Resolving the ecosystem effects of the winter krill fishery (*Winter Krill Project*)

Survey Report May 2022

Martin Collins, Tracey Dornan, Kate Owen, Meghan Goggins and Ryan Irvine

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1. Introduction

1.1 Rationale

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 South Georgia (SG) fishery area. The motivation behind this is that the commercial krill fishery around SG operates exclusively during the winter period, yet information on the stock dynamics and distribution of krill during this period are sparse. Although Marine Protected Area (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.

Following the fit of a scientific echosounder system to the *MV Pharos SG*, a key part of the project is to undertake acoustic transects to estimate krill biomass and distribution at the beginning (May), middle (July) and end (September) of the krill fishing season. The acoustic transects will be accompanied by seabird / marine mammal observations, with additional cetacean observations carried out in July. In addition, gentoo penguins will be tracked from Bird Island and Maiviken during winter to investigate foraging overlap with krill distribution, the krill fishery and the limits of the MPA No-take Zone.

There are three main aims of this first field campaign.

1) Fit PTT tags to gentoo penguins to facilitate tracking.
2) Collect acoustic transect data to estimate krill distribution and biomass and calibrate acoustic instruments.
3) Collect concurrent seabird and marine mammal observations during daytime acoustic surveys.

1.2 Fieldwork summary

Survey transects (Figure 1) are based on those surveyed historically as part of the British Antarctic Survey's Eastern Core Box (ECB) and annual Western Core Box (WCB) survey. During the survey, the first priority was the four western transects of the ECB (Figure 1), with two further transects to be undertaken in the ECB if time and conditions allowed. The four western transects were deemed essential as these overlap with the main krill fishing grounds. In addition, and if time and weather allowed, the two eastern transects of the WCB were to be undertaken (in conjunction with routine Bay of Isles plankton trawls). Acoustic transects were planned to be conducted during daylight, but if time allowed, some transects would be repeated at night to assess day night differences in krill behaviour and aggregation.

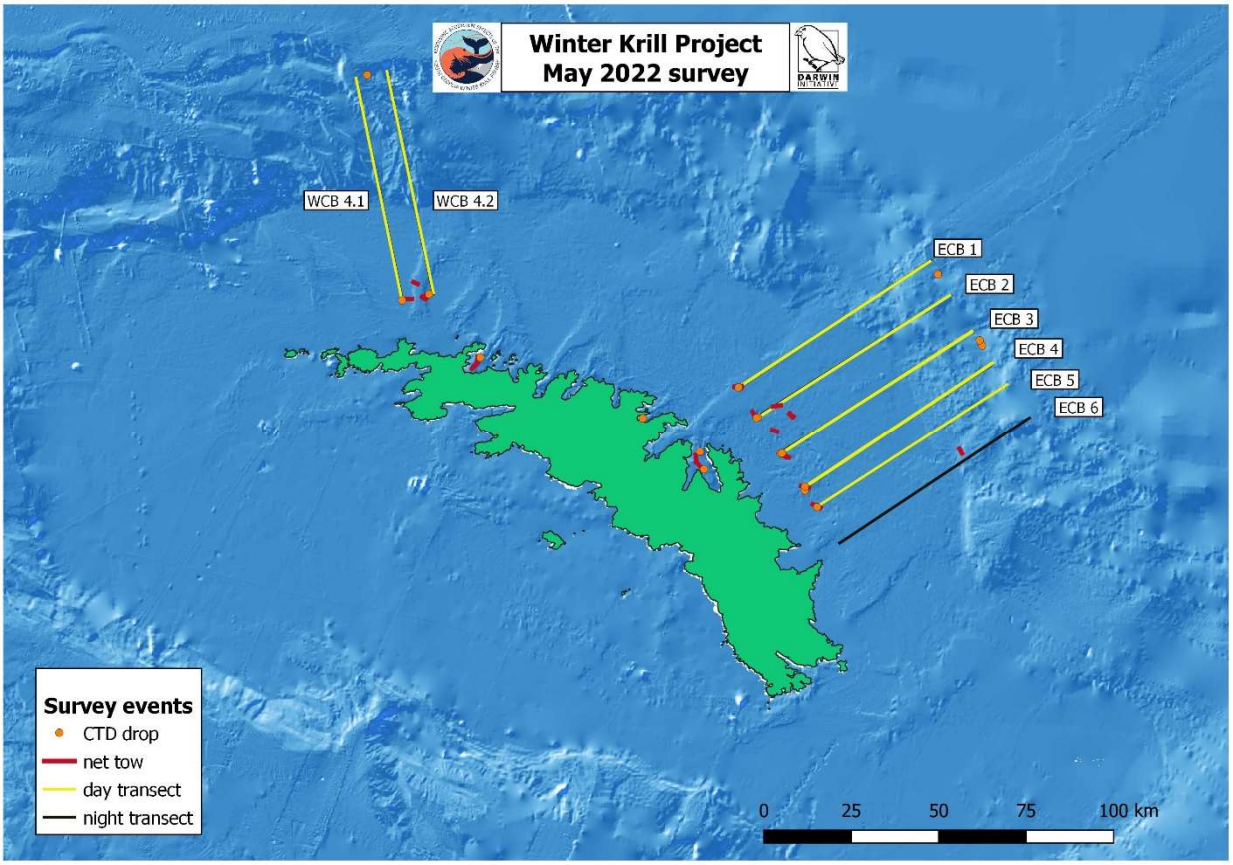

Figure 1. Map of the survey area during the May 2022 Winter Krill survey. Yellow lines show day & night transects; the black line shows a transect only completed at night.

Each transect was approximately 35 nautical miles long (shorter than previous ECB transects), extending from the coast beyond the shelf break. Transects were undertaken at around 8-10 knots, or the optimal speed to achieve the cleanest data, with two transects completed each day. Two of the night transects were cut short due to wind and swell (Table 1).

