

## Darwin Plus: Overseas Territories Environment and Climate Fund Annual Report

To be completed with reference to the "Project Reporting Information Note"  
(<https://darwinplus.org.uk/resources/information-notes>)

It is expected that this report will be a **maximum of 20 pages** in length, excluding annexes)

**Submission Deadline: 30<sup>th</sup> April 2023**

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### Darwin Plus Project Information

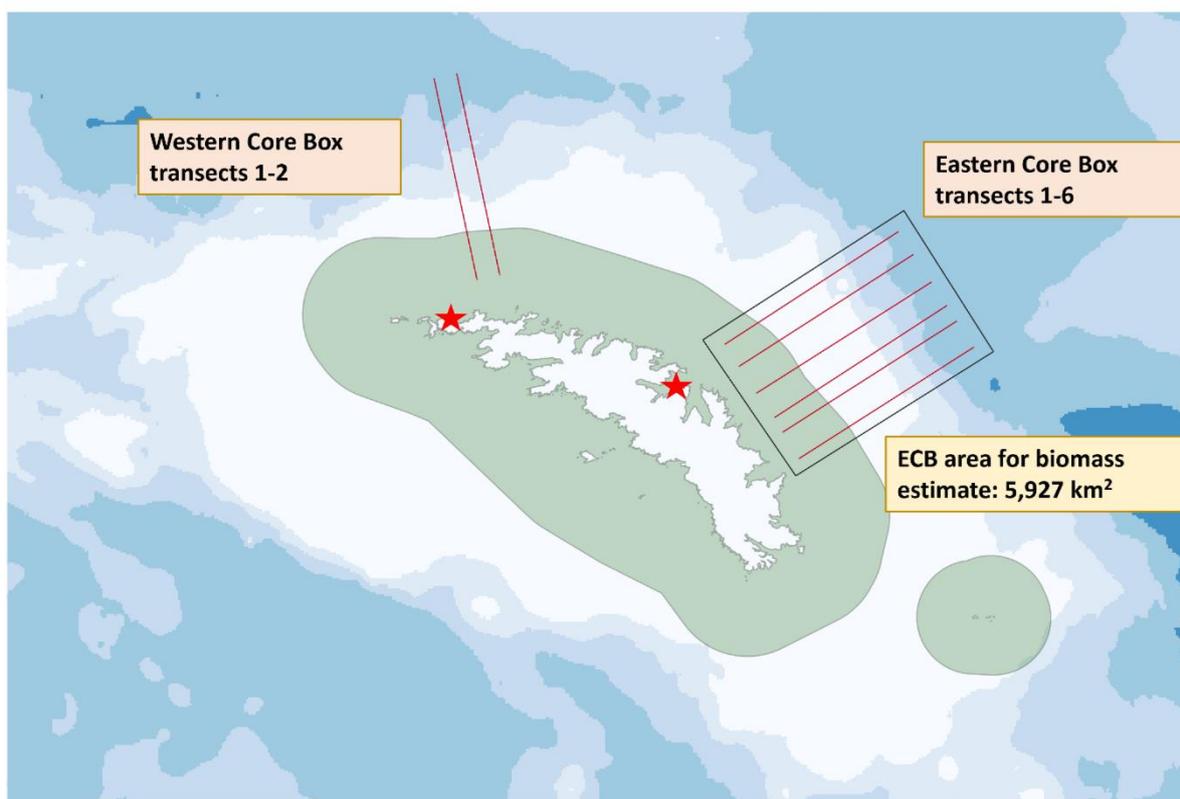
Project reference	DPLUS149
Project title	Resolving ecosystem effects of the South Georgia winter krill fishery
Territory(ies)	South Georgia and the South Sandwich Islands
Lead Partner	British Antarctic Survey
Project partner(s)	Government of South Georgia and the South Sandwich Islands (GSGSSI) and Antarctic Research Trust (ART)
Darwin Plus grant value	£469,653.00
Start/end dates of project	1 December 2021 – 31 May 2024
Reporting period (e.g. Apr 2022-Mar 2023) and number (e.g. Annual Report 1, 2)	1 April 2022 – 31 March 2023, Annual Report 2
Project Leader name	Martin Collins
Project website/blog/social media	<a href="https://www.bas.ac.uk/project/winter-krill-at-south-georgia/">https://www.bas.ac.uk/project/winter-krill-at-south-georgia/</a>
Report author(s) and date	Martin Collins, Sophie Fielding, Jen Jackson, Norman Ratcliffe, Cecilia Liszka, Geraint Tarling, Tracey Dornan (all BAS), Mark Belchier, Sue Gregory, Vicki Foster (all GSGSSI), Klemens Putz (ART).

**Report formats:** This report should be sent in MS Word only (if you have concerns about layout you may submit a PDF but this is in addition to a Word version). If you have already answered a question in one section, do not repeat the information in another section, but refer back to the section number.

### 1. Project summary

Our project is entitled 'Resolving ecosystem effects of the South Georgia winter krill fishery', hereafter referred to as the Winter Krill Project. The main objectives of the Winter Krill Project are to obtain information on i) the distribution and abundance of *Euphausia superba* (Antarctic krill) during the winter; and ii) overlap between the distribution of krill-dependent predators and krill in the fishery area. The motivation behind this is that the commercial krill fishery around South Georgia (SG) operates exclusively during the winter period, yet information on the stock dynamics and distribution of krill during this period are sparse. Although MPA restrictions include a 30 km no-take zone around the SG coast, there is evidence to suggest that the foraging habits of

krill-dependent predators such as penguins and seals vary depending on the abundance of krill, and that this may result in overlap between them and the krill fishery, particularly during low krill years. There is also evidence of baleen whales returning to SG in large numbers during the summer and of some remaining during the winter, with the increased prey demand potentially further increasing competition for krill resources. Our project will address this gap in winter data, in turn improving management of the SG ecosystem and enabling the ecosystem-based management of the krill fishery.



*Figure 1: Map of part of the South Georgia and South Sandwich Islands Marine Protected Area (SGSSI MPA) showing the survey area with the six Eastern Core Box (ECB) and two Western Core Box (WCB) transects shown in red. The black box around the ECB shows the area of the region used to estimate krill biomass over. The red stars indicate the locations of gentoo penguin tag deployment at Bird Island (west) and Maiviken (central), respectively. The green area indicates the No Take Zone where fishing is prohibited (a 30 km distance from the SG coastline and a 12 nm (22.2 km) distance from the coastline of Clerke Rocks to the south-east).*

## **2. Project stakeholders/partners**

Formal project partners are the GSGSSI and the Antarctic Research Trust (ART). The project team includes members of these organisations and they, as well as the BAS project team members, are included in all project meetings and communications. These partnerships were developed based on the mutual interest of all partners in the project and its outcomes and the value that the partners could add to the project by being involved, and the project was developed with the involvement of both. The GSGSSI has a central role in the management of the SG ecosystem, MPA and the krill fishery; hence they have been directly involved in developing and executing the acoustic element of the project. The role of the ART is enabling the conservation of Antarctic and sub-Antarctic animals and has therefore been involved directly in the penguin monitoring aspect of the project, including providing the satellite tags.

Monthly meetings of the full project team are held (hybrid, with Zoom link for those not in Cambridge) on the first Monday of each month, for which minutes are recorded and shared with all team members. We have also created a shared OneDrive folder which all project team members can access, and where all documentation related to the project is saved. In between these meetings, regular communication is maintained with partners either via email or by Zoom meeting. All partners are therefore involved in all project planning, decision-making and evaluation elements. In addition to the formal project partners, we have a range of interested stakeholders that we are maintaining communications with. This includes the Association for Responsible Krill Harvesting (ARK), AkerBiomarine, WWF, Birdlife International, Cefas, Pew Charitable Trusts, RSPB, South Georgia Heritage Trust (SGHT), South Georgia Association (SGA), Plymouth Marine Laboratory (PML), South Atlantic Environmental Research Institute (SAERI) and the UK Foreign, Commonwealth and Development Office (FCDO) and we update our list as required. Following our initial Stakeholder Meeting that we held on January 24<sup>th</sup> 2022, at the start of the project, we are providing our stakeholders with six monthly updates on the project. We circulated the last one on 31<sup>st</sup> October 2022 (also available on our [website](#)) and the next one is due to go out in April 2023. On December 7<sup>th</sup> 2022 we held a project workshop that was attended by all key project personnel and official partners, as well as some other key stakeholders.

We have also developed a relationship with colleagues at the College of Staten Island (New York) who are conducting research of a similar nature to us on the US research vessel Lawrence Gould and with whom we are discussing potential collaboration during the July 2023 survey.

### 3. Project progress

#### 3.1 Progress in carrying out project Activities

Following completion of the fit of the acoustic system to the *Pharos SG* during Y1 of the project (**Activities 1.1-1.3**), efforts have shifted to training in the methods, and implementation of Y1 survey activities.

**Activities 1.4 & 1.5:** Prior to the first survey, *Pharos SG* officers and crew were trained in the operation of the system and this has been maintained throughout the surveys and as updates to protocols have been made. Where updates or clarifications to acoustic operating methods have occurred, copies have been printed and placed beside the echosounder on the *Pharos SG*. The KEP Science staff employed during Y1 (Kate Owen and Meghan Goggins), Y2 (Carrie Gunn and George Perry) and GSGSSI Government Officers were trained in calibration and acoustic operation methods prior to the first surveys of each year (May 2022 and March/April 2023 respectively). NB: As agreed in Change Request March 2023, the timing of the first Y2 survey was brought forward to March/April as a result of the *Pharos SG* having to go into dry dock during May 2023.

**Activity 1.6:** A first version of the manual for acoustics operation was finalised during the first survey in May 2022 and provided to all those involved in the project. This was updated, based on experience from the Y1 surveys, prior to the March/April 2023 survey. It is saved on a shared project drive, and hard copies were printed out both for the KEP research station and the *Pharos SG*.

**Activities 2.1 -2.3:** The acoustic and predator surveys for Y1 were carried out in May, July and September 2022. The locations of the surveys are shown in Figure 1. Reports from each of the surveys are available on our project [website](#). Planning is also well underway for Y2 surveys with the first survey (originally scheduled for May but rescheduled to March/April 2023) recently completed. Additional matched funding (not included in original proposal) was secured from FCDO to support the participation of a dedicated seabird observer experienced in JNCC methods (Ryan Irvine) during the 2022 surveys (**Activity 2.2**). Additional matched funding has also been secured from BAS/GSGSSI to support the participation of seabird observers for the July and

September 2023 surveys (this was not possible for March/April as the timing of the date change was too late to secure someone). In Y1, Irvine led the seabird observation activities during each of these surveys and provided additional training for KEP science staff in seabird observation methods. He is also providing continuity training and data sheets for the incoming observers to enable consistency between years. Additional funding was also secured from the South Georgia Heritage Trust and Friends of South Georgia Island for the deployment of passive acoustic DIFAR sonobuoys during the July survey (**Activity 2.3**). The sonobuoys detect cetacean vocalisations and this has supplemented the at-sea transect work, being used to acoustically locate whales in real time, and to record their vocalisations. In addition, 24 SPOT 257 PTT satellite tags were purchased (from Wildlife Computers, with matched funding from project partners, Antarctic Research Trust). 12 were deployed in Y1 (6 each from Bird Island (BI) and Maiviken) and 12 for Y2 (not yet deployed but have been shipped ready for deployment in May/June 2023). (**Activity 2.5**). In Y1 an additional 9 birds at BI were equipped with PathTrack Nanofix remote download GPS tags (provided by BAS). These allowed tracking of additional birds in greater detail than is possible with satellite tags. Up to 10 GPS tags are also available for deployment at BI in Y2.

**Activities 3.1-3.4:** The acoustic data obtained during the three Y1 surveys were cleaned and processed in Echoview (version 13.0.378), and calibrated with *in situ* temperature, salinity and speed of sound derived from CTD measurements. Time-varied gain background noise was removed (De Robertis & Higginbottom 2007), and intermittent noise was removed and replaced with a 7x7 average Sv (Wang et al. 2016). A surface exclusion of 7 m was applied to account for the transducer depth (4.3 m) and non-linearity in the echo response in the 120 kHz transducer nearfield (2.7 m). Krill aggregations were identified using the SHAPES algorithm (Coetzee 2000), applied to clean 120 kHz acoustic data filtered using a 3x3 dilation (Macaulay et al. 2019). The algorithm detected swarms with a minimum length of 15 m and height of 3 m. Adjacent swarms were joined together if they were horizontally <15 m and vertically <5 m apart. Data pertaining to individual swarms and their associated characteristics e.g. length, depth, height, area and density were exported from Echoview for subsequent analysis. The Nautical Area Scattering Coefficient (NASC) was integrated over 1 nm x 250 m bins and exported from Echoview. This was then converted into biomass by multiplying it by a coefficient calculated from the krill target strength, based on the length-frequency obtained from the plankton trawls (**Activity 3.1**). All raw data has been stored in the BAS Polar Data Centre (PDC) in a dedicated Winter Krill project directory which links to data collected on the *Pharos SG*, organised by survey. Work is currently underway to establish a link to this from the South Georgia Data Portal so the data can be accessed via both routes (**Activity 3.2**). Final clean data will also be uploaded to the PDC and SG Data Portal at the end of the project once analyses are complete.

The distribution of krill throughout the season and over a diurnal period is shown in Figure 2. Estimates of krill density ( $\text{g m}^{-2}$ ) and biomass (tonnes) within the ECB area (calculated as 5927  $\text{km}^2$ , shown in Figure 1) have also been made for each of the survey periods, based on all transect data (day and night); as well as daytime only and night-time only transects (Figure 3 and Table 1).

