whales. This may potentially involve a smaller number of larger-scale KBAs that cover wider parts of the Falklands shelf and allow for spatio-temporal variation in prey occurrence and thus whale distribution.

12.3. Ongoing work

This report provided a summary overview of the initial results from the West Falkland baleen whale survey, including feedback from two feasibility studies. A number of more detailed analyses from the survey are underway to expand on the information presented here, including abundance estimation using DISTANCE software, an investigation of the suitability of the photo-identification data for mark-recapture analysis, and the genetic and isotope analysis of the faecal and bone samples. The outputs of these analyses will be forthcoming, and are anticipated to include scientific publications. The results from the acoustic feasibility study have already been used to inform the development of a suite of acoustic monitoring work commencing in Berkeley Sound in late 2018. Additionally, collaborations are being formed with organisations in other regions of the south-west Atlantic to investigate whether photo-identification matches can be made between the Falklands and other countries to demonstrate the seasonal movements of sei whales in the wider region.

Both the Berkeley Sound study (Weir, 2017a) and the West Falkland work (this report) have demonstrated that a range of standard cetacean research techniques are applicable to sei whales, and it is recommended that survey work continues in the Falkland Islands to expand the existing datasets to include additional areas and techniques, increase sample sizes to facilitate evidence-based management approaches, and provide inter-annual comparisons of sei whale abundance and distribution to better inform their longer-term conservation in the Islands. These data should also be incorporated into the ongoing marine spatial planning work in the Falkland Islands, to include a re-evaluation of the applicability of the currently-proposed cKBAs for achieving effective whale conservation.

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Appendix 1: Environmental data recorded during sei whale survey work

Beaufort sea state

Code	Description at sea	Mean wind speed (knots)	Probable wave height in metres (max) in open seas
0	Sea like a mirror	0	0
1	Ripples	2	0.1
2	Small wavelets, no whitecaps	5	0.2 (0.3)
3	Large wavelets, scattered whitecaps	9	0.6 (1.0)
4	Waves becoming longer, frequent whitecaps	13	1.0 (1.5)
5	Moderate waves, many whitecaps, chance of spray	19	2.0 (2.5)
6	Large waves, extensive white foam crests, some spray	24	3.0 (4.0)

Swell height

Code	Visibility (km)
1	<1
2	1–5
3	6–10
4	11–15
5	16–20
6	>20

Sun glare

Code	Intensity
N	None
L	Low/weak
M	Moderate
S	Severe

Code	% of viewing area*
1	<20
2	20–40
3	40–60
4	60–80
5	100

*Viewing area is defined as the 180º area forward of the beam for boat-based surveys

Precipitation

Code	Type
N	None
R	Rain
F	Fog / mist
H	Hail
S	Snow

Code	Intensity
N	None
L	Low
M	Moderate
S	Severe

Appendix 2: Community participants during sei whale survey work

Trip 1: 24th - 27th March 2018

- Anne Robertson
- Mike Evans
- Donna Evans

Trip 2: 27th - 31st March 2018

- Keith Knight
- Dale Evans
- Thomas Stockting (FITV)

Appendix 3: Whale collision report, 28 March 2018

This report was submitted to the FIG Environment Committee and discussed at the EC meeting on 28 June 2018.

Between February and April 2018, a sei whale research survey was underway in Queen Charlotte and King George Bays under Falkland Islands Government Research Licence No: R11/2017. The yacht *Golden Fleece* was the research platform. On 28 March 2018 at 16:33 UTC a visual sighting survey had just resumed in King George Bay following a lunch break. The vessel was travelling on a straight south-easterly heading towards Christmas Harbour, under motor and at a steady speed of 6 knots (11 km/hr). Weather conditions comprised ~20 knots of wind, Beaufort 4 sea state, a swell height of 1 m and good visibility exceeding 20 km.

At 16:36 UTC a sei whale was sighted 150 m ahead of, and 24 degrees starboard of, the vessel's bow, travelling left-to-right and away from the vessel's trackline. At 16:37 UTC a sei whale suddenly appeared at the surface immediately (<10 m) in front of the bow and travelling directly towards the vessel. It was unclear whether this was the same whale that had been sighted at 16:36, in which case it must have made an unexpected rapid and marked (>90 degrees) alteration in direction. However, it could also have been a previously-undetected animal surfacing after a long dive.

The whale dove at the bow but not deeply. Observers situated on the roof of the wheelhouse were able to track the submerged animal for a brief period. The whale travelled underneath the *Golden Fleece* at an angle, reappearing (still submerged) on the port side (Figure 1). As it passed under the vessel, the whale made contact with the hull causing a brief vibration of the vessel and an audible sound. The submerged animal was completely lost from sight while still emerging from the port side of the vessel, and is assumed to have moved deeper down the water column following contact with the vessel.

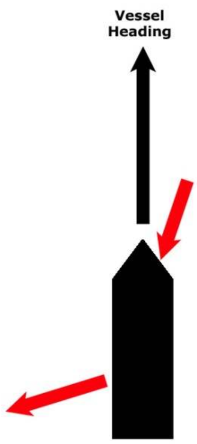

Figure 1. Schematic showing the whale's track (red arrows) relative to the *Golden Fleece*.

The vessel was stopped and the area monitored until 16:52 UTC, but the whale was not seen again. The choppy sea conditions and numerous blows from other scattered whales in the area limited the potential for conclusive re-sightings of the same individual.

Conclusions

- It was not possible to ascertain the condition of the whale following the brief collision due to the animal diving and being lost from sight. However, had the whale been compromised then it may be expected that it would have reappeared at the surface within the 15 min period of monitoring after the event (which exceeds typical dive times for Falkland sei whales).

- The entire sequence of events from the whale appearing at close range directly in front of the vessel to being lost from sight happened within a 30-sec period, providing very limited scope to take any avoidant action. The vessel had been travelling on a steady straight course for several minutes prior to the incident, and at a relatively slow speed (6 knots).
- It is unclear whether the choppy sea conditions at the time of the sighting masked the sound of the approaching vessel to the whale. However, the vessel had been conducting the whale survey in the Falklands since 22 February without any such incidents and often in similar weather conditions.
- It had been anecdotally-noted by the team that, for unknown reasons, other sei whales encountered on 28 February were spending more time at the surface (and at shallow depths just below the surface) around the vessel than had been typically observed on other days. Consequently, following the collision and a second close encounter the decision was taken to limit the proximity of any subsequent approaches to whales for photo-identification for the remainder of that day.
- The incident highlights the potential for whale–vessel collisions in the Falklands even when vessels are moving reasonably slowly and in a straight line, and have a team of observers onboard specifically looking out for whales. It also emphasises the potential for vessel strikes on sei whales, which are often considered to be at relatively low risk of collision compared with other whale species (e.g. right whales) due to their faster swimming speed, elusive behaviour and pelagic distribution in most regions.

Appendix 4: Examples of Photographic Quality (PQ) ratings assigned during sei whale photo-identification work

PQ1 - Excellent




PQ2 - Good




PQ3 - Fair

PQ4 - Poor