Table 1. Details of transects undertaken during the May 2022 Winter Krill survey

Date	Event	Transect	Day or Night	Transect Length (nm)	Notes
10/5/2022	2	ECB 1	Night	35	
11/5/2022	3	ECB 2	Night	35	
11/5/2022	6	ECB 1	Day	35	
11/5/2022	8	ECB 2	Day	35	
11/5/2022	11	ECB 3	Night	35	
12/5/2022	12	ECB 4	Night	35	
12/5/2022	15	ECB 3	Day	35	
12/5/2022	17	ECB 4	Day	35	
12/5/2022	20	ECB 5	Night	35	
13/5/2022	21	ECB 6	Night	35	
13/5/2022	24	ECB 5	Day	35	
13/5/2022	25	ECB 3	Day	35	ECB 6 cancelled due to wind & swell
13/5/2022	28	ECB 1	Night	35	
14/5/2022	29	ECB 2	Night	35	
14/5/2022	32	ECB 1	Day	35	
14/5/2022	33	ECB 2	Day	35	
14/5/2022	37	ECB 3	Night	13	Cut short due to swell & wind
15/5/2022	38	ECB 4	Night	15	Cut short due to swell & wind
15/5/2022	41	ECB 3	Day	35	
15/5/2022	43	ECB 4	Day	35	
19/5/2022	53	WCB 4.1	Night	35	
20/5/2022	54	WCB 4.2	Night	35	
20/5/2022	57	WCB 4.1	Day	35	
20/5/2022	59	WCB 4.1	Day	35	

1.3 Fieldwork narrative

04-05-2022 Martin Collins (MC), Tracey Dornan (TD) and Ryan Irvine (RI), depart FIPASS for South Georgia aboard *MV Pharos SG*. Echosounder was switched on and recording to collect opportunistic data on transit and observe echosounder performance.

07-05-2022 Force 9 conditions negatively affecting acoustic data quality – considerable dropout and transient noise.

08-05-2022 Arrived Cumberland Bay in the evening, awaiting morning to dock at King Edward Point (KEP). Echosounder recording off overnight.

09-05-2022 Docked at KEP. A good weather window for surveys is forecast for 10th – 13th May. Discussed plans with KEP marine biologists Kate Owen (KO) and Megan Goggins (MG). Decided to tag gentoo penguins at Maiviken tomorrow morning prior to departure on survey. KEP CTD frame adjusted to accommodate the new RBR Concerto CTD.

10-05-2022 MC, TD, MG and KO walked from KEP to Maiviken in the morning. Four gentoo penguins fitted with Wildlife Computers PTT tags (see Appendix II for details, including broadcast

schedule). Departed KEP on the *MV Pharos SG* at 18:00 UTC to begin surveys. Successfully tested CTD to 200 m wire out in Cumberland Bay (Ev01). All transects and events are manually logged on Science Bridge Event Logs in South Georgia time (UTC -2). Echosounders set to record on departure. Undertook ECB1 (Ev2) and ECB2 (Ev3) transects overnight, starting on-shelf, turning off-shelf and ending on-shelf.

11-05-2022 Large krill swarm spotted on echosounder on-shelf overnight. First 30-minute plankton trawl on-shelf in nautical twilight (07:00 South Georgia time (UTC -2); Ev4) caught a small number of krill followed by CTD (Ev5). Repeated ECB1 (08:10; Ev6) and 2 (Ev8) transects in daylight, with CTD (Ev7) conducted off-shelf (12:15) on transit between ECB1 and 2. Seabird and marine mammal observations were run concurrently with daytime acoustic transects. Humpback and fin whales sighted in association with krill swarms. Southern right whales (6-10) also sighted – no obvious krill swarms. *MV Pharos SG* engineer Kim suggested filling ballast tanks to see if this reduced noise on echosounder, and this appeared to help.

Early evening CTD (Ev9) followed by target plankton trawl (Ev10). Target haul captured krill (450 ml) for length measurements (mode 35 mm, but some very small krill present). Small krill retained for confirmation of ID. A sub-sample of krill (176) retained at -20°C for additional research on diet, parasites and stable isotopes by Alison Cleary and Gabi Stowasser (both BAS). Ran ECB3 (Ev11) and 4 (Ev12) transects overnight.

Warning sign on EK80 of GPS sensor timed out – accidental switch off of ships GPS, restored quickly – EK80 data has a bad fix at this point but otherwise unaffected.

12-05-2022 Paused recording briefly to back up acoustic data during pre-dawn non-target plankton trawl (Ev13; just 12 krill caught). CTD station (Ev14) at the start of daylight transect of ECB3 (Ev15). CTD in between offshore transect ends (Ev16), followed by ECB4 daylight transect (Ev17). Acoustic data still has patches of noise – wind speed ~25 kts and swell of 4-5 m not ideal for acoustic data, particularly when the wind is forward of the beam and the vessel pitches more. 20+ whales seen, but conditions prevented ID of most.

CTD (Ev18) at the end of ECB4 was followed by a plankton trawl (Ev19) targeting a near surface swarm after dark and caught good catch of small krill. Calmer overnight – conducted night ECB5 (Ev20) and 6 (Ev21) transects.

13-05-2022 Pre-dawn, non-target plankton trawl (Ev22) had small catch of krill and was followed by CTD (Ev23). Started daytime ECB5 (Ev24) transect in good weather, but 35 knot winds (SSE), swell >3m and sea state 4/5 made the collection of good acoustic and seabird observations data difficult. Conditions precluded CTD and ECB6 cancelled. Instead, repeated ECB3 (off-shore to on-shore) in slightly calmer conditions (Ev25). CTD (Ev26) at the end of the transect was followed by krill target trawl in dark (Ev27), which caught 4.7 kg of krill. Ping interval not met warning coincides with very dense swarm at surface under echosounder. As weather is predicted to be good over next 2 days, we head back to the start of ECB1, to repeat ECB1 (Ev28) and ECB2 (Ev29) overnight.