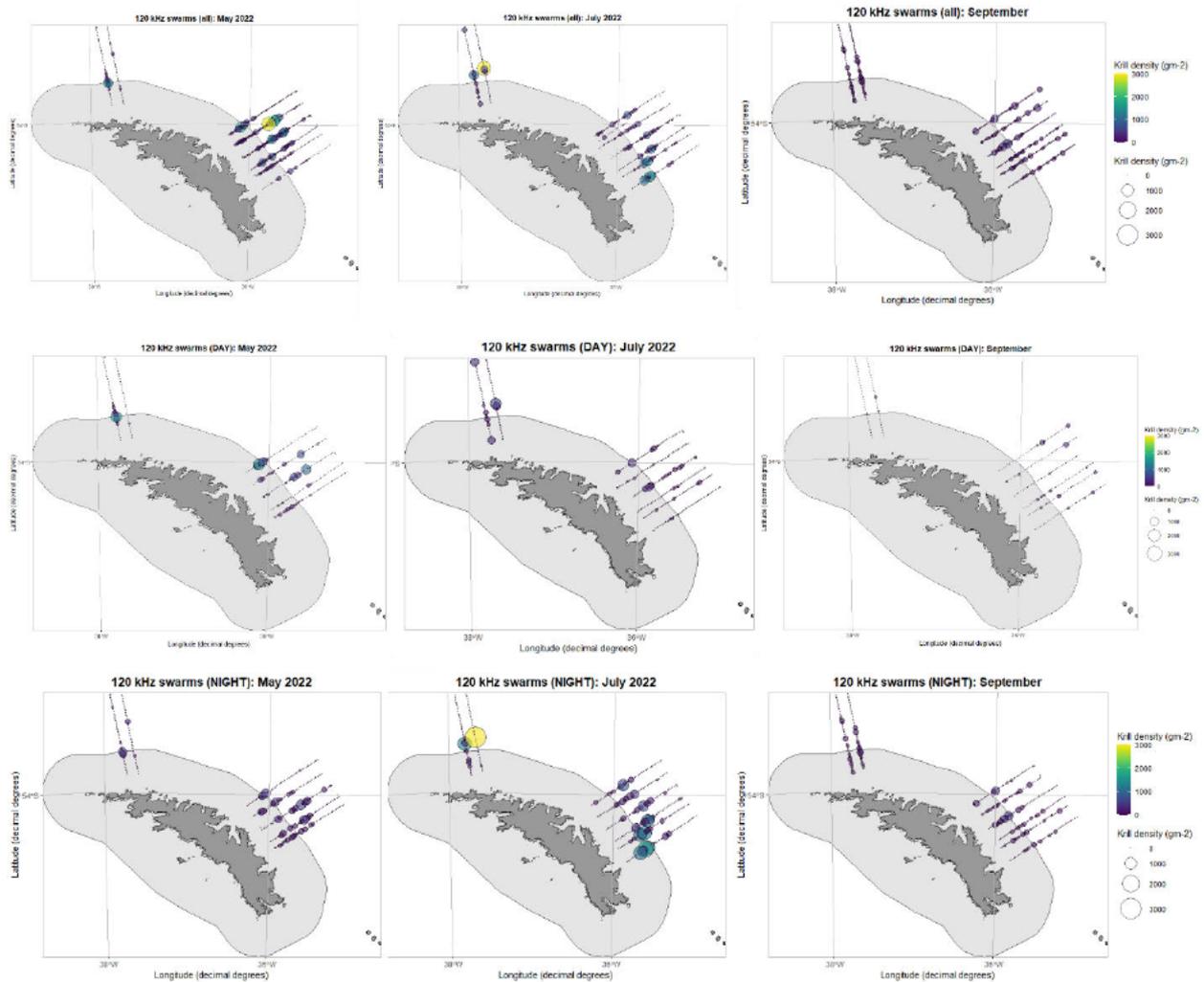


Figure 2: Maps showing the distribution of krill biomass in 2022 as estimated using the CCAMLR swarms algorithm ( $\text{g m}^{-2}$ ) and integrated over 1 nm by 250 m intervals. The top panel includes transect data from day and night (using the first occupation of each transect); the middle panel shows only daytime transect data; and the bottom panel shows only night-time transect data. For all panels, May is shown on the left, July in the centre and September on the right.

Table 1: Estimates of krill density ( $\text{g m}^{-2}$ ) and biomass (tonnes) for the ECB area in May, July and September 2022. 'A' refers to estimates calculated using both day and night-time transect data (first occupation only); 'D' refers to where only daytime transects were used, and 'N' refers to where only night-time transects were used.

Survey	May (A)	Jul (A)	Sep (A)	May (D)	Jul (D)	Sep (D)	May (N)	Jul (N)	Sep (N)
<b>Mean density (<math>\text{g m}^{-2}</math>)</b>	44.9	41.2	12.7	49.5	9.3	6.6	40.4	71.6	19.0
<b>CV</b>	20%	31%	24%	37%	55%	25%	14%	24%	26%
<b>Biomass (tonnes)</b>	266,345	244,126	75,408	293,525	55,348	39,345	239,288	424,264	112,902
<b>Lower interval</b>	161,064	94,757	39,759	82,492	-4,086	20,316	175,884	222,922	55,583
<b>Upper interval</b>	371,625	393,496	111,057	504,558	114,782	58,374	302,692	625,607	170,221

Based on the distribution of krill at 1 nm intervals along the transects, in both the ECB and WCB, krill generally appear closer to the inshore than offshore end, with greatest densities found over the shelf or at the shelf-break. In May and July, krill densities in the ECB are broadly similar, yet they decrease rapidly in September. In the WCB, densities appear to be at their highest in July but potentially higher in September than May. This is suggestive of a westward movement of krill from the ECB region earlier in the season, towards the WCB region later in the winter. Average density and areal biomass estimates could only be calculated for the ECB due to the need for a minimum of three transects for statistically robust estimates. Using all (both day and night) transect data, estimates of krill density in the ECB area ranged from 44.9 g m<sup>-2</sup> in May to 12.7 g m<sup>-2</sup> in September, although using night-time only data these were 40.4 g m<sup>-2</sup> in May to 19 g m<sup>-2</sup> in September. Similarly, biomass estimates in the ECB area ranged from ~266,350 tonnes in May to ~75,400 tonnes in September (all data) or ~239,300 tonnes in May to 112,900 tonnes in September (night-time data). Distinct diurnal variability in biomass estimates was also revealed in July and September, although this was not the case for the May survey where day and night-time biomasses were similar. This diurnal variability also influences our interpretation of how krill biomass changes over the course of the season. For example, if we consider all transect data together, krill biomass appears to decline from a maximum in May to a minimum in September. A similar conclusion would be reached using only the daytime transect data (the current preferred CCAMLR protocol), although the decrease between May and July would be more marked. On the other hand, if we consider night-time transects only, we observe an increase in biomass between May and July, before a marked decrease between July and September. The reasons for this diurnal variability are unclear at present and are the subject of ongoing analysis. However, one working hypothesis is that krill are diurnally vertically migrating, perhaps with a seasonal or other environmental component that causes this to vary throughout the year, and that during daytime the krill are pressed close to the seafloor and therefore less detectable on the acoustics. The second hypothesis is that the krill are off-shelf during the day and move onto the shelf at night.

Based on the analyses undertaken to date, one paper (based on the krill acoustic analyses) is being prepared for the CCAMLR ASAM Working Group in June 2023 (submission May 2023), and two papers (one based on krill and predator distributions; one based on krill fishery dynamics) are being prepared for the CCAMLR EMM Working Group in July 2023 (submission June 2023). In addition, a paper presenting preliminary cetacean analyses has been prepared for submission to the International Whaling Commission (IWC) meeting in April-May 2023. These will also form the basis of peer-reviewed publications that will be prepared for submission once the Y2 data has been analysed (**Activity 3.4**).

**Activities 4.1-4.2:** Data from the tracked penguins was relayed via the ARGOS systems and near real-time tracks were shown on the [BAS project site](#) whilst transmitting. The data obtained through the project is stored in the Polar Data Centre and a link to the PDC repository will also be created from the South Georgia Data Portal (**Activity 4.1**). We tracked 12 gentoo penguins (*Pygoscelis papua*) with Wildlife Computers SPOT 257 satellite tags; six from Maiviken on the central north coast of South Georgia and six from Bird Island at its western tip. These transmit signals to the ARGOS satellite system, so locations are obtained irrespective of where the birds travelled. Around 13 fixes are obtained per day with accuracy varying from 120 m to 25 km (as indicated by a fix-specific error ellipse). Tags were mounted in the centre of the back using Tesa tape, adhesive and cable ties.

We similarly equipped nine birds with PathTrack Nanofix GPS tags at Bird Island through additional BAS matched funding that was not part of the original Darwin Plus application. These tags took positions every 30 minutes with an error ellipse of ~50 m. The location and time

data were relayed to one of four base stations deployed next to the main gentoo penguin roost sites on Bird Island. Three tags contained an inbuilt time-depth-recorder (TDR) which will allow investigation of diving behaviour.

Tags were deployed in two batches during May and July/Aug which was intended to ensure coverage of the winter period. Data were truncated on 23 September, after which the birds had started laying eggs and the winter season of interest was deemed to be over. Four tags on Maiviken lasted a shorter time than expected, which was likely due to tags becoming detached prematurely. Three GPS tags provided no data: one disappeared and was not seen again but two were recovered and found to have faulty antennas (despite pre-deployment testing). Most tags lasted for several months and tracked birds travels over several hundreds to the low thousands of km (Table 2).

**Table 2:** Summary of deployments on gentoo penguins at South Georgia in 2022. Site names are BI for Bird Island and MV for Maiviken. ID names are given by Antarctic Research Trust sponsors for PTTs and after the Bird Island and King Edward Point field assistants for GPS. Distances are the total distance travelled across the entire deployment (not the maximum distance from the release location). Three further GPS tags were deployed at BI but produced no data.

ID	Site	Device	Release Date	Duration (days)	Distance (km)	Recovered
Imogen	BI	GPS	11/05	116	1872	No
Kate	BI	GPS	11/05	105	1229	Yes
Meghan	BI	GPS	28/07	56	945	Yes
Heidi	BI	GPS	28/07	30	466	Yes
Marine	BI	GPS	30/07	52	1201	No
Erin	BI	GPS	30/08	23	311	No
Rosemarie	BI	PTT	10/05	136	1088	No
Amaya	BI	PTT	10/05	136	966	No
Alicia	BI	PTT	10/05	131	1311	Yes
BA_S83	BI	PTT	10/05	136	2966	No
Sophie	BI	PTT	03/07	82	787	Yes
Putzy	BI	PTT	03/07	82	558	Yes
Peter	MV	PTT	10/05	85	980	No
Luna	MV	PTT	10/05	65	977	No
Kowalski	MV	PTT	10/05	117	1263	No
Wuschel	MV	PTT	10/05	137	2711	No
Gabriela	MV	PTT	11/07	33	411	No
Ehrismaa	MV	PTT	11/07	7	149	No

The tracking data were processed using the R package CRAWL (Johnson et al. 2008) which estimates the most likely path based on estimated movement metrics and error ellipses of the ARGOS and GPS fixes. Penguins equipped at Bird Island remained in the local area (Fig. 3a & b), utilising the area to the north and south of Willis Island most intensively in a pattern similar to the 2009-2010 breeding season (Ratcliffe et al. 2018). However, some also ranged east along Church and Right Whale Bays (where one of the satellite tagged birds eventually settled to breed) and south to Elephant Cove before returning to Bird Island (Fig. 3a). Previous satellite tracking of gentoo penguins from Bird Island also found most birds remained local, although in that study one bird did move to the SE of South Georgia (Tanton et al. 2004). Birds from Maiviken used the area off Cumberland Bay most intensively (Fig. 3c). Two made directed movements to the Cooper Island / Drygalski Fjord region in the SE of South Georgia and remained there for the rest of the study (Fig. 3d), while others moved west along the north coast in a series of hops, visiting numerous roost site en route. There was very little overlap in the wintering distributions of the birds from Bird Island and Maiviken in 2022 (Fig. 3a).