14-05-2022 Non-target RMT1 at the start of ECB1 (Ev30), caught small catch, with a couple of krill. Following the CTD (Ev31), ECB1 (Ev32) was repeated in daylight, with an early sighting of a blue whale and several humpbacks (no krill on echosounder). Subsequently several humpbacks sighted in association with krill swarms. Swell picked up later in the day

resulting in some noise on acoustics and CTD was cancelled. EK80 appears to be noisier off-shore and when the vessel is pitching. However, majority of krill swarms appear to be near-shore and near shelf break. ECB2 (Ev33) completed by sunset and followed by CTD (Ev34). First evening target plankton trawl (Ev35) failed as cod-end detached, a second 15-minute trawl (Ev36) resulted in a good krill catch. Started ECB3 night trawl (Ev37) but called an early end to transect at 21:30 due to poor weather and headed to curtailed end of ECB4 (Ev38) heading inshore.

15-05-2022 Pre-dawn RMT1 (Ev39) had small catch and was followed by CTD at transect start point (Ev40). ECB3 (Ev41) and 4 (Ev43) were repeated in daylight, with CTD (Ev42) between offshore ends of transects. Weather and sea conditions ideal (light winds, calm sea). CTD (Ev44) at the end of ECB4, followed by target plankton trawl (EV45) that failed at first attempt (twisted net) and was repeated (Ev46) with a catch of 2.8 L of krill in 15 minutes (samples frozen for diet / parasite studies). Headed to Cumberland Bay.

16-05-2022 Routine KEP non-target plankton trawls (Ev47 & 48) conducted in Cumberland Bay either side of nautical twilight (dawn), along with CTD (Ev49). Docked at KEP at 09:00.

19-05-2022 Departed KEP at 11:45 for final WCB transects, Bay of Isles plankton trawls, calibration and other ships activities (Bird Island call and patrol around the south of the island). Vessel transited to Bay of Isles in calm, clear weather, with seabird / mammal obs during transit. Arrived Bay of Isles at 16:00 and did CTD (Ev50) in 260 m. KEP routine plankton trawls (Ev51, 52) completed either side of nautical twilight (17:25-18:30). Vessel headed out to do WCB4.1 (Ev53) and 4.2 (Ev54) overnight in good conditions.

20-05-2022 Pre-dawn, non-target plankton trawl (Ev55) at start point of WCB 4.1 had small catch and was followed by CTD (Ev56). Started daylight WCB4.1 (Ev57) in good conditions, and encountered fin and humpback whales, but off-shelf, there was no krill and no whales. Weather deteriorated with 25 knots from SSW and CTD (Ev58) was completed in swell, with vessel struggling to hold station. Start of WCB4.2 (Ev59) was noisy on the acoustics, with the vessel pitching in southerly swell. Weather reduced ship's speed on two engines to 8 knots, so last 2 miles were after sunset, but still light. Very little seen on EK80 and no confirmed whale sightings. CTD (Ev60) completed at the end of WCB4.2. Attempted target fishing with RMT1 between near-shore end of WCB 4.1 and 4.2. First attempt (Ev61) failed, with net inverted (but some krill measured and frozen). Second attempt (Ev62) was much better with 2 L of krill. Third net (Ev63) targeted a different swarm, with another 2.5 L catch from 15 mins. Samples frozen for diet / parasite studies. Vessel slowly headed towards Elsehul overnight.

21-05-2022 *MV Pharos SG* headed around the coast to Bird Island at dawn, arriving off Bird Island (BI) around 08:00. Doc dispensed Covid boosters on-board and then went to BI to give winterers a booster. Completed BI at 11:15 and set off SW towards the 1000 m contour for patrol of the south of the island. Seabird/ marine mammal observations continue. Three humpbacks just as we left BI. Weather calm, with patchy mist, with vessel doing 12 knots on 3 engines.

22-05-2022 Passed south of Annenkov overnight. Ice-light was off for first part of the night and no birds found on deck. Weather calm with misty. A few whales spotted, but many distant blows were not seen again. Fin and humpback whales near the Office Boys just after

lunch. Continued north and then west close to the 1000 m contour. More whales encountered during the afternoon and then at dusk a large group of humpback (with some fin) whales was encountered feeding on a surface krill swarm at the offshore edge of the ECB. The RMT1 net was fished (Ev64) for 15 mins in the upper 25 m and caught 5 L of krill. The length was similar to earlier nets (mode ~ 28 mm) and a further 176 krill were frozen for diet studies. Whilst the net was in the water humpbacks were surfacing near the stern of the vessel. Continued towards Stromness Bay overnight on a transect line from the 1000 m contour to the mouth of Stromness Bay (Ev65).

23-05-2022 Proceeded in Stromness Bay at first light and anchored in Husvik Harbour, to the south of the Tonsberg Peninsula. CTD deployed to 33 m (Ev66) and rope set under bows to facilitate calibration. Zodiac took Nestor & Jenna Plank (KEP doc) ashore. Rods prepared for calibration in accordance with the Acoustic Calibration Protocol and the 38.1 mm tungsten carbide sphere deployed with a large shackle beneath to provide extra weight. The sphere was set at around 13.5 m beneath the transducers (~ 17 m depth) and calibration began at 10:00. The sphere was under the 120 kHz transducer, so 120 kHz was calibrated first. Calibration completed at 11:30, with low RMS error. The calibration was saved and accepted.

The 38 kHz calibration began after lunch (12:30), but the first iteration produced an error message (*Calibration result value outside of the expected range. Alongship beamwidth Athwartship beamwidth*) and was saved, but not accepted. The calibration was twice repeated but produced the same error. Calibration was re-run (simulated) on the data to exclude fish / seal / penguin interference, but still produced errors. All calibration files were saved, but not accepted. Rods put away at 18:00 and a few birds landed on the deck when the lights were on, but were quickly released. Vessel proceeded overnight towards Cumberland Bay.

24-05-2022 MV *Pharos SG* arrived at KEP at 08:30 (approx.).

02-06-2022 Following discussion and advice from Simrad, the 38 kHz calibration was completed by reprocessing the final EK80 calibration RAW files (Pharos_SG-D20220523-T181829.raw and Pharos_SG-D20220523-T185102.raw) with a 3 dB threshold on TS deviation, and excluding 'suspect' pings i.e. those with an uncompensated TS far from the theoretical TS of the sphere at 38 kHz (-42.19 dB). By excluding 'hits' with a TS Uncomp ≤-45.75 dB, Alongship and Athwartship beam angles were within acceptable range of 6.3°-7.7° (±10% of 7° beam angle). The calibration was saved and updated on the echosounder.

1.4 Fieldwork personnel

Martin Collins	BAS, Winter Krill Project Principal Investigator
Tracey Dornan	BAS, Biological oceanographer / Acoustician
Meghan Goggins	BAS, Marine Biologist - KEP
Kate Owen	BAS, Marine Biologist - KEP
Ryan Irvine	SAERI, Ornithologist and marine mammal observation

2. Penguin tracking

One of the aims of the Winter Krill Project is to track foraging gentoo penguins during winter, when their foraging range potentially overlaps with the krill fishery. During this round of fieldwork four gentoo penguins were fitted with Wildlife Computers SPOT-367A PTT satellite tags at Maiviken on 10-05-2022, with four more attached to gentoos at Bird Island. An additional 6 GPS tags were deployed on gentoos at Bird Island, which download to base stations (see Appendix II). Predator tracks will be analysed in relation to acoustic estimates of krill abundance and distribution to estimate the potential overlap between predators and the krill fishery. A further 2 SPOT PTT tags will be deployed at both Maiviken and Bird Island in advance of the July survey to ensure the predator tracking data is available throughout the entire winter season.

Two of the Maiviken-tagged gentoos remained in the Cumberland Bay area (Figure 2), but two travelled SE to forage in the Cooper Bay / Drygalski Fjord area. The Bird Island tagged birds remained around the west end of the island.

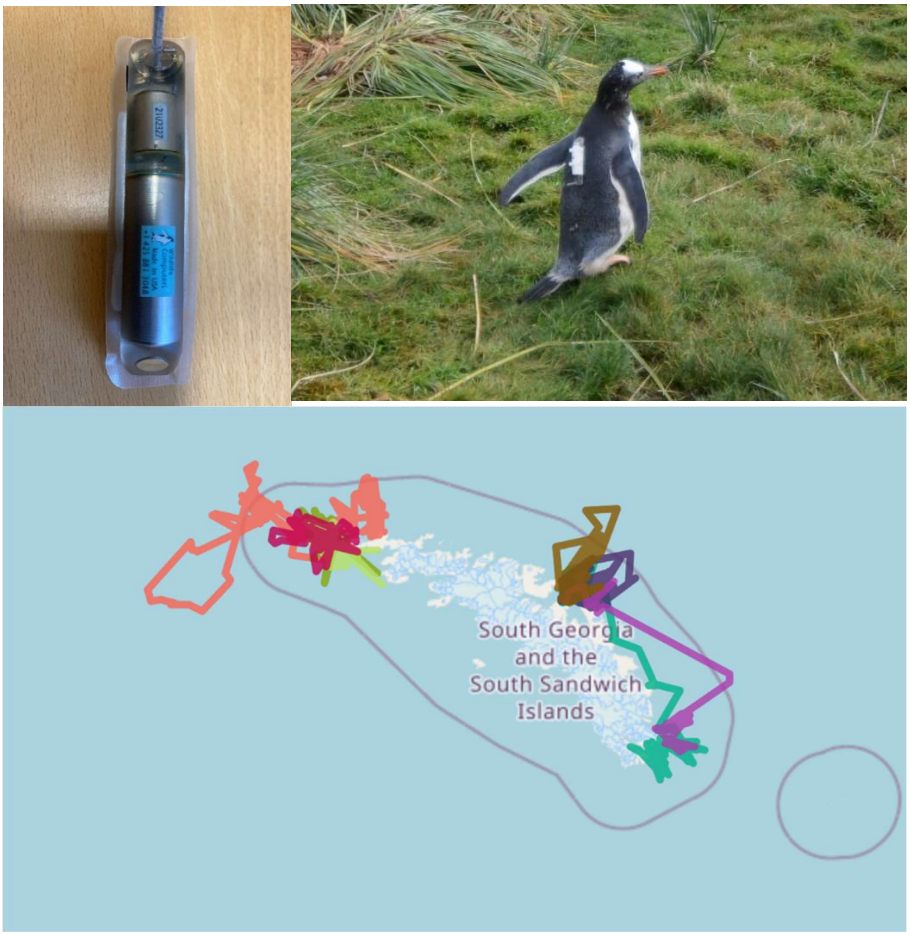

Figure 2. Photographs of a Wildlife Computers SPOT 367A PPT tag (upper left), a tagged gentoo penguin (upper right) and a map of tagged gentoo movements from May 10th to June 5th. The different colours represent different penguins.

3. Acoustic surveys

3.1 Introduction

The *MV Pharos SG* was fitted with a Simrad EK80 split-beam echosounder, with 38 and 120 kHz transducers in March 2022 with the aim of collecting acoustic data to accompany all predator observations and net tows during the Winter Krill project surveys. The transducers are mounted within a blister on the ship's hull enabling data collection through the water column while underway at speeds up to 10 knots. While Simrad EK80 WBTs, are able to operate in both continuous wave (CW) and/or frequency modulated (FM; wide frequency band chirp) transmission modes, the EK80 was operated in CW mode only, as CW meets project aims and generates smaller data files.

The EK80 was run continuously on transits between the Falkland Islands and South Georgia, as well as during dedicated Eastern and Western Core Box (ECB and WCB) survey transects (see Figure 1). Six ECB transects were run, with the majority being completed day and night. ECB 1-4 were run twice. Daytime ECB5 transect was cut short off-shore, and daytime ECB6 was not run, as bad conditions prevented the collection of good quality acoustic or seabird observation data. Two WCB transects were run day and night.