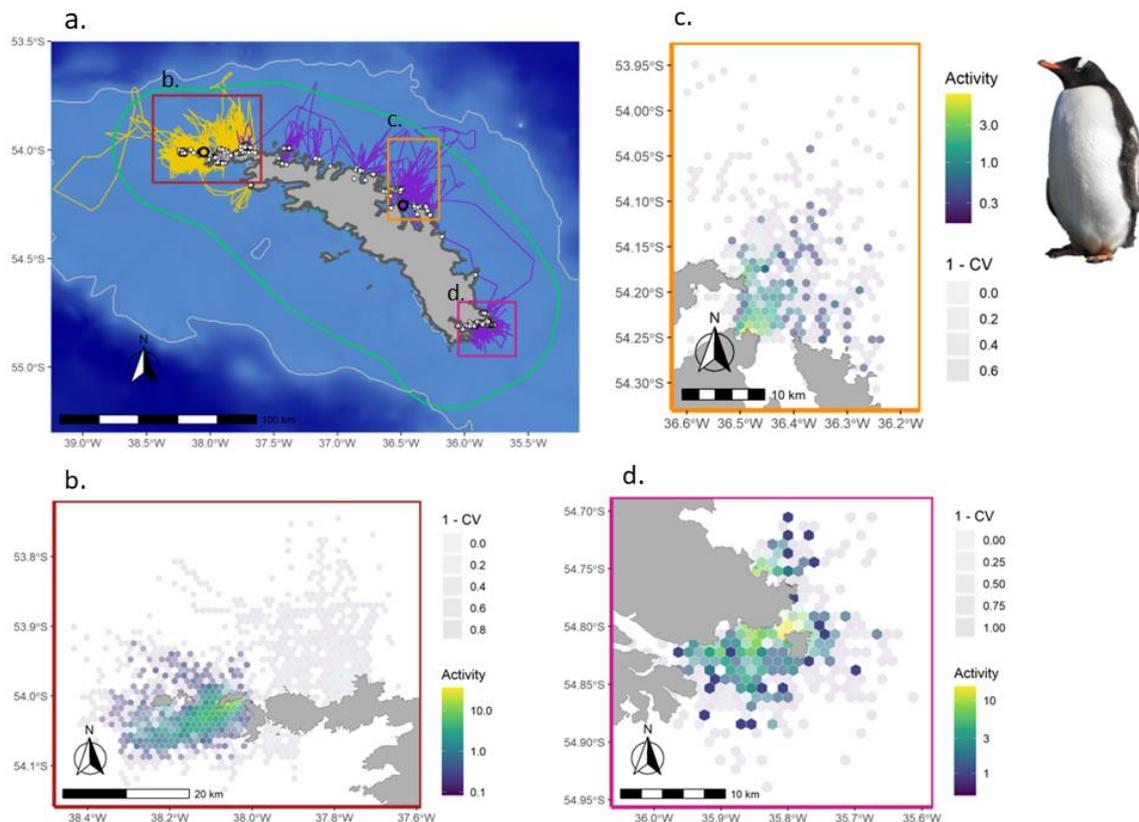


Figure 3: (a.) Distribution of tracks from Bird Island (yellow) and Maiviken (purple) with NTZ boundary in green and 400m isobath in grey. Coloured circles are release locations and white ones where birds spent time ashore. Boxes link by colour and letter to the insets. (b.-d.) hexagonal grid maps of the proportion of activity (time wet within bounding box) across all individuals in each of the cells. Colour represents the intensity and opacity the consistency of use.

Birds remained almost entirely over the continental shelf and spent 83.5% of their activity within the No Take Zone. Compared to 2018, birds from Maiviken in 2022 remained closer inshore and spent more time within the NTZ, which is likely to be due to higher krill availability in 2022 compared to 2018. This demonstrates the effectiveness of the NTZ in years of more “typical” krill abundance and supports the notion that gentoo penguin foraging metrics, in conjunction with krill stock assessments, could be used to adjust the NTZ boundary on an annual basis (Ratcliffe et al. 2021) (**Activity 4.2**).

Another field season is planned for 2023, which will involve the deployment of 12 satellite tags (8 at Maiviken and 4 at Bird Island). After the completion of the fieldwork, the 2023 data will be combined with those from 2022 and will be modelled as described above. Further analyses will be developed to analyse penguin movement metrics, dive statistics, habitat preference and overlap with the NTZ and krill fishing grounds.

**Activities 4.3-4.5:** All the cetacean data obtained during Y1 of the project has been archived on the PDC. A dedicated Winter Krill project directory has been set up which links to data collected on the Pharos, organised by survey. We are also in the process of linking this to the SG Data Portal (**Activity 4.3**). On all surveys, seabird and marine mammal observations in accordance with standard JNCC Seabirds at Sea methods (Tasker et al., 1984) were conducted concurrently with all daytime krill-acoustic transects. On the July survey there was an additional team of three marine mammal researchers using distance sampling methods to carry out visual

surveys and passive acoustic monitoring using DIFAR sonobuoys. During the July survey, a minimum of two marine mammal researchers at any one time collected visual data on cetacean and pinniped sightings. These were in addition to the single observer collecting seabird and marine mammal data using JNCC methods. Watches were carried out from the bridge with observers searching 180° forward of the ship from a deck height of 9.3 m (average eye height of 10.9 m). Acceptable survey conditions were considered to be Moderate or Good visibility and sea state 6 or less. Distances to marine mammals were measured using 7 x 50 binoculars (Fujinon 7x50 FMTRC-SX) equipped with reticles or estimated by eye when this was not possible. Reticule values were converted to an angular measure from the horizon to mammals and then to the distance from the ship. Radial angles from the ship to mammals were measured using angle boards mounted on the bridge. All sighting data, including distance, angle, species, group size and behaviour, were entered directly into a laptop using the program Logger (Gillespie et al. 2011), along with vessel location and environmental data relevant to sighting conditions (wind speed and direction, sea state, visibility and precipitation). DIFAR sonobuoys (Ultra Electronics HIDAR units) were used to acoustically locate whales in real time, and to record their vocalisations. Sonobuoy signals were received by VHF radio onboard the research vessel, digitised, recorded, processed using specialist modules in PAMGuard passive acoustic monitoring software ([www.pamguard.org](http://www.pamguard.org)). The DIFAR bearings to whale calls were also resolved and classified to species and call-type using PAMGuard and plotted on an interactive map in real time. Continuous recordings were made at a sample rate of 48,000 samples per second, and data from all buoys were monitored visually and aurally by an on-duty acoustician for the full duration of each deployment.

The planned survey transects of around 500 km of effort were completed on each of the three surveys with some additional opportunistic effort. During the July survey a total of 27.1 hours of visual effort were achieved by the cetacean research team on transect in SG waters, in sea state 6 or less. In addition, the seabird observer trained in JNCC methods recorded sightings of marine mammals in each of the three surveys. Table 3 gives the cetacean effort and sightings obtained by the JNCC trained observer and Table 4 gives the cetacean sightings obtained by the dedicated cetacean researchers during the July survey. There were sufficient sightings with distances and angles to groups of humpback whales (n=40) and southern right whales (n=25, including ‘like’ right whale category) to generate an overall detection function for each species. Estimated strip half width for humpback whales was 1713 m (95% CI 1407 m – 2086 m) and 987 m (95% CI 722 m – 1349 m) for southern right whales.

Table 3: Survey effort and cetacean observations by JNCC marine mammal and seabird observer. Sighting rates are individuals.km<sup>-1</sup>.

Survey	May			July			September		
	Effort (km) in good visibility with wind force <6								
	650 km			483 km			510 km		
	# of sightings	# of inds	Sighting rate	# of sightings	# of inds	Sighting rate	# of sightings	# of inds	Sighting rate
<b>Blue whale</b>	1	1	0.002	0	0	0.000	0	0	0.000
<b>Fin whale</b>	23	45	0.069	5	6	0.012	2	6	0.012
<b>Humpback whale</b>	22	45	0.069	35	63	0.130	7	14	0.027
<b>Killer whale</b>	0	0	0.000	2	3	0.006	0	0	0.000
<b>Large cetacean spp.</b>	26	52	0.080	21	22	0.046	4	6	0.012

<b>Southern right whale</b>	7	18	0.028	9	9	0.019	0	0	0.000
<b>Sperm whale</b>	0	0	0.000	0	0	0.000	2	2	0.004

Table 4. Summary of cetacean sightings from cetacean researcher team during July survey.

Species	Number of sightings	Number of individuals	Mean group size
Humpback whale	41	83	2.0
Like humpback whale	6	6	1.0
Southern right whale	20	31	1.6
Like southern right whale	5	5	1.0
Fin whale	10	20	2.0
Like fin whale	4	15	3.8
Sperm whale	2	2	1.0
Killer whale	8	16	2.0
Blue/fin whale	1	2	2.0
Unid large baleen	33	45	1.4
Like sei whale	1	2	2.0
Unid large whale	7	8	1.1
Unidentified whale	2	4	2.0

Humpback whales (*Megaptera novaeangliae*) were the most frequently seen species in all periods and mainly along the SG shelf, with the pattern of sightings suggesting possible westerly movement of this species distribution along the north SG shelf over the winter period. Fin whales (*Balaenoptera physalus*) were also sighted in all surveys, with the highest sighting rates in May and they were seen over deeper waters in July. Southern right whales (*Eubalaena australis*) were encountered in May and July. Surface feeding southern right whales were seen at dusk on three occasions, all at the inshore end of transects. Further details of these observations are given in Calderan et al. (in press). Blue (*B. musculus intermedia*), sperm (*Physeter macrocephalus*) and killer whales (*Orcinus orca*) were occasionally encountered. Acoustic surveys using DIFAR sonobuoys in July identified many humpback whale vocalisations, and located these mostly in shelf waters. Southern right whales rarely vocalised, and detections of fin and blue whales suggested that both had a more offshore distribution (i.e. outside of shelf waters) in July. Maps showing the distributions of humpback, fin and southern right whales throughout the surveys, and the potential locations of vocalising whales from the passive acoustic DIFAR sonobuoys are given in Figs. 4 to 8 (**Activity 4.4**). 10 images suitable for photo identification were obtained during the survey. All humpback whale flukes were submitted to Happywhale ([www.happywhale.com](http://www.happywhale.com)) for comparison with other photo-ID databases, and southern right whale images will be compared to the SG photo-identification catalogue for this species. Estimates of consumption, detailed spatial analysis and associations between whale distributions and krill occurrence, density and swarm characteristics will be completed once the second year of data has been collected (**Activities 4.4-4.5**).

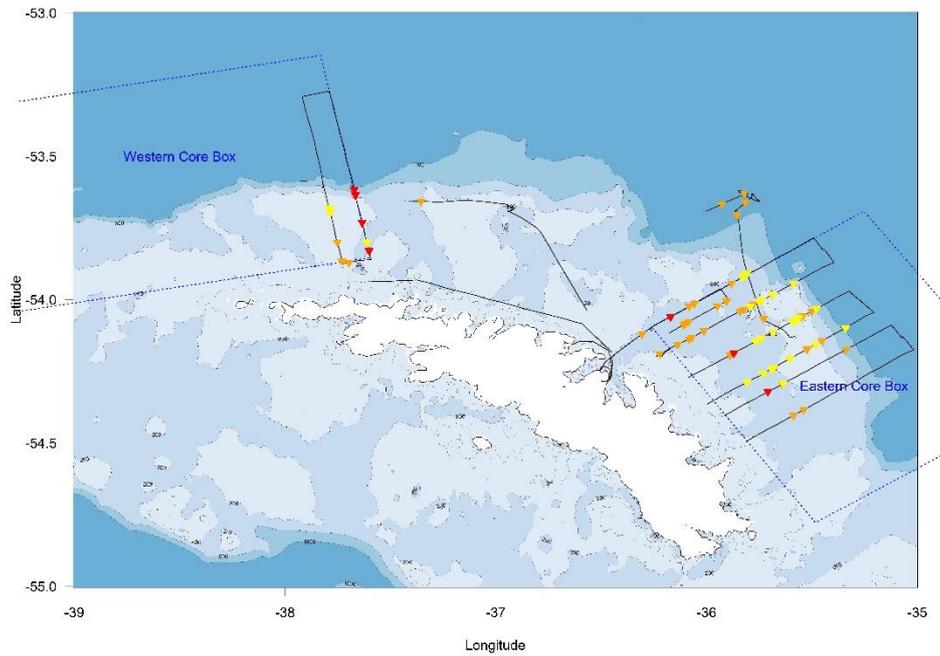


Figure 4: Visual sightings of humpback whales during May (yellow triangles), July (orange triangles) and September (red triangles) surveys.

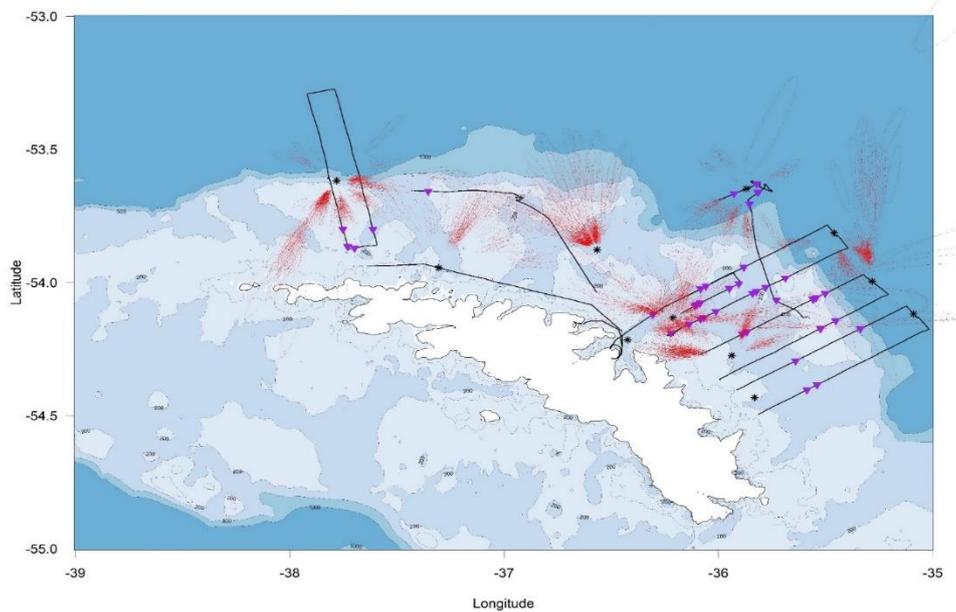


Figure 5: Visual survey effort (black lines) and sonobuoy deployments (black asterisks) in July. Purple triangles indicate humpback whale sightings. Red ellipses indicate potential location of vocalising whales from each detected call based on simple assumptions about detection range and bearing accuracy.

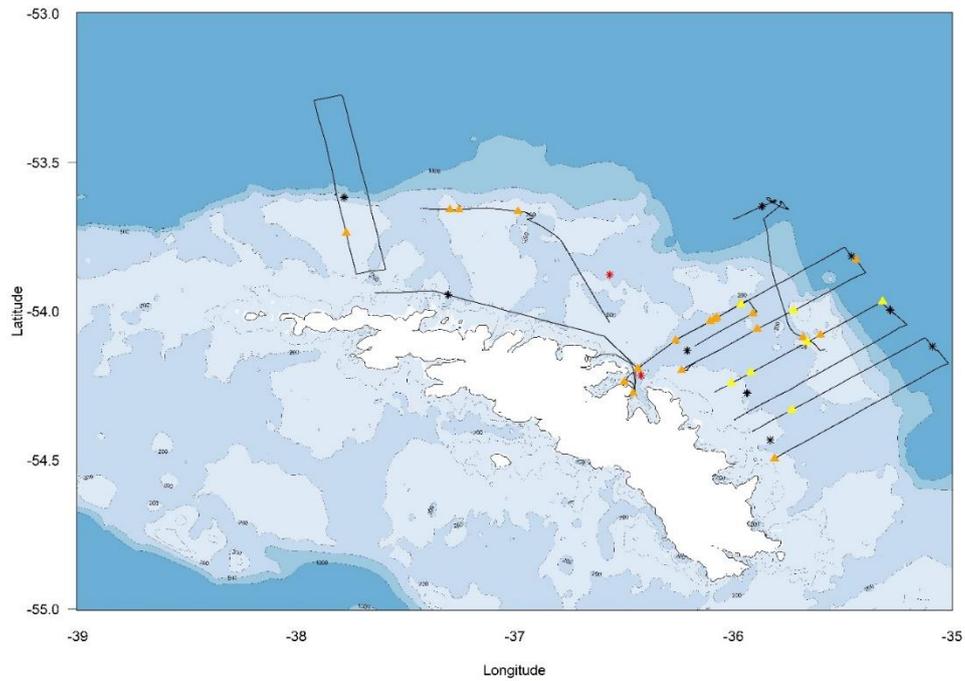


Figure 6: Visual survey effort (black lines) and sonobuoy deployments (black asterisks) in July. Yellow triangles indicate southern right whale sightings in May, orange in July. Right whales were detected on two sonobuoys in July with very few calls (sonobuoys where right whales were detected are shown in red).

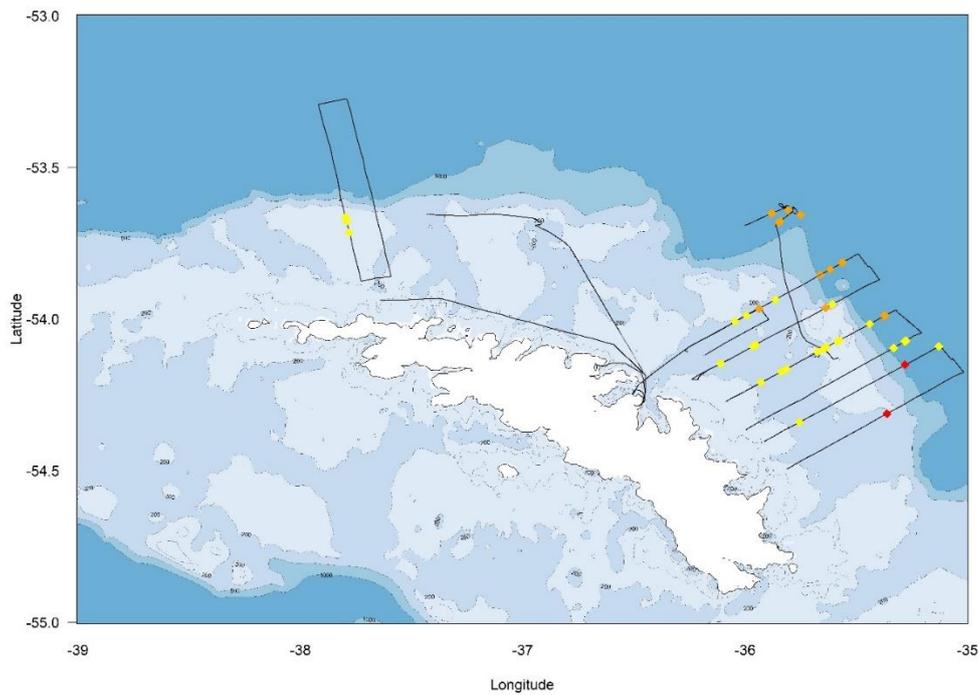


Figure 7: Visual sightings of fin whales during May (yellow triangles), July (orange triangles) and September (red triangles) surveys.

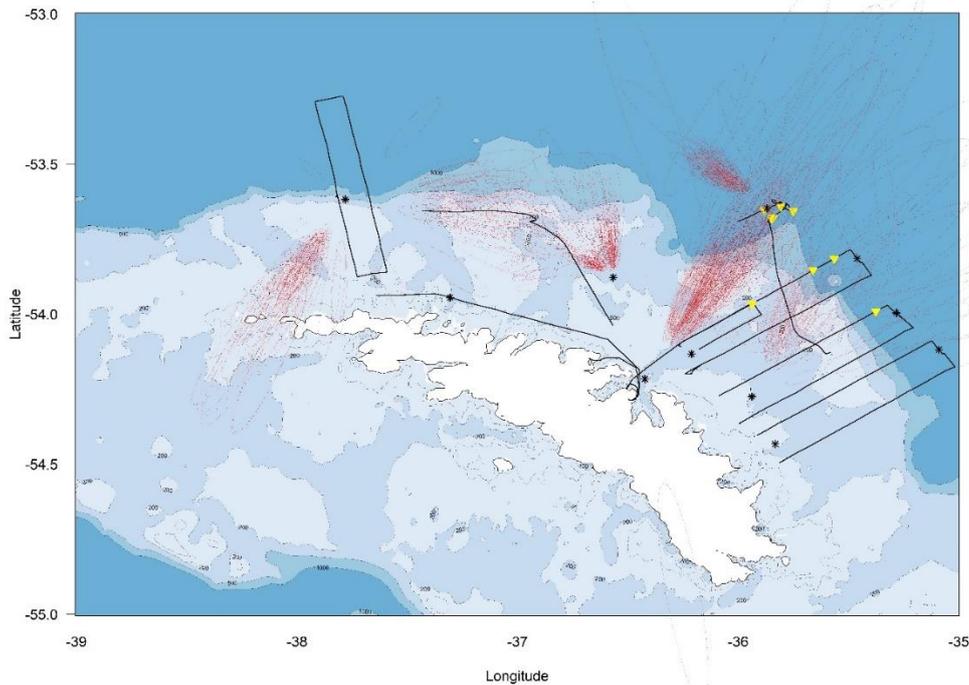


Figure 8: Visual survey effort (black lines) and sonobuoy deployments (black asterisks) in July. Yellow triangles indicate fin whale sightings. Red ellipses indicate potential location of vocalising whales from each detected call based on simple assumptions about detection range and bearing accuracy.

**Activities 4.6-4.7:** All the seabird and fur seal data obtained during Y1 of the project has been archived on the PDC and links are being created to the SG data portal (**Activity 4.6**). During the surveys a total of 28 species of seabird were recorded along the set transect lines in the ECB and WCB. Blue petrel and diving petrel were the two most abundant and dominant species throughout the surveys. The distribution of blue petrels (Fig. 9) varied for each month with the peak densities in May found on transect line ECB3 and with a distribution offshore of the shelf. This shifted in July to the westernmost transects ECB1 and ECB2 and nearshore of the shelf. Far fewer birds were recorded in September and the peaks were found in ECB6. The numbers of blue petrel recorded in the WCB were low apart from one feeding flock in WCB4.1 in September close to the shelf.

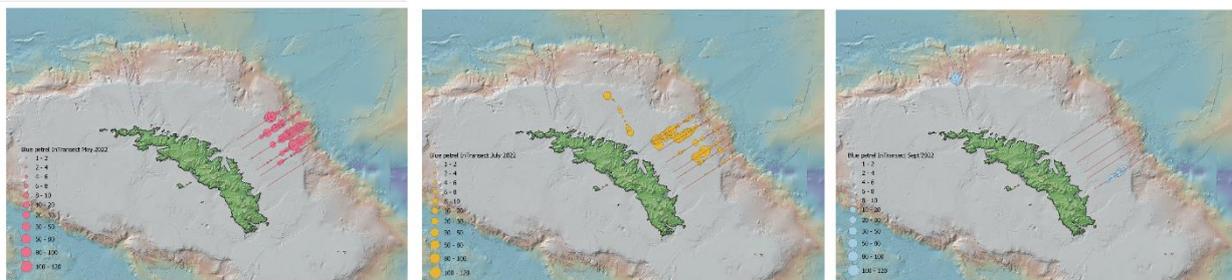


Figure 9: Distribution maps of blue petrels throughout 2022 season.

During the surveys, the two diving petrel species were combined, as separating common diving petrel and South Georgia diving petrel in the field during surveys is very difficult and time consuming. Peak densities of diving petrels were found nearshore of the shelf in all months (Fig. 10). In May, peaks were found nearshore of the shelf in ECB1 and ECB3. This may be related to time of day since both transects 1 and 3 started at sunrise, whereas densities were low in ECB2

and ECB4 on the same days near to dusk in the nearshore areas. The highest densities were found in the WCB for both July and September.

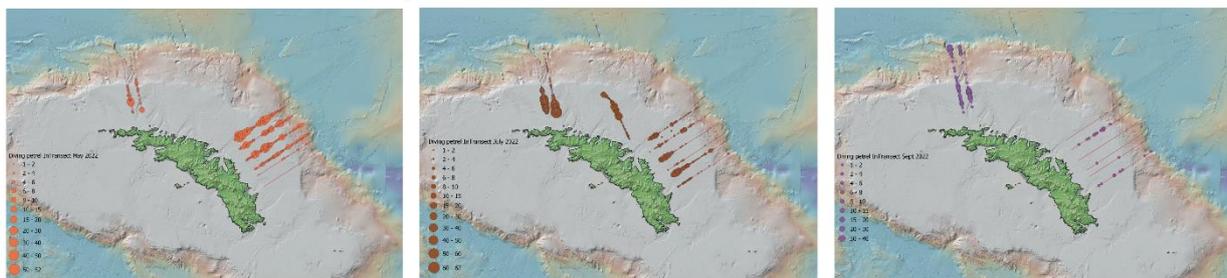


Figure 10: Distribution maps of diving petrels throughout 2022 season.

Antarctic fur seal numbers varied greatly throughout the surveys. Densities and raw numbers can be found in Table 11. Numbers were very low in May with a peak count of 37 on the second run of ECB3. July saw a sharp change in the abundance and distribution with peaks on the western side of the ECB, including a count of 2362 for ECB2. September saw a drop in numbers from July however there was still a peak count of 727 on ECB3. Only 13 fur seals were recorded in total in the WCB during the entire survey.

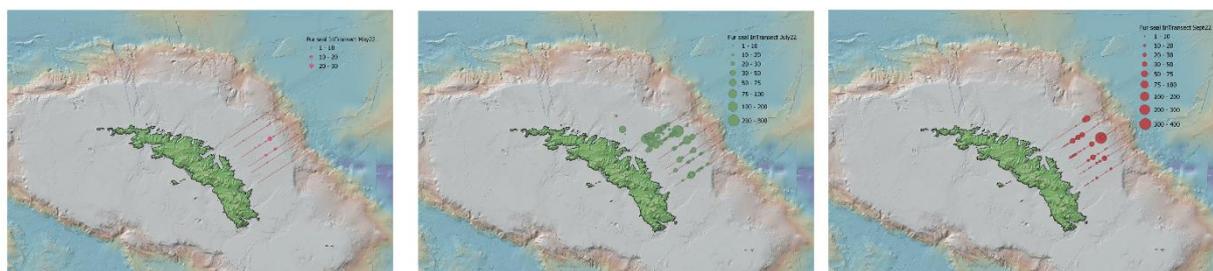


Figure 11: Distribution maps of fur seals throughout 2022 season.

Data on sightings of other key species is presented in Table 5. The peak in numbers of both cape petrel and Antarctic petrel in July were due to the presence of the krill fishing vessels in the area. Albatross numbers were relatively low throughout and black-browed, grey-headed and light-mantled had all but moved away from the area during July. Kerguelen petrel numbers peaked in July but they were entirely absent in September (**Activity 4.7**).

Table 5: Sightings data and densities per km of other key seabird species throughout the 2022 season.

Other species		May			July			Sept		
		Number	Km	no/km	Number	Km	no/km	Number	Km	no/km
Antarctic petrel	ECB	3	644.66	0.004654	645	418.14	1.542546	1	388.44	0.002574
	WCB	0	128.39	0	0	126.67	0	0	129.25	0
Black-bellied storm-petrel	ECB	102	644.66	0.158223	3	418.14	0.007175	3	388.44	0.007723
	WCB	16	128.39	0.12462	0	126.67	0	10	129.25	0.077369
Black-browed albatross	ECB	17	644.66	0.02637	2	418.14	0.004783	4	388.44	0.010298
	WCB	1	128.39	0.007789	1	126.67	0.007895	6	129.25	0.046422
Cape petrel	ECB	185	644.66	0.286973	456	418.14	1.090544	116	388.44	0.29863
	WCB	21	128.39	0.163564	6	126.67	0.047367	31	129.25	0.239845
Grey-headed albatross	ECB	41	644.66	0.063599	1	418.14	0.002392	1	388.44	0.002574
	WCB	8	128.39	0.06231	0	126.67	0	34	129.25	0.263056
Kerguelen petrel	ECB	14	644.66	0.021717	75	418.14	0.179366	0	388.44	0

	WCB	21	128.39	0.163564	50	126.67	0.394726	0	129.25	0
Snow petrel	ECB	14	644.66	0.021717	9	418.14	0.021524	45	388.44	0.115848
	WCB	2	128.39	0.015578	0	126.67	0	1	129.25	0.007737
Wandering albatross	ECB	51	644.66	0.079111	10	418.14	0.023915	15	388.44	0.038616
	WCB	18	128.39	0.140198	22	126.67	0.17368	8	129.25	0.061896
Gentoo penguin	ECB	34	644.66	0.052741	190	418.14	0.454393	118	388.44	0.303779
	WCB	14	128.39	0.109043	0	126.67	0	12	129.25	0.092843
King penguin	ECB	27	644.66	0.041883	62	418.14	0.148276	106	388.44	0.272886
	WCB	0	128.39	0	4	126.67	0.031578	13	129.25	0.10058

**Activity 4.8:** As mentioned above, based on the analyses undertaken to date, one paper (based on the krill acoustic analyses) is being prepared for the CCAMLR Acoustic Survey & Analysis Methods (ASAM) Working Group in June 2023 (submission May 2023), and two papers (one based on krill and predator distributions; one based on krill fishery dynamics) are being prepared for the CCAMLR Ecosystem Monitoring & Management (EMM) Working Group in July 2023 (submission June 2023). In addition, a paper presenting preliminary cetacean analyses has been prepared for submission to the International Whaling Commission (IWC) meeting in April-May 2023.