ECB and WCB transect data will be used to derive krill biomass estimates and model distribution within the key krill fishing grounds.

3.2 EK80 operation and performance

During EK80 operation all other ships echosounders were turned off to reduce interference. The EK80 was operated using Simrad EK80 v. 21.15.1 software from the bridge of the *MV Pharos SG*. The .raw data files were written directly to an external hard drive and backed up at the end of each day. Raw data were collected to a range of 1200 m, with a ping interval of 2 seconds, see Table 2 for details of additional settings.

Table 2. EK80 settings used throughout acoustic surveys

Variable	38 kHz	120 kHz
Mode	Active	Active
Transmit pulse duration (ms)	1.024	1.024
Transmit power (W)	2000	250
Pulse type	CW	CW
Range (m)	1200	1200
Ping interval (ms)	2000	2000

Sea state, swell, wind and vessel speed all affected acoustic data quality. While the echosounder performed best in flat calm conditions, wind on the beam was better than head on, with vessel pitching resulting in considerable amounts of transient noise and poor data quality. Wind speed of ≤20 kts and swell ≤ 2 m resulted in reasonable quality data. Higher vessels speeds of 9-9.5 kts often produced less noisy data as the vessel was more stable. However, all of these factors interact. In general, good conditions for conducting seabird and marine mammal observations also result in good quality acoustic data.

At times the echosounder was unable to meet the 2s ping interval. This was initially resolved by ensuring that all Output Range settings were set to 1200 m with 'Auto' unchecked. However, during one period of ship rolling, the echosounder was unable to meet ping interval on a regular 1 minute interval. It would appear that the roll of the vessel was perfectly in sync with the echosounder ping interval, preventing the return signal from the ping reaching the transducer. This was resolved by increasing vessel speed, which appeared

to break the cycle. A few ping intervals were also missed when passing over a particularly dense krill swarm directly under the echosounder.

Vessel noise was an issue in some transects. To reduce noise originating within the vessel, ballast tanks were topped up.

Krill swarms were regularly seen on transects (Figure 3), with more swarms seen on the shelf than offshore. The EK80 was used to identify and target surface krill swarms after dusk.

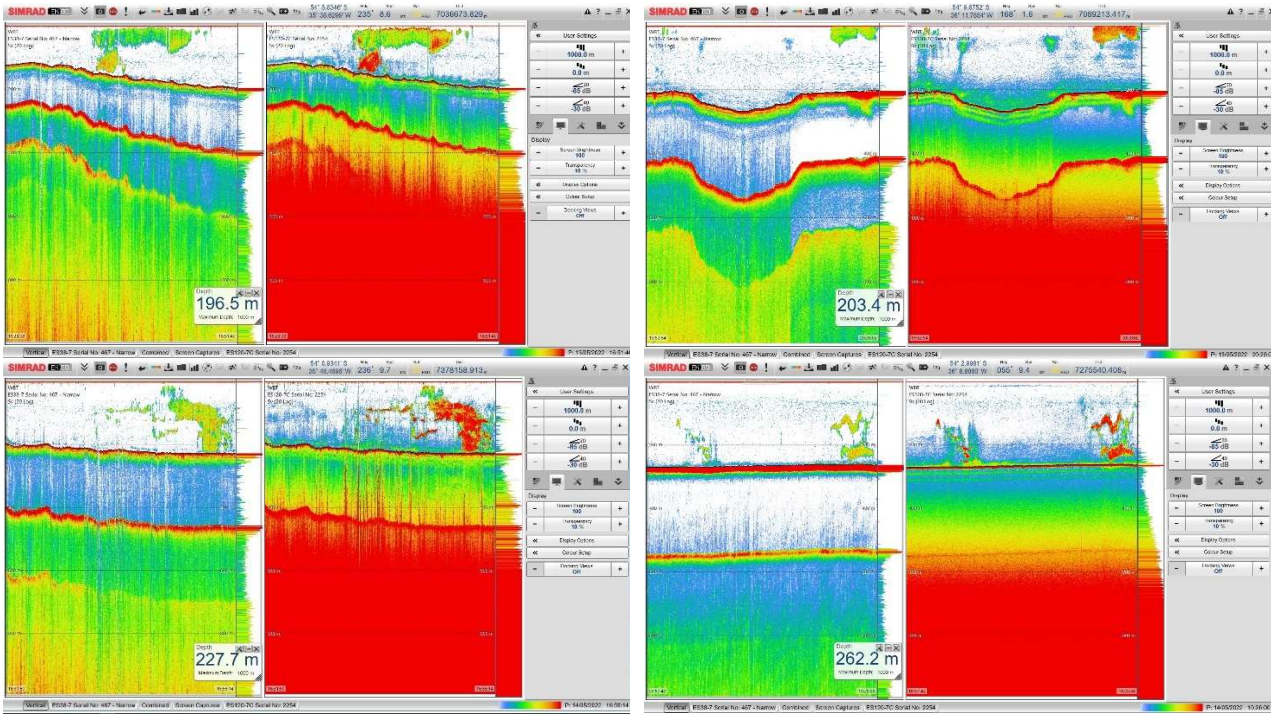

Figure 3. Screen grabs from the EK80, showing krill swarms during daytime transects and a swarm targetted with the RMT1 net (upper right). Each panel shows 38 kHz echogram on the left and 120 kHz on the right.

3.3 File locations

All raw data collected were saved in a folder labelled with the start of the survey transect dates '20220510_WK'. All files were prefixed with 'Pharos_SG'.