**Activities 5.1-5.2:** The initial stakeholder meeting was held on 24<sup>th</sup> January 2022 and the next meeting is not due until the end of the project. However, on 7<sup>th</sup> December 2022 we also held a project team workshop to share and discuss preliminary findings, which included primary project partners and some key stakeholders. An update to all stakeholders was sent out following the completion of the first year's surveys in October 2022. This was emailed to all those on the stakeholder list and uploaded [on our website](#). The next update is due in April/May 2023.

**Activity 5.3:** A general interest article on the project (by Cecilia Liszka, Kate Owen & Meghan Goggins) was published in the South Georgia Association newsletter in November 2022. An article predominantly focussed on the acoustic and field elements of the project was published in association with RBR (oceanographic instrument manufacturer) on their [website](#) and promoted via LinkedIn, Twitter and Instagram in February 2023. A second general interest article (by Cecilia Liszka & Martin Collins) is due to be published in Ocean Challenge magazine in April 2023, a magazine sent to all members of the Challenger Society for Marine Science. A third article by Cecilia Liszka & Martin Collins was accepted for publication in the Marine Biologist (magazine for members of the Marine Biological Association) in December and will be published in the July 2023 issue.

**Activities 5.4-5.5:** One paper (Calderan et al, in press) has been accepted for publication in the Journal of Marine Mammal Science. At least two further papers are being developed and will be submitted for review towards the end of the project. The final stakeholder meeting will also be held at the end of the project.

Activities under Output 6 (**Activities 6.1 & 6.2**) will come once all the surveys are completed, in the last 6 months of the project.

### 3.2 Progress towards project Outputs

#### Output 1: Long-term capability for winter pelagic ecosystem assessment enabled for South Georgia

This output was largely achieved during Y1 with the fit of the echosounder and initial training as described in the first annual report. However, further progress has been made to the longer-term capability of the GSGSSI to undertake pelagic ecosystem assessment throughout not just the winter but the rest of the year, with agreement by the GSGSSI to survey at least 4 acoustic transects approximately every other month. This will be accompanied by the plankton trawls and CTD deployments to gather data required for acoustic calibration and krill biomass estimation. Training also continues to be provided to KEP, GSGSSI and *Pharos SG* staff and crew, maintaining the capability to run the surveys.

### **Output 2: Winter krill acoustic and predator surveys / tracking undertaken.**

The first acoustic surveys, along with wider predator tracking and observation, successfully took place between May and September 2022 and the reports describing the activities and preliminary results are available on our project web page. The second year of surveys is currently underway, as the May survey was brought forward to March/April due to the change in timing of the *Pharos SG* dry docking schedule. Permits are already in place for the 2023 season. Phil Hollyman and Carrie Gunn are leading the March/April survey, focussing on acoustic transects, net sampling, CTDs and cetacean observations. Due to the short notice we were unfortunately unable to secure a seabird observer in time. Cecilia Liszka will lead the July survey with support from Carrie Gunn and George Perry; Garry Taylor (seabird observer) and Conor Ryan (cetacean observer). Carrie Gunn and George Perry will lead the September survey alongside Paul French (seabird observer), Russell Leaper, Susannah Calderan and Paula Olson (cetacean researchers) who will employ distance sampling, passive acoustic and photo ID methods along transects.

### **Output 3: Winter krill stock assessment in South Georgia fishery area for each of two years, including krill swarm characteristics**

Estimates of krill biomass and density across the ECB (area covered by the transects) for the first year have been produced. Krill swarm characteristics, including length, depth, height and density, have also been obtained for the first year of surveys for both the ECB and WCB transects. These data are being submitted in a paper to CCAMLR EMM in June 2023. Work on this output will continue upon the collection of the second year of data.

### **Output 4: Winter predator abundance, distribution and tracking data analysed**

The distributions of cetaceans, fur seals and seabirds have been analysed based on data collected from the first year of surveys. This data is being submitted in papers to the IWC in May 2023 and CCAMLR EMM in July 2023. The movement of gentoo penguins from BI and KEP based on the PTT and GPS tracking tags have also been analysed for the first year and this will also be submitted to CCAMLR EMM in July 2023. Work on this output will continue upon the collection of the second year of data.

### **Output 5: Stakeholder engagement and dissemination of results in scientific and popular literature and at international fora**

A full stakeholder communication was sent out and uploaded on our project web page in October 2022 providing an update on the first year of fieldwork and initial findings. A workshop with the core project team and some key stakeholders was held in December 2022 where preliminary results were shared and discussed. Three articles for general readership have been produced: one has already been published in the South Georgia Association newsletter in November 2022; one is due for publication in *Ocean Challenge* in April 2023 and the third is due for publication in the *Marine Biologist* in July 2023.

One paper presenting observations of southern right whale surface feeding on krill swarms in the survey area has been accepted for publication following minor revisions in the scientific journal, *Marine Mammal Science*.

Three papers are being prepared for CCAMLR submission: one on the krill acoustic results for CCAMLR ASAM in June 2023, one on the broader krill and predator results, and one on the fishery operation in relation to krill in the survey area for CCAMLR EMM in July 2023. These will also be worked up into papers for the scientific literature.

### **Output 6: Updates to SGSSI management plans and legislation**

Initial results of the project will be presented at the GSGSSI MPA Review Workshop in June 2023. Work on this output will continue once all surveys are completed.

### **3.3 Progress towards the project Outcome**

**Outcome:** *An understanding of the winter distribution of Antarctic krill and potential impacts of the krill fishery on dependent predators facilitates ecosystem-based management of the krill fishery.*

After the first full year of acoustic and predator surveys, the project is already providing new understanding of the distribution of krill during the winter period throughout the area favoured by the fishery and key krill predators. We are sharing our results with the wider krill community as they emerge so that we can better understand and interpret our results. An example of this was the presentation of results at the Scientific Committee on Antarctic Research (SCAR) Krill Expert Group (SKEG) workshop where other presentations on the vertical distribution of krill during winter shed light on the diurnal variability we have observed in our acoustic results. However, we are also aware that this is only one year of data and that limited conclusions can be drawn at this stage. We hope that a deeper understanding will emerge after the second year of data has been analysed. Moving beyond that, the ongoing bi-monthly surveys that have been agreed with GSGSSI will continue to inform their understanding of krill distribution and abundance within the Marine Protected Area.

### **3.4 Monitoring of assumptions**

**Assumption 0.1:** Stakeholder community engage in discussions regarding management.

**Comments:** Stakeholders engaged in the initial meeting and were enthusiastic about the project and its expected outcomes.

**Assumption 0.2:** Acoustic fit to *Pharos SG* successful in Year 1

**Comments:** The acoustic system has been fitted to *Pharos SG* and been calibrated and tested. The fitting of the instrument was more expensive than envisaged and hence additional funds were sourced to cover the additional costs.

**Assumption 0.3:** GSGSSI update MPA Management Plan

**Comments:** Initial results of the project will be presented at the GSGSSI MPA Review Workshop in June 2023. Further input to the MPA Management Plan will occur towards the end of the project.

**Assumption 1.1:** Dry-docking is necessary for transducer fit. Vessel owners have agreed and dry-dock scheduled for Feb/March 2022; possible Covid-related uncertainty over dry-dock schedule.

**Comments:** The acoustic system has been fitted to *Pharos SG* and been calibrated and tested.

**Assumption 1.2:** GSGSSI staff are available for training.

**Comments:** Staff were available and training was provided.

**Assumption 2.1:** *Pharos SG* is available and not diverted for emergency or suffers mechanical issues.

**Comments:** The vessel was available for all surveys as planned during the 2022 season, but the first survey of the 2023 season was brought forward due to changes in dry dock timing for the vessel.

**Assumption 2.2:** Weather is suitable. *Pharos SG* will seek appropriate weather windows to undertake transects.

**Comments:** A 3-day weather window is required for the ECB to be run successfully and a 1-2 day window is required for the WCB. In general the weather was favourable during the surveys and the cetacean observers managed to obtain >27 hours of effort data in sea state 6 or less during the July survey.

**Assumption 2.3:** Birds can be captured and tags function correctly (previous work shows these assumptions are safe). Permits will be issued by GSGSSI.

**Comments:** Birds were able to be captured and most of the tags functioned correctly. As detailed above, 4 PTTs deployed on Maiviken lasted a shorter duration than expected and instructions have been improved to mitigate this occurring again.

**Assumption 3.1** *Pharos SG* can collect high quality acoustic data. Appropriate weather windows to undertake transects (wind > 30 knots).

**Comments:** A 3-day weather window is required for the ECB to be run successfully and a 1-2 day window is required for the WCB. In general the weather was favourable during the surveys and acoustic data quality was sufficient.

**Assumption 4.1:** Dependent on success of both at-sea acoustics and penguin tracking.

**Comments:** Penguin tracking and krill acoustics during 2022 were successful.

**Assumption 4.2:** Data quantity and quality adequate to obtain density estimates for baleen whales that can be extrapolated to the broader SG region. Multiple surveys and careful, adaptive transect design reduce this risk.

**Comments:** Sufficient data were obtained to be able to obtain density functions for humpback and southern right whales in 2022.

**Assumption 4.3:** Numbers of detected cetaceans are sufficient to allow comparisons to be made. Multiple surveys maximise detection opportunities.

**Comments:** This will occur after the second year of surveys.

**Assumption 5.1:** Publication in scientific journals will take time and is likely to occur after the end of the project.

**Comments:** This will occur at the end of the project.

**Assumption 5.2:** Newsletters willing to publish articles.

**Comments:** Newsletters have been very happy to publish articles (4 published/accepted so far).

**Assumption 5.3:** Stakeholders engage in meetings. Key stakeholders have provided letters of support.

**Comments:** Stakeholders have proven engaged in the project judging by responses to updates and invitations to meetings.

**Assumption 6.1:** MPA review, which is due towards the end of the project, takes place.

**Comments:** A workshop to support the MPA review is scheduled for June 2023 at which results from this project to date will be presented. We will continue to feed in throughout the process.

#### **4. Project support to environmental and/or climate outcomes in the UKOTs**

Determining the abundance of krill during the winter and the impact of the winter krill fishery on krill-dependent predators is critical to ensuring the sustainable management of South Georgia's krill fishery and, more broadly, the Marine Protected Area. Until now, it has proved difficult to collect data on krill during winter, as suitably equipped vessels (such as the BAS ships) return north during the austral winter. The fit of the scientific echosounder system to the *Pharos SG* is critical to obtaining winter data for this project, but also enables the Government of SGSSI to undertake acoustic surveys in the future and at any time of year. This possibility is already being realised with the inception of bi-monthly acoustic and plankton surveys of at least four ECB transects and two WCB transects throughout the year. The provision of winter data on krill will support both domestic management of the krill fishery and also contribute to CCAMLR's management. An update on the project and results to date have already been shared at a project workshop involving our OT partner, and further updates will be shared more widely in June when the GSGSSI hold their 5 yearly MPA review workshop. This will be the first major opportunity to feed project results into ongoing environmental and climate management in the OT.

#### **5. Gender equality and social inclusion**

BAS are committed to equality, diversity and inclusion see (<https://www.bas.ac.uk/jobs/working-for-bas/our-cultural-values-equality-and-diversity/>) and aims to embrace diversity in all its forms and provide staff with a sense of belonging regardless of their characteristics, culture, experience, education or economic background.

From a gender equality perspective, the project has a well-balanced team. The project management team has a 50:50 gender balance and the post-doc employed on the project is female.

Please quantify the proportion of women on the Project Board <sup>1</sup> .	50%
Please quantify the proportion of project partners that are led by women, or which	66%

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<sup>1</sup> A Project Board has overall authority for the project, is accountable for its success or failure, and supports the senior project manager to successfully deliver the project.

have a senior leadership team consisting of at least 50% women <sup>2</sup> .	
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## 6. Monitoring and evaluation

Project delivery is monitored and evaluated by a Project Management Group (PMG) that is led by the Project Manager (Collins) and Marine Ecologist (Liszka) and includes all partners and the cetacean consultants (Leaper and Calderan). The PMG meets on the first Monday of each month to discuss and review the overall progress of the project activities in the context of the agreed log-frame and to agree and plan the next steps. Meetings were initially held on zoom but are now held in a hybrid format. This allows the BAS-based team to meet in person where possible, and facilitates full participation of all other partners. Information is shared between partners using email and a shared OneDrive folder, and key documents are also posted on the project web-page.

The BAS Finance Team (key contact Abby Lawrence) is responsible for financial management and works closely with the Project Leader and Marine Ecologist to ensure that spending is within budget.

Collins and Liszka also meet weekly to discuss project progress, issues and plans, and to review progress alongside the logframe.

## 7. Lessons learnt

The project has benefitted from excellent communication between partners, facilitated by the use of Zoom for meetings. Monthly meetings have been held between all partners, with updates provided on all aspects of the project with reference to the agreed log-frame.

Methods and protocols have been updated as necessary throughout the project in response to changing circumstances and user feedback, for example refining the acoustic calibration and operation protocols to ensure that anyone is easily able to run the acoustic surveys and ensure that the data are collected in a standardised way. Copies have been made available in hard and online format.

Careful planning and preparation was key to the success of the first year of fieldwork, including close communication within and between the project team to ensure correct and timely purchase of equipment; liaison with the GSGSSI and *Pharos SG* for planning the surveys; with wider colleagues to ensure equipment reached the OT in time; and with staff in the OT to ensure adequate training. This approach is being followed for the second year.

The cost of fitting the echosounder to the hull of the *Pharos SG* were greater than budgeted and additional funding was diverted from other BAS / GSGSSI research to cover this. Estimating the cost at the project planning phase was difficult, as it was uncertain and depended on both the vessel operator and dry-dock operator.

## 8. Actions taken in response to previous reviews (if applicable)

The following points were raised following our Annual Report 1 to be addressed at the next Annual Report – see comments below.

1. Is the project formally collecting information from fishing vessels on seabird warp strike and any bi-catch during the krill fisheries season?

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<sup>2</sup> Partners that have formal governance role in the project, and a formal relationship with the project that may involve staff costs and/or budget management responsibilities.

Comment: Information on by-catch is not collected specifically as part of the project. However, there are CCAMLR observers on every vessel and they are tasked with reporting on by-catch. Collecting data on warp strike is not within the scope of the project but it is an issue that CCAMLR are aware of, particularly in respect of net monitoring cables. CCAMLR has recently re-established the Working Group on Incidental Mortality Associated with Fisheries to look at questions such as warp striking on the krill fishery.

2. It is not clear to what extent the project will be able to undertake more intensive seabird surveys alongside the cetacean surveys?

Comment: As detailed in the sections above, a dedicated seabird observer was recruited to the project using additional matched funding for each survey of 2022, and for July and September of 2023.

3. The project highlights two core areas, but is there any contingency plans if krill swarms, and hence predators are concentrated outside these areas during the survey periods?

Comment: The two core areas covered by the projects were selected on the basis of a) where the fishery historically and currently operates, b) where it is in close proximity to the locations of predator breeding and foraging sites, and c) based on current and historical monitoring efforts. Our data on krill occurrence during the surveys come from the acoustic data collected on transects, so any consideration of moving our survey effort would be for future surveys. It would take those data into account but also have to balance that against comparability between years if transects were to change, with gathering sufficient data over an area to generate reliable estimates of biomass, and any trade-off in loss of data from current transects necessitated by the vessel's schedule. Considering the hypothesised move of the krill and fishery westwards in 2022, there is ongoing discussion to look at adding some transects in between the ECB and WCB for future survey effort supported by GSGSSI, but likely not within the scope of this project.

4. With reference to the Report form, the project should review all its assumptions (the Report considers only those related to the Outcome); provide more detail on how the project is supporting GSGSSI to meet its obligations under multi-lateral agreements; and provide a little more detail concerning the project's sustainability and legacy.

Comment: All assumptions have been reported on in the section above. Further detail on how the project is supporting GSGSSI and on sustainability and legacy has been added.

There were also come comments for feedback in the original award letter which were addressed in the half year report.

## **9. Risk Management**

Please see attached risk register.

## **10. Other comments on progress not covered elsewhere**

None.

## 11. Sustainability and legacy

The project is a high priority for the OT Government as it seeks to manage its waters to the highest standards. The long-term legacy of the project is secured by a) the fit of the state-of-the-art scientific echosounder to the *Pharos SG* and that equipment can be transferred to any future GSGSSI chartered vessel, and b) that results from this project will feed directly into considerations for managing conservation and the krill fishery around SG.

In light of the preliminary results obtained by the project so far, agreement has been reached with GSGSSI to undertake bi-monthly acoustic surveys of krill along at least 4 transects in the ECB throughout the year, adding to the longer-term legacy and sustainability of the project by providing data on krill occurrence and distribution throughout the year.

To support this, detailed manuals and protocols for carrying out the acoustic surveys and calibrations have been provided to the *Pharos SG* and the marine biologists at KEP. Staff at GSGSSI and KEP as well as the crew on the *Pharos SG* have been trained in the methods and objectives of the project so that expertise is being maintained in the OT.

## 12. Darwin Plus identity

A project website has been established (<https://www.bas.ac.uk/project/winter-krill-at-south-georgia/#about>), which features the Darwin logo and highlights Darwin Plus as the funder. Darwin Plus funding with the logo has been acknowledged on all presentations given about the project e.g. at our project workshop in December 2022 and the SCAR Krill Action Group Workshop in March 2023, and in an article about the first year of surveys that was published in the South Georgia Association Newsletter in November 2022. Darwin Plus funding support will also be acknowledged in articles for Ocean Challenge magazine and the Marine Biologist magazine that are due to be published in April and July 2023 respectively.

## 13. Safeguarding

Has your Safeguarding Policy been updated in the past 12 months?	Yes
Have any concerns been investigated in the past 12 months	No
Does your project have a Safeguarding focal point?	<i>Yes we have a safeguarding lead across BAS</i>
Has the focal point attended any formal training in the last 12 months?	<i>Yes the lead has attended a formal training session on her role and responsibilities as safeguarding lead</i>
What proportion (and number) of project staff have received formal training on Safeguarding?	<i>25% of our total staff have been trained. They are primarily staff living and working on a research vessel. More training is planned this year.</i>
Has there been any lessons learnt or challenges on Safeguarding in the past 12 months? Please ensure no sensitive data is included within responses.	<i>The most challenging part has been to engage staff who had an inaccurate idea of what safeguarding was and who affected. We do not employ staff working with children, however many of our staff live and work in isolated environments and under challenging conditions. These make them more vulnerable than others.</i>

Does the project have any developments or activities planned around Safeguarding in the coming 12 months? If so please specify.

*More training across all BAS personnel is planned this year.*

#### 14. Project expenditure

Table 1: Project expenditure during the reporting period (1 April 2022 – 31 March 2023)

Project spend (indicative) in this financial year	2022/23 D+ Grant (£)	2022/23 Total actual D+ Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs				
Consultancy costs				
Overhead Costs				
Travel and subsistence				
Operating Costs				
Capital items				
Others (Please specify)				
<b>TOTAL</b>	187,693.77	186,533.9		

Table 2: Project mobilising of matched funding during the reporting period (1 April 2022 – 31 March 2023)

	Matched funding secured to date	Total matched funding expected by end of project
Matched funding leveraged by the partners to deliver the project.		
Total additional finance mobilised by new activities building on evidence, best practices and project (£)		

**15. OPTIONAL: Outstanding achievements or progress of your project so far (300-400 words maximum). This section may be used for publicity purposes**

I agree for the Biodiversity Challenge Funds Secretariat to publish the content of this section (please leave this line in to indicate your agreement to use any material you provide here).

The Winter Krill project has successfully achieved its first full year of surveys, obtaining the first comprehensive and concurrent set of data on the winter distribution and abundance of Antarctic krill; key cetacean and seabird species; fur seals; and the winter habitat use of gentoo penguins. Based on these data, we have been able to generate the first reliable estimates of krill biomass at South Georgia during the winter, and the distribution of krill biomass in relation to the krill fishery. We have presented these results to the international krill community through the Scientific Committee on Antarctic Research (SCAR) Krill Expert Group (SKEG). We have published a peer-reviewed paper in the Journal of Marine Mammal Science (Calderan et al, 2023) describing observations of southern right whales actively feeding in South Georgia waters during the winter period. We are also contributing directly to the Government of South Georgia and South Sandwich Islands (GSGSSI) Marine Protected Area (MPA) Review 2023.

Please also include an engaging image, video or graphic\* that you consent to be publicised alongside the above text. Please ensure:

- that you have left the above agreement clause to indicate your consent. Text without this will not be used
- any images or videos are sent as separate files and not embedded in the body of the report

\*If you have no photos or videos for reasons of sensitivity, then please state that clearly and the Defra Comms team can work to create an alternative graphic.

Image, Video or Graphic Information:

File Type (Image / Video / Graphic)	File Name or File Location	Caption, country and credit	Online accounts to be tagged (leave blank if none)	Consent of subjects received (delete as necessary)
Graphic	Winterkrill_Final_A3	Infographic about the "Winter Krill" project.		Yes
Photo	Humps_2	Humpback whales from South Georgia in July 2022		Yes
Photo	Tagged gentoos_owen	Satellite tagged gentoo penguins on the beach at Maiviken, South Georgia, with Pharos SG in the background		Yes
Photo	Blue petrel	Blue petrel at sea off South Georgia in May 2022		Yes

## Annex 1: Report of progress and achievements against logframe for Financial Year 2022-2023 – if applicable

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
<p><b>Impact:</b> Potential ecosystem impacts of the South Georgia krill-fishery are understood and mitigated through enhanced ecosystem-based fisheries management, ensuring the conservation and protection of South Georgia's iconic wildlife populations.</p>		<p>The first year of surveys were successful, providing winter biomass estimates of krill, demonstrating likely differences in krill distribution between summer and winter and highlighted the use of the area by foraging baleen whales in winter.</p>	
<p><b>Outcome:</b> An understanding of the winter distribution of Antarctic krill and potential impacts of the krill fishery on dependent predators facilitates ecosystem-based management of the krill fishery.</p>	<ol style="list-style-type: none"> <li>1. Krill Fishery Management Plan updated in Y3 (Mar 2024) to take account of distribution of fishing effort and impacts on the ecosystem.</li> <li>2. Scientific papers presented to CCAMLR &amp; IWC (2023 &amp; 2024) on the winter distribution of krill, swarm characteristics and krill-predator distribution and food requirements during winter to directly contribute to CCAMLR management of the krill fishery.</li> <li>3. Marine Protected Area provisions updated (if necessary) to take account of project results.</li> </ol>	<p>The first year of data collection has been achieved with three surveys completed in 2022 and detailed reports available via the project website. Papers are prepared for IWC meeting (May) and CCAMLR ASAM (June 2023) and EMM (July) meetings.</p>	<p>A paper will be prepared for CCAMLR meetings later this year, outlining the project and with preliminary results from the first two surveys. A more detailed paper will be prepared for the CCAMLR ASAM meeting in June 2023.</p>
<p><b>Output 1.</b> Long-term capability for winter (and other times of year) pelagic ecosystem assessment enabled for South Georgia.</p>	<ol style="list-style-type: none"> <li>1. Scientific echosounder fitted to the MV <i>Pharos SG</i> in Y1 (March 2022).</li> <li>2. GSGSSI Government Officer / KEP staff trained in acoustic methods, echosounder calibration and at-sea surveys by Sep 2022.</li> </ol>	<p>The scientific echosounder system has been fitted to the <i>Pharos SG</i> (see Section 3.1), which facilitates the rest of the project and enables future acoustic surveys for krill and other organisms to be undertaken by the vessel in South Georgia waters (or elsewhere).</p>	
<p><b>Activity 1.1</b> Plans prepared for fit of acoustic transponders to <i>Pharos SG</i>.</p>		<p><b>Complete.</b> Plans were prepared in good time for dry-dock. Hardware was purchased with matched funding from UK Govt. Blue Belt Programme.</p>	
<p><b>Activity 1.2</b> Transducers and associated electrical kit fitted to <i>Pharos SG</i> during dry-dock.</p>		<p><b>Complete.</b> The echosounders and associated electronics were fitted to the</p>	

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
		<i>Pharos SG</i> during dry-dock in March in Montevideo.	
<b>Activity 1.3</b> Transducers tested in SG waters prior to krill season.		<b>Complete.</b> The system has been calibrated and tested by Co-I Fielding in Falkland Island waters in early April 2022.	
<b>Activity 1.4</b> GSGSSI GOs and KEP science team trained in operation of echosounders on <i>Pharos SG</i> .		<b>Complete.</b> GOs and KEP staff were trained on the echosounder, calibration and project activities throughout the 2022 survey period.	
<b>Activity 1.5</b> GSGSSI GOs and KEP science team trained in acoustic calibration methods generally and bespoke to <i>Pharos SG</i> .		<b>Complete.</b> GOs and KEP staff were trained on the echosounder, calibration and project activities throughout the 2022 survey period.	
<b>Activity 1.6</b> Manual developed for acoustics operation on <i>Pharos SG</i>		<b>Complete.</b> A manual was prepared following the first survey of 2022 and has since been updated to reflect learnings during the three surveys in 2022.	
<b>Output 2.</b> Winter krill acoustic and predator surveys / tracking undertaken.	<ol style="list-style-type: none"> <li>1. Three surveys (minimum of four transects) conducted during each of two winter krill seasons (2022 and 2023).</li> <li>2. Cetacean focussed surveys conducted in each austral winter (2022 &amp; 2023).</li> <li>3. Six gentoo penguins tracked from each of Bird Island and Maiviken during each winter season (2022 &amp; 2023; 24 in total).</li> </ol>	<ol style="list-style-type: none"> <li>1. Three surveys were successfully undertaken in 2022, the first survey of 2023 has been successfully delivered, and plans are in place for the remaining two surveys of 2023, with time agreed for each survey and staff travel arranged. Permits have been issue by GSGSSI under the Wildlife &amp; Protected Areas Ordinance.</li> <li>2. The first cetacean focussed survey took place in July 2022, with sonobuoys deployed to provide additional data. The second will take place in September 2023, with additional cetacean research carried out in July 2023.</li> <li>3. Tags were successfully deployed in 2022. Tags for 2023 have been purchased and received in the field ready for deployment.</li> </ol>	
<b>Activity 2.1</b> Acoustic surveys conducted shortly before, during and at the end of the krill fishing season in Y1 and Y2 (austral winters 2022 & 2023).		<b>In Progress.</b> First set of surveys were undertaken in May, July and Sept 2022, and the first survey of 2023 has been undertaken. The last two surveys are planned for July and Sept 2023.	The last two surveys will take place this austral winter as per project plan.