3.4 EK80 calibration

During the survey transects the EK80 was run using the settings from an initial calibration in Berkley Sound on 30-04-2022. EK80 transducers were then calibrated post-survey at Husvik Harbour (Figure 4) in Stromness Bay on 23-05-2022. Sound speed and absorption coefficients were calculated by the EK80 software from CTD measurements of temperature (2.2°) and salinity (33.6 PSU) averaged between 4-20 m. Calibration was completed using a 38.1 mm tungsten carbide sphere and standard calibration protocols (Demer et al. 2015). Theoretical TS of the sphere at 30 kHz = -42.19dB, 120 kHz = -39.66 dB. Ping interval was set to 1000 ms and data collection range set to 200 m. Transducer draft was not applied to the EK80 during calibration, but must be applied in post-processing. Mean vessel draft during calibration = 3.875 m, transducer blister depth = 0.5 m, therefore transducer depth = 4.375 m below surface.

The 120 kHz calibration was successful and parameters applied to the EK80 instrument (see Table 3 for calibration parameters). However, the 38 kHz calibration produced a 'suspect calibration results' warning – *Calibration result values outside of expected range: Alongship beamwidth, Athwartship beamwidth*. Acceptable beam width ranges are 6.3°-7.7° i.e. ±10% for a 7° beam transducer. Following advice from Simrad a new calibration was run on 02-06-2022 by replaying calibration .raw files, setting TS deviation threshold to 3 dB, and subsequently suspending (removing) hits with a 'TS uncomp' value ≤ -45.75 dB, as these are far lower than the expected target TS of -42.19 dB. By reprocessing with these suspect hits suspended acceptable calibration results were achieved and the calibration updated on the EK80 system.

Figure 4. Kate Owen being trained in EK80 calibration (left). Tracey Dornan, Ryan Irvine and Bob Bosun using rods to manoeuvre the calibration sphere within the transducer beam during calibration (right).

Table 3. EK80 calibration parameters before (Berkley Sound) and after (Husvik Harbour) May 2022 acoustic survey. The EK80 survey data should be processed using Husvik Harbour .ecs files updated with mean temperature, salinity and sound speed values from survey CTD readings. NOTE: transducer draft should be applied post processing.

Location	Berkley sound	Berkley sound	Husvik Harbour	Husvik Harbour
Frequency (kHz)	38	120	38	120
Date of calibration	30-04-2022	30-04-2022	23-05-2022	23-05-2022
Date EK80 updated	30-04-2022	30-04-2022	02-06-2022	23-05-2022
Calibration applied (Y/N)	Y	Y	Y	Y
Transducer depth (m)	0	0	0	0
Acidity (pH)	8.0	8.0	8.0	8.0
Mean Temperature (°C)	9.2	9.2	2.2	2.2
Salinity	34.500	34.500	33.600	33.600
Sound velocity (m/s)	1487.98	1487.98	1458.78	1458.78
Mode	Active (CW)	Active (CW)	Active (CW)	Active (CW)
Transducer type	ES38-7	ES120-7C	ES38-7	ES120-7C
Transceiver Serial no.	467	2254	467	2254
Pulse length (ms)	1.024	1.024	1.024	1.024
Max Power (W)	2000	250	2000	250
2-way beam angle (dB)	-20.7	-20.7	-20.7	-20.7
Transducer gain (dB)	26.82	27.09	27.66	27.03
Sa correction (dB)	-0.03	-0.06	-0.08	-0.04
Angle sensitivity along	18.0	23.0	18.0	23.0
Angle sensitivity athwart	18.0	23.0	18.0	23.0
3 dB Beam along	6.59	6.37	6.37	6.72
3 dB Beam athwart	7.07	6.49	6.31	6.72

3.5 EK80 future calibration

While calibration was successful, we recommend the following:

- The calibration sphere be lowered to a depth of 20 m for calibrating both frequencies.
- Set the TS deviation in the EK80 calibration wizard between 2-3 dB – this may take longer to achieve good coverage of the beam during calibration, but should reject any target results that are too far above and below the expected TS of the sphere.
- Ensure that all other echosounders plus the ships Doppler are off.
- Ensure all line knots as well as sphere are dipped in detergent solution prior to calibration.

4. CTD Operations

4.1 Introduction

Whenever conditions allowed, a conductivity temperature depth profiler (CTD) was deployed before the start of daytime transects (on-shelf), on route between daytime transects (off-shelf) and at the end of daytime transects (on-shelf) (see Figure 1). The CTD was typically deployed to a depth of 200 m or a few metres above the seabed at shallower stations. These CTD profiles will be used to derive estimates of temperature, salinity and hence sound speed and absorption coefficient to apply calibration files to acoustic data during processing for the survey. In addition, a CTD was deployed prior to calibration to determine sound speed and absorption coefficient, essential to the calibration process.

4.2 CTD instrumentation

A Ruskin RBR*concerto* fast 8 logger CTD, depth rated to 750 m, was used to measure temperature and salinity. The CTD was mounted in a steel frame formed of 10 mm rods (see Figure 4) and deployed from a deck mounted winch using 6 mm cable. While it is advised not to place metal within a 15 cm radius of the CTD sensor, the manufacturers have agreed to provide a correction factor to account for use of the CTD in the frame.

Table 4. CTD Data collection parameters

Instrument	RBR Concerto Fast 8
Serial	209870
Mode	Continuous
Frequency	8Hz
Firmware	1.138