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
<b>Activity 2.2</b> At-sea observations of seabirds and marine mammals undertaken in association with each acoustic survey.		<b>In Progress.</b> Observations were carried out on all three surveys of 2022 ( <a href="https://www.bas.ac.uk/project/winter-krill-at-south-georgia/">https://www.bas.ac.uk/project/winter-krill-at-south-georgia/</a> ). They are planned for the July and September surveys of 2023.	With additional funding secured from the GSGSSI, we will have a Seabirds at Sea specialist on the July & Sept surveys in 2023, who will undertake surveys and train KEP science team.
<b>Activity 2.3</b> Cetacean surveys conducted on <i>Pharos SG</i> in association with each mid-season acoustic survey.		<b>In Progress.</b> The first survey was carried out in July 2022. This activity was supplemented by the purchase of acoustic equipment and acquisition of SonoBuoys for acoustic detection of whales that were deployed during the July survey. The same activity is planned for September 2023. In addition, a dedicated cetacean researcher has been recruited to conduct observations on the July 2023 survey.	Plans are in place for the cetacean experts to join the July and September 2023 surveys.
<b>Activity 2.4</b> Survey summary reports prepared after each survey and published on GSGSSI website.		<b>In progress.</b> Reports for the first three surveys of 2022 have been prepared and published on the project website ( <a href="https://www.bas.ac.uk/project/winter-krill-at-south-georgia/">https://www.bas.ac.uk/project/winter-krill-at-south-georgia/</a> ). The rest will follow as they are produced.	Remaining reports will be posted on the project website following each survey.
<b>Activity 2.5</b> Six gentoo penguins tracked from each of Bird Island and Maiviken during each winter season (2022 & 2023; 24 in total).		<b>In Progress.</b> The tags (Wildlife Computers) were successfully purchased and deployed at Bird Island and Maiviken in 2022. Tags for 2023 have been purchased and received in the field ready for deployment in the same locations. The project website displayed all tracks in 2022 and will do the same in 2023. Eight GPS tags were also been provided by BAS to improve sampling at Bird Island for 2022 and seven are available for 2023.	Tags will be deployed in May 2023 to collect data throughout the winter period and overlap with the acoustic surveys. Data will be displayed in real-time on the project website.
<b>Output 3.</b> Winter krill stock assessment in South Georgia fishery	1. Acoustic data collected, cleaned and analysed within 3 months of completion of winter surveys (by Dec 2022 & Dec 2023).	All data from 2022 has been analysed and archived as planned. Plans are in place for all three surveys in 2023, with time allocated on <i>Pharos SG</i> and staff travel arrangements	

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
area for each of two years, including krill swarm characteristics.	<ol style="list-style-type: none"> <li>2. Estimate of krill density and swarm characteristics derived for each season (March 2023, March 2024).</li> <li>3. Cetacean observations characterised in relation to krill swarms in order to identify any associations between swarm characteristics, and particular whale species (Mar 2024).</li> <li>4. At-sea data on seabirds and fur seals archived (Dec 2022 &amp; 2023) and analysed (Mar 2023 &amp; 2024) in relation to krill abundance and fishery (Y1 &amp; Y2).</li> </ol>	in hand. All data will be archived following each survey and detailed analyses with both years' data undertaken.	
<b>Activity 3.1</b> Acoustic data cleaned and processed using Echoview software after each year's surveys.		<b>In progress.</b> Data from 2022 has been cleaned and processed as described in section 3.1 above.	Acoustic data from 2023 will be cleaned and processed after each survey.
<b>Activity 3.2</b> Acoustic data (cleaned raw data & processed) lodged on GSGSSI Data Portal after each year's surveys.		<b>In progress.</b> Data from 2022 has been archived on the BAS PDC.	Acoustic data will be lodged on BAS PDC and links created to GSGSSI Data Portal.
<b>Activity 3.3</b> Acoustic data analysed to estimate winter biomass and swarm characteristics from each survey, linked to environment.		<b>In progress.</b> Data from 2022 has been analysed as described in section 3.1 above.	Acoustic data from 2023 will be analysed for biomass and swarm characteristics and further detailed analyses of both years carried out.
<b>Activity 3.4</b> Papers prepared for CCAMLR WG-EMM and WG-ASAM and for peer review publication.		<b>In progress.</b> Papers are being prepared for CCAMLR WG-EMM and WG-ASAM in 2023 with results from 2022 surveys.	Papers for CCAMLR WG-EMM and WG-ASAM will be submitted in May & June 2023 with results from 2022 surveys and developed into scientific publications.
<b>Output 4.</b> Winter predator abundance, distribution and tracking data analysed.	<ol style="list-style-type: none"> <li>1. Gentoo penguin data archived and analysed in relation to krill abundance, swarm characteristics, operating area of fishery and the MPA No-take Zone (Dec 2022 &amp; Dec 2023).</li> </ol>	Data from 2022 has been analysed and preliminary analysis provided as per Section 3.1 above. Remaining detailed analyses will be carried out when the 2023 data has been obtained. All the preparatory work has been undertaken ready for the remaining surveys in July and Sept 2023.	

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
	<ol style="list-style-type: none"> <li>2. Cetacean observation data archived (Dec 2022 &amp; 2023) and analysed (Mar 2023 &amp; 2024) to provide (i) spatial habitat use patterns of krill-feeding baleen whales in South Georgia in winter; (ii) concordance with areas of high krill density; (iii) overlap with krill fishery; (iv) estimate of seasonal krill consumption by whales at South Georgia in winter.</li> <li>3. Cetacean observations characterised in relation to krill swarms in order to identify any associations between swarm characteristics, and particular whale species (Mar 2024).</li> <li>4. At-sea data on seabirds and fur seals archived (Dec 2022 &amp; 2023) and analysed (Mar 2023 &amp; 2024) in relation to krill abundance and fishery (Y1 &amp; Y2).</li> </ol>		
	<p><b>Activity 4.1</b> Data from tracked penguins relayed via the Argos satellite system; uploaded to BAS and ART websites for track visualisation and archived on the GSGSSI Data Portal</p>	<p><b>In progress.</b> Data was uploaded in real time on the BAS website for 2022 and has been archived in the BAS PDC.</p>	<p>Satellite tags will be deployed in May 2023. Data will be visualised in real time via the project website. Links between the BAS PDC and GSGSSI Data Portal will be established.</p>
	<p><b>Activity 4.2</b> Gentoo penguin data analysed in relation to krill abundance, swarm characteristics and operating area of fishery.</p>	<p><b>In progress.</b> Data from 2022 has been analysed as described in section 3.1 above and see tracks on project website (<a href="https://www.bas.ac.uk/project/winter-krill-at-south-georgia/#about">https://www.bas.ac.uk/project/winter-krill-at-south-georgia/#about</a>).</p>	<p>Analysis of second year's data will be undertaken and further detailed analyses of both years carried out.</p>
	<p><b>Activity 4.3</b> Cetacean observation data archived on the GSGSSI Data Portal following each survey.</p>	<p><b>In progress.</b> Data from 2022 has been archived on the BAS PDC.</p>	<p>Data will be collected and archived.</p>
	<p><b>Activity 4.4</b> Cetacean distribution data analysed in relation to krill density, the krill fishery and to determine spatial patterns of use and winter krill consumption estimates.</p>	<p><b>In progress.</b> Data from 2022 has been analysed as described in section 3.1 above.</p>	<p>Analysis of second year's data will be undertaken and further detailed analyses of both years carried out.</p>
	<p><b>Activity 4.5</b> Cetacean observations characterised in relation to krill swarms in order to identify any associations between swarm characteristics, and particular whale species.</p>	<p><b>In progress.</b> Data from 2022 has been analysed as described in section 3.1 above.</p>	<p>Analysis of second year's data will be undertaken and further detailed analyses of both years carried out.</p>

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
<b>Activity 4.6</b> At-sea seabird and fur seal data archived on the GSGSSI Data Portal.		<b>In progress.</b> Data from 2022 has been archived on the BAS PDC.	Data from seabird/ marine mammal observations on all surveys will be archived.
<b>Activity 4.7</b> Seabird / fur seal data analysed in relation to the distribution and abundance of krill and in relation to the activity of the krill fishery.		<b>In progress.</b> Data from 2022 has been analysed as described in section 3.1 above.	Analysis of second year's data will be undertaken and further detailed analyses of both years carried out.
<b>Activity 4.8</b> Papers prepared for annual meetings of CCAMLR ASAM & EMM Working Groups and IWC and prepared for peer reviewed publications.		<b>In progress.</b> Papers on krill acoustics and the overall project are in prep for CCAMLR WGs ASAM and EMM and will be submitted in May/June 2023. A paper on the cetacean analysis was submitted to IWC in April 2023 for their 2023 meeting.	Papers in prep will be submitted for CCAMLR EMM and ASAM Working Groups in 2023 and developed into scientific publications.
<b>Output 5.</b> Stakeholder engagement and dissemination of results in scientific and popular literature and at international fora.	<ol style="list-style-type: none"> <li>1. Minimum of three papers submitted to peer reviewed journals (open access) by March 2024 and submitted to CCAMLR / IWC Working Groups (2023 &amp; 2024).</li> <li>2. Articles published for general audience (e.g., South Georgia Association Newsletter; Penguin News, MBA Newsletter) and on BAS, ART and GSGSSI websites (min 2 per year).</li> <li>3. Stakeholder meetings held at the initiation of the project to outline plans (by Dec 2021) and at the end (March 2024) to disseminate and discuss the project results.</li> <li>4. Six-monthly updates circulated to stakeholders and published on BAS / GSGSSI website.</li> </ol>	The initial stakeholder meeting was held in Jan 2022 and project website established. General interest articles have been published and more are planned. One scientific paper is in press and more will follow later in, or at the end of, the project. A further stakeholder meeting is planned for the end of the project and papers to CCAMLR are in preparation.	
<b>Activity 5.1</b> Stakeholder meeting at the outset of the project – likely over zoom to engage with all stakeholders and provide information about project and timelines.		<b>Complete.</b> Initial stakeholder meeting held in Jan 2022 and recording available via project website.	
<b>Activity 5.2</b> Six-monthly updates circulated to stakeholders and published on BAS, GSGSSI & ART websites.		<b>In Progress.</b> Updates have been sent to stakeholders, most recently in October 2022. A project workshop with selected	Updates to be circulated in May and November 2023.

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
		key stakeholders was held in December 2022.	
<b>Activity 5.3</b> Articles prepared for general audience is publications such as the South Georgia Association Newsletter & UK Marine Biological Association Newsletter.		<b>In Progress.</b> Articles published in November 2022 issue of SGA Newsletter; April issue of Ocean Challenge magazine, and an online article on RBR website (as described in section 3.1 above).	An article has been accepted for the July issue of the MBA “Marine Biologist” magazine.
<b>Activity 5.4</b> Minimum of three papers submitted to peer review journal (by March 2024).		<b>In progress.</b> One peer reviewed paper on southern right whale feeding observations is currently in press.	Additional papers will follow when we have two seasons of data.
<b>Activity 5.5</b> Stakeholder meeting towards the end of the project (Dec 2023) to disseminate and discuss the results.		<b>Not started.</b>	The final stakeholder meeting will be held towards the end of the project e.g. Dec 2023 to update on project progress.
<b>Output 6.</b> Updates to SGSSI management plans and legislation	<ol style="list-style-type: none"> <li>1. Krill Fishery Management Plan revised to take account of project results and stakeholder input (Mar 2024).</li> <li>2. SGSSI MPA Management Plan and Order updated (Mar 2024; if required).</li> </ol>	This output will be completed in the final year of the project.	
<b>Activity 6.1</b> Krill Fishery Management Plan reviewed and revised to take account of project results and stakeholder input.		<b>Towards end of project.</b>	Feeding into the GSGSSI MPA review process in June 2023 workshop.
<b>Activity 6.2</b> SGSSI MPA Management Plan and MPA Order reviewed and updated (if required) to take account of project results and stakeholder input.		<b>Towards end of project.</b>	Feeding into the GSGSSI MPA review process in June 2023 workshop.

**Annex 2: Project’s full current logframe as presented in the application form (unless changes have been agreed)**

Project Summary	Measurable Indicators	Means of Verification	Important Assumptions
<p><b>Impact:</b> Potential ecosystem impacts of the South Georgia krill-fishery are understood and mitigated through enhanced ecosystem-based fisheries management, ensuring the conservation and protection of South Georgia’s iconic wildlife populations. (Max 30 words)</p>			
<p><b>Outcome:</b> An understanding of the winter distribution of Antarctic krill and potential impacts of the krill fishery on dependent predators facilitates ecosystem-based management of the krill fishery. (Max 30 words)</p>	<p>0.1 Krill Fishery Management Plan updated in Y3 (May 2024) to take account of distribution of fishing effort and impacts on the ecosystem.</p>	<p>0.1 Krill Fishery Management Plan published on the GSGSSI website.</p>	<p>Stakeholder community engage in discussions regarding management.  Acoustic fit to Pharos SG successful in Year 1  GSGSSI update MPA Management Plan.</p>
	<p>0.2 Scientific papers presented to CCAMLR &amp; IWC (2022 &amp; 2023) on the winter distribution of krill, swarm characteristics and krill-predator distribution and food requirements during winter to directly contribute to CCAMLR management of the krill fishery.</p>	<p>0.2 Paper(s) submitted to CCAMLR &amp; IWC (2022 &amp; 2023) and to peer reviewed journals (May 2024). CCAMLR &amp; IWC papers available on websites. Project papers cited in text of CCAMLR and IWC reports.</p>	
	<p>0.3 Marine Protected Area provisions updated (if necessary) to take account of project results.</p>	<p>0.3 MPA Order and MPA Management Plan updated and published on GSGSSI website.</p>	
<p><b>Outputs:</b>  1. Long-term capability for winter (and other times of year) pelagic ecosystem assessment enabled for South Georgia.</p>	<p>1.1 Scientific echosounder fitted to the MV <i>Pharos</i> SG in Y1 (March 2022).</p>	<p>1.1 Photographs taken pre- and post-fitting.</p>	<p>Dry-docking is necessary for transducer fit. Vessel owners have agreed and dry-dock scheduled for Feb/March 2022; possible Covid-related uncertainty over dry-dock schedule.</p>

	1.2 GSGSSI Government Officer / KEP staff trained in acoustic methods, echosounder calibration and at-sea surveys by Sep 2022.	1.2 Training record for GSGSSI staff. Training manual written.	GSGSSI staff are available for training.
2. Winter krill acoustic and predator surveys / tracking undertaken.	2.1 Three surveys (minimum of four transects) conducted during each of two winter krill seasons (2022 and 2023).	2.1 Survey reports available on GSGSSI & BAS website and submitted to CCAMLR ASAM Working Group after each field season.	<i>Pharos SG</i> is available and not diverted for emergency or suffers mechanical issues.
	2.2 Cetacean focussed surveys conducted in each austral winter (2022 & 2023).	2.2. Survey reports submitted to GSGSSI (available on website) and IWC Scientific Committee following each field season.	Weather is suitable. <i>Pharos SG</i> will seek appropriate weather windows to undertake transects.
	2.3 Six gentoo penguins tracked from each of Bird Island and Maiviken during each winter season (2022 & 2023; 24 in total).	2.3 Argos locations updated daily on BAS website map, on ART website and archived with GSGSSI / Polar Data Centre.	Birds can be captured and tags function correctly (previous work shows these assumptions are safe). Permits will be issued by GSGSSI.
3. Winter krill stock assessment in South Georgia fishery area for each of two years, including krill swarm characteristics.	3.1 Acoustic data collected, cleaned and analysed within 3 months of completion of winter surveys (by Dec 2022 & Dec 2023).	3.1 Raw acoustic data archived on GSGSSI Data Portal.	<i>Pharos SG</i> can collect high quality acoustic data. Appropriate weather windows to undertake transects (wind > 30 knots).
	3.2 Estimate of krill density and swarm characteristics derived for each season (March 2023, March 2024).	3.2 Krill density estimates and swarm characteristics provided to CCAMLR in WG papers.	
4. Winter predator abundance, distribution and tracking data analysed.	4.1 Gentoo penguin data archived and analysed in relation to krill abundance, swarm characteristics, operating area of fishery and the MPA No-take Zone (Dec 2022 & Dec 2023).	4.1. Paper submitted to CCAMLR's Working Group on Ecosystem Monitoring and Management (WG-EMM) in Y2 & Y3 (2023 & 2024).	Dependent on success of both at-sea acoustics and penguin tracking.

	4.2 Cetacean observation data archived (Dec 2022 & 2023) and analysed (Apr 2023 & 2024) to provide (i) spatial habitat use patterns of krill-feeding baleen whales in South Georgia in winter; (ii) concordance with areas of high krill density; (iii) overlap with krill fishery; (iv) estimate of seasonal krill consumption by whales at South Georgia in winter.	4.2 Papers submitted to IWC's Scientific Committee and CCAMLR WG-EMM and available on websites (July 2023, July 2024).	Data quantity and quality adequate to obtain density estimates for baleen whales that can be extrapolated to the broader SG region. Multiple surveys and careful, adaptive transect design reduce this risk.
	4.3 Cetacean observations characterised in relation to krill swarms in order to identify any associations between swarm characteristics, and particular whale species (Apr 2024).	4.3 Papers submitted to IWC's Scientific Committee and CCAMLR WG-EMM (Y3, 2024).	Numbers of detected cetaceans are sufficient to allow comparisons to be made. Multiple surveys maximises detection opportunities.
	4.4 At-sea data on seabirds and fur seals archived (Dec 2022 & 2023) and analysed (Mar 2023 & 2024) in relation to krill abundance and fishery (Y1 & Y2).	4.4 Data archived on GSGSSI Data Portal. Paper submitted to CCAMLR's WG-EMM.	
5. Stakeholder engagement and dissemination of results in scientific and popular literature and at international fora.	5.1 Minimum of three papers submitted to peer reviewed journals (open access) by May 2024 and submitted to CCAMLR / IWC Working Groups (2023 & 2024).	5.1. Darwin Plus acknowledged as funding source, noting award number in publications.	Publication in scientific journals will take time and is likely to occur after the end of the project.
	5.2 Articles published for general audience (e.g., South Georgia Association Newsletter; Penguin News, MBA Newsletter) and on BAS, ART and GSGSSI websites (min 2 per year).	5.2 Records of all articles kept and Darwin Plus acknowledged.	Newsletters willing to publish articles.

	5.3 Stakeholder meetings held at the initiation of the project to outline plans (by Dec 2021) and at the end (April/May 2024) to disseminate and discuss the project results.	5.3 Meeting report / minutes published on GSGSSI website.	Stakeholders engage in meetings. Key stakeholders have provided letters of support.
	5.4 Six-monthly updates circulated to stakeholders and published on BAS / GSGSSI website.	5.4 Updates published on websites.	
6. Updates to SGSSI management plans and legislation.	6.1 Krill Fishery Management Plan revised to take account of project results and stakeholder input (Mar 2024).	6.1 Updated plan published on GSGSSI website.	
	6.2 SGSSI MPA Management Plan and Order updated (May 2024; if required).	6.2 Updated MPA Management Plan published on GSGSSI website and (any) changes to legislation enacted.	MPA review, which is due towards the end of the project, takes place.

**Activities** (each activity is numbered according to the output that it will contribute towards, for example 1.1, 1.2 and 1.3 are contributing to Output 1)

**Output 1 Long-term capability for winter pelagic ecosystem assessment enabled for South Georgia**

- 1.1 Plans prepared for fit of acoustic transponders to *Pharos SG*.
- 1.2 Transducers and associated electrical kit fitted to *Pharos SG* during dry-dock.
- 1.3 Transducers tested in SG waters prior to krill season.
- 1.4 GSGSSI GOs and KEP science team trained in operation of echosounders on *Pharos SG*.
- 1.5 GSGSSI GOs and KEP science team trained in acoustic calibration methods generally and bespoke to *Pharos SG*.
- 1.6 Manual developed for acoustics operation on *Pharos SG*.

**Output 2 Winter krill acoustic and predator surveys / tracking undertaken 2.1 *Pharos SG* echosounders calibrated in Cumberland Bay in advance of each season**

- 2.2 Acoustic surveys conducted shortly before, during and at the end of the krill fishing season in Y1 and Y2 (austral winters 2022 & 2023).
- 2.3 At-sea observations of seabirds and marine mammals undertaken in association with each acoustic survey.
- 2.4 Cetacean surveys conducted on *Pharos SG* in association with each mid-season acoustic survey.
- 2.5 Survey summary reports prepared after each survey and published on GSGSSI website.
- 2.6 Six gentoo penguins tracked from each of Bird Island and Maiviken during each winter (2022 & 2023) season (24 in total).

### **Output 3 Winter krill stock assessment in South Georgia fishery area for each of two years, including krill swarm characteristics**

- 3.1 Acoustic data cleaned and processed using Echoview software after each year's surveys.
- 3.2 Acoustic data (cleaned raw data & processed) lodged on GSGSSI Data Portal after each year's surveys.
- 3.3 Acoustic data analysed to estimate winter biomass and swarm characteristics from each survey, linked to environment.
- 3.4 Papers prepared for CCAMLR WG-EMM and WG-ASAM and for peer review publication.

### **Output 4 Winter predator abundance, distribution and tracking data analysed**

- 4.1 Data from tracked penguins relayed via the Argos satellite system; uploaded to BAS and ART websites for track visualisation and archived on the GSGSSI Data Portal.
- 4.2 Gentoo penguin data analysed in relation to krill abundance, swarm characteristics and operating area of fishery.
- 4.3 Cetacean observation data archived on the GSGSSI Data Portal following each survey.
- 4.4 Cetacean distribution data analysed in relation to krill density, the krill fishery and to determine spatial patterns of use and winter krill consumption. Estimates.
- 4.5 Cetacean observations characterised in relation to krill swarms in order to identify any associations between swarm characteristics, and particular whale species.
- 4.6 At-sea seabird and fur seal data archived on the GSGSSI Data Portal.
- 4.7 Seabird / fur seal data analysed in relation to the distribution and abundance of krill and in relation to the activity of the krill fishery.
- 4.8 Papers prepared for annual meetings of CCAMLR ASAM & EMM Working Groups and IWC and prepared for peer reviewed publications.

### **Output 5 Stakeholder engagement and disseminated of results in scientific and popular literature and at international fora**

- 5.1 Stakeholder meeting at the outset of the project (Dec 2021) – likely over zoom to engage with all stakeholders and provide information about project and timelines.
- 5.2 Six-monthly updates circulated to stakeholders and published on BAS, GSGSSI & ART websites.
- 5.3 Articles prepared for general audience in publications such as the South Georgia Association Newsletter & UK Marine Biological Association Newsletter.
- 5.4 Minimum of three papers submitted to peer review journal (by May 2024).
- 5.5 Stakeholder meeting towards the end of the project (Apr/May 2024) to disseminate and discuss the results.

### **Output 6 Updates to SGSSI management plans and legislation**

- 6.1 Krill Fishery Management Plan reviewed and revised to take account of project results and stakeholder input.
- 6.2 SGSSI MPA Management Plan and MPA Order reviewed and updated (if required) to take account of project results and stakeholder input.

## Annex 3: Standard Indicators

**Table 1 Project Standard Indicators**

DPLUS Indicator number	Name of indicator using original wording	Name of Indicator after adjusting wording to align with DPLUS Standard Indicators	Units	Disaggregation	Year 1 Total	Year 2 Total	Year 3 Total	Total to date	Total planned during the project
DPLUS-A01	GSGSSI Government Officer / KEP staff trained in acoustic methods, echosounder calibration and at-sea surveys by Sep 2022	Number of people from key national and local stakeholders completing structured and relevant training	People proportion	Stakeholder group: Local Communities, Nationals, public sector, civil society, private sector	4	6		6	6
DPLUS-C01	GSGSSI Government Officer / KEP staff trained in acoustic methods, echosounder calibration and at-sea surveys by Sep 2022	Number of best practice guides and knowledge products published and endorsed	Number	Product typology (methodologies)	6	6		6	6
DPLUS-C05	Scientific papers presented to CCAMLR & IWC on the winter distribution of krill, swarm characteristics and krill-predator distribution and food requirements during winter to directly contribute to CCAMLR management of the krill fishery	Number of projects contributing data, insights, and case studies to national Multilateral Environmental Agreements (MEAs) related reporting processes and calls for evidence	Number	Scientific papers/papers to CCAMLR & IWC	0	1		1	4
DPLUS-C17	Minimum of three papers submitted to peer reviewed journals (open access) by March May 2024	Number of unique papers submitted to peer reviewed journals	Number	None	0	1		1	3
DPLUS-B01	Marine Protected Area provisions updated (if necessary) to take account of project results.	Number of new/improved habitat management plans available and endorsed	Number of instruments	Policy typology (Local, National Policy)	0	0		0	1

**Table 2      Publications**

<b>Title</b>	<b>Type</b> (e.g. journals, manual, CDs)	<b>Detail</b> (authors, year)	<b>Gender of Lead Author</b>	<b>Nationality of Lead Author</b>	<b>Publishers</b> (name, city)	<b>Available from</b> (e.g. weblink or publisher if not available online)
Southern right whale ( <i>Eubalaena australis</i> ) surface feeding on krill in austral winter at South Georgia	Journal article	Susannah V. Calderan, Tracey Dornan, Sophie Fielding, Ryan Irvine, Jennifer A. Jackson, Russell Leaper, Cecilia M. Liszka, Paula A. Olson, Martin A. Collins (2023)	Female	British	Wiley-Blackwell	In press (Journal of Marine Mammal Science)

## Checklist for submission

	Check
Different reporting templates have different questions, and it is important you use the correct one. Have you checked you have used the <b>correct template</b> (checking fund, type of report (i.e. Annual or Final), and year) and <b>deleted the blue guidance text</b> before submission?	Y
<b>Is the report less than 10MB?</b> If so, please email to <a href="mailto:BCF-Reports@niras.com">BCF-Reports@niras.com</a> putting the project number in the Subject line.	Y
<b>Is your report more than 10MB?</b> If so, please discuss with <a href="mailto:BCF-Reports@niras.com">BCF-Reports@niras.com</a> about the best way to deliver the report, putting the project number in the Subject line.	N
<b>Have you included means of verification?</b> You should not submit every project document, but the main outputs and a selection of the others would strengthen the report.	Y
<b>Do you have hard copies of material you need to submit with the report?</b> If so, please make this clear in the covering email and ensure all material is marked with the project number. However, we would expect that most material will now be electronic.	N
If you are submitting photos for publicity purposes, do these meet the outlined requirements (see section 15)?	Y
Have you involved your partners in preparation of the report and named the main contributors	Y
Have you completed the Project Expenditure table fully?	Y
Do not include claim forms or other communications with this report.	