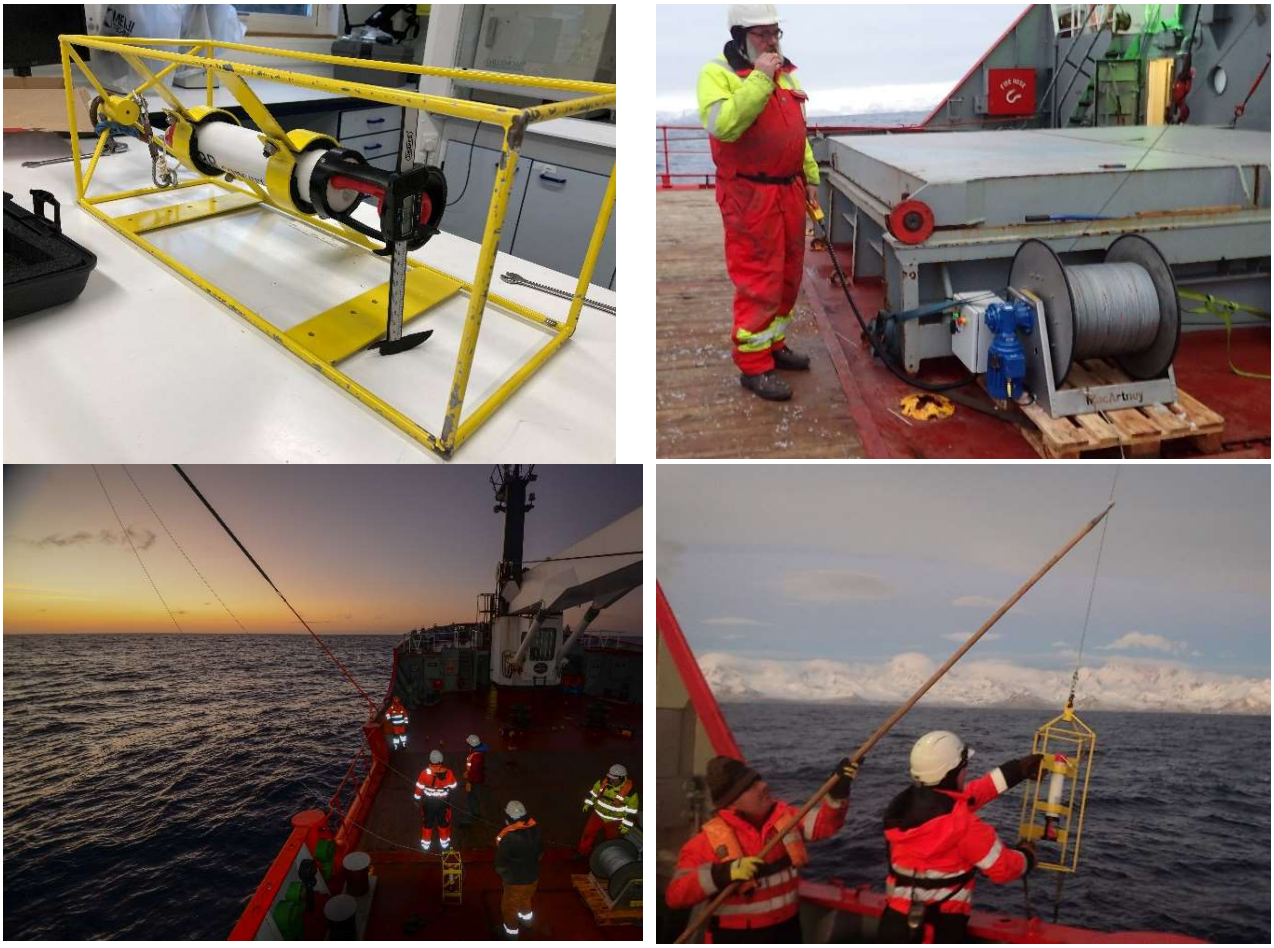

Figure 5. CTD mounted in the existing KEP CTD frame (upper left); CTD winch on the foredeck of *MV Pharos SG* (upper right); CTD on deck ready for deployment (lower left) and being deployed (lower right).

Once the CTD was set up for deployment at the beginning of the survey, the unit was kept sealed throughout ECB sampling to reduce potential for any leaks. Data was downloaded from the instrument after each deployment via WiFi directly to a laptop. Only when the CTD unit was ashore at KEP was the unit end cap opened.

Data was downloaded and processed from the instrument using Ruskin Software and exported as excel files. Twenty CTDs were conducted, including the test CTD in Cumberland Bay (Ev1) and the CTDs in Cumberland Bay (CBE) and Bay of Isles (BoI) to accompany the KEP monthly plankton trawls.

Table 5. Details of CTD deployments during the Winter Krill surveys in 2022.

Event no.	Location	Type	Wire Out (m)	Depth (m)	Temp 10 m	Temp 200 m
1	CBE	Test	200	194	2.88	-
5	ECB1	Coastal	200	201	2.52	1.79
7	ECB1/2	Offshore	210	211	1.89	1.89
9	ECB2	Coastal	200	203	2.43	1.75
14	ECB3	Coastal	140	138	2.45	-
16	ECB3/4	Offshore	200	210	1.90	1.82
18	ECB4	Coastal	NR	170	2.65	-
23	ECB5	Coastal	110	111	2.67	-
26	ECB3	Coastal	NR	126	2.58	-
31	ECB1	Coastal	NR	212	2.35	1.81
34	ECB2	Coastal	190	193	2.54	-
40	ECB3	Coastal	140	142	2.54	-
42	ECB3	Offshore	300	314	1.79	1.46
44	ECB4	Coastal	NR	164	2.61	-
49	CBE	KEP Routine	200	204	2.82	1.89
50	BoI	KEP Routine	250	254	2.41	1.88
56	WCB4.1	Coastal	105	104	2.40	-
58	WCB4.1	Offshore	190	193	2.58	-
60	WCB4.2	Coastal	100	100	2.42	-
66	Husvik	Calibration	30	33	2.13	-

CTD data was assigned survey and event numbers and redundant (above water) data deleted. Data was collated in an Access Database (*South Georgia CTD*).

5. Plankton trawls

To monitor the zooplankton community and gain an estimate of krill length frequencies required to calculate krill biomass, a series of plankton trawls were conducted during nautical twilight. The majority of trawls were conducted at the near shore end of transects. A rectangular mid-water trawl net with a 1 m^2 mouth opening and a cod end mesh size of 610 µm was used to sample zooplankton and target surface krill swarms. The net was deployed and recovered open via a winch from the poop deck of the *MV Pharos SG*. Once 110 m of wire was paid out, the net was typically towed for 30 minutes, with the exception of some target hauls, which were towed for 15-20 minutes. With a vessel speed of 2-2.5 kts, and 110 m of wire paid out, the net is assumed to fish at an approximate depth of 20-25 m. This is based on the depth of similar net deployments, when the net was fitted with temperature depth loggers.

Morning trawls were non-target and evening trawls typically targeted a krill swarm identified on the echosounder during the previous transect (Table 6). The plankton trawl is regularly deployed from the *MV Pharos SG*, as part of long-term plankton monitoring at KEP. Full details of the results of the plankton tows will be uploaded to and accessed via the BAS KEP plankton database.

Twenty-one plankton trawls were conducted, including the two trawls in Cumberland Bay and the two in Bay of Isles that are part of the KEP science programme (Table 6). Krill were sorted from catches and 200

measured (TL) from each trawl, or the total catch if less than 200 were caught. Measurements were made on laminated graph paper (Figure 6) from the front of the eye to the tip of the telson in accordance with CCAMLR guidelines (CCAMLR, 2011). Length-frequency showed a mode at around 27-29 mm TL, but larger krill were caught in Event 10 (Figure 7). Some small krill (likely *E. superba*) (10-15 mm TL) were caught, but were preserved to confirm identification. Where possible, 176 krill were individually frozen in ice-cube trays, with 22 krill in each of 8 trays. Krill were frozen individually at -20 in the on-board science freezer but transferred to plastic bags and placed in the KEP -80 freezer at the end of each survey period. The rest of the catch was preserved and will be identified and quantified at KEP.

Table 6. Details of plankton trawls

Event no.	Location	Type	Catch Summary	Krill Measured	Krill Frozen
4	ECB1	Coastal	Small catch, a few krill	0	0
10	ECB2	Coastal -Target	0.85L – mostly krill	200	176
13	ECB3	Coastal	Small catch – just 12 krill	12	12
19	ECB4	Coastal - Target	Good krill catch	200	176
22	ECB5	Coastal	Small catch; no krill	0	0
27	ECB3	Coastal - Target	4.5 L catch, mostly krill; 0.5 L subsample retained	200	176
30	ECB1	Coastal	Small catch; no krill	0	0
35	ECB2	Coastal - Target	Failed; cod-end detached	0	0
36	ECB2	Coastal - Target	15 min tow; 3L mostly krill	200	176
39	ECB3	Coastal	Small catch; many small krill, but only larger measured	29	22
45	ECB4	Coastal -Target	Failed; net twisted, no catch	0	0
46	ECB4	Coastal - Target	15 min tow	200	176
47	CBE	KEP non-target	Small catch, no krill	0	0
48	CBE	KEP non-target	Small catch, no krill	0	0
51	BoI	KEP non-target	Small catch, no krill	0	0
52	BoI	KEP non-target	Small catch, no krill	0	0
55	WCB4.1	Coastal	Small catch, no krill	0	0
61	WCB4.1/2	Coastal - Target	Cod-end inside net, but some catch salvaged	150	88
62	WCB4.1/2	Coastal - Target	Repeat trawl, 2.8 L mostly krill; 200 ml sub-sample retained	200	88
63	WCB4.1/2	Coastal - Target	15 mins on different swarm to 62; 5L mostly krill	200	0
64	ECB	Offshore - Target	Mostly krill 5.2 Litres	200	176

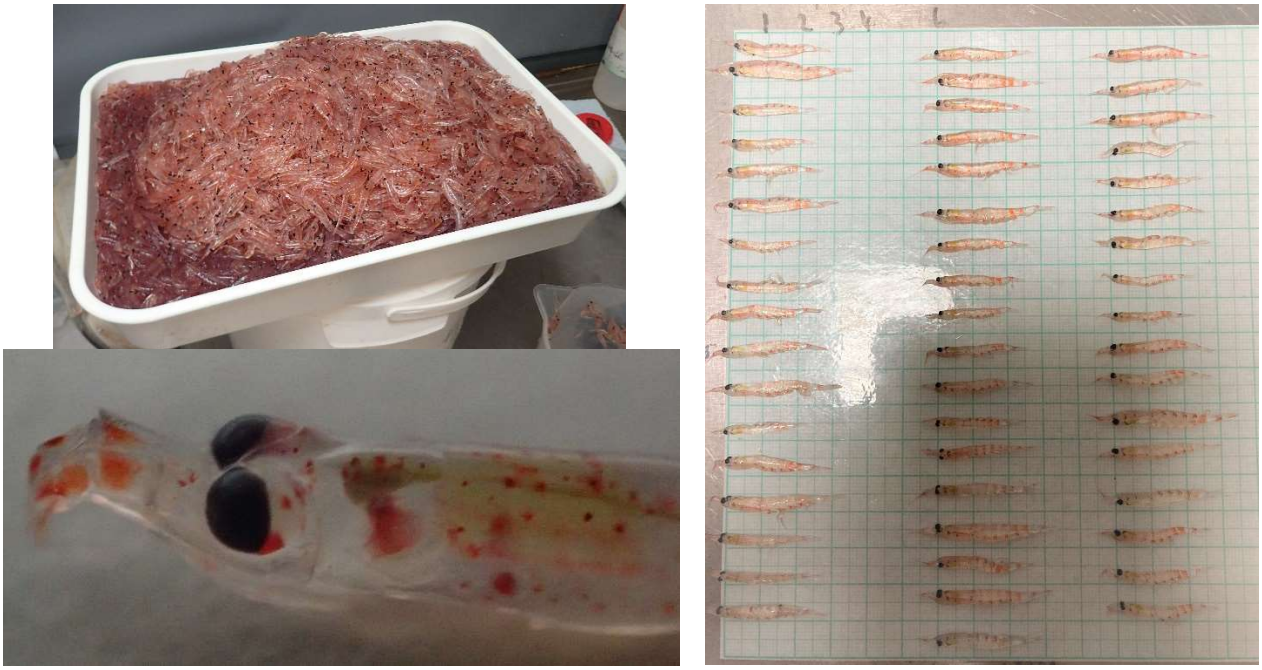

Figure 6. Catch of krill from Event 62 (top left), small krill (bottom left) and krill lined up to be measured on laminated graph paper (right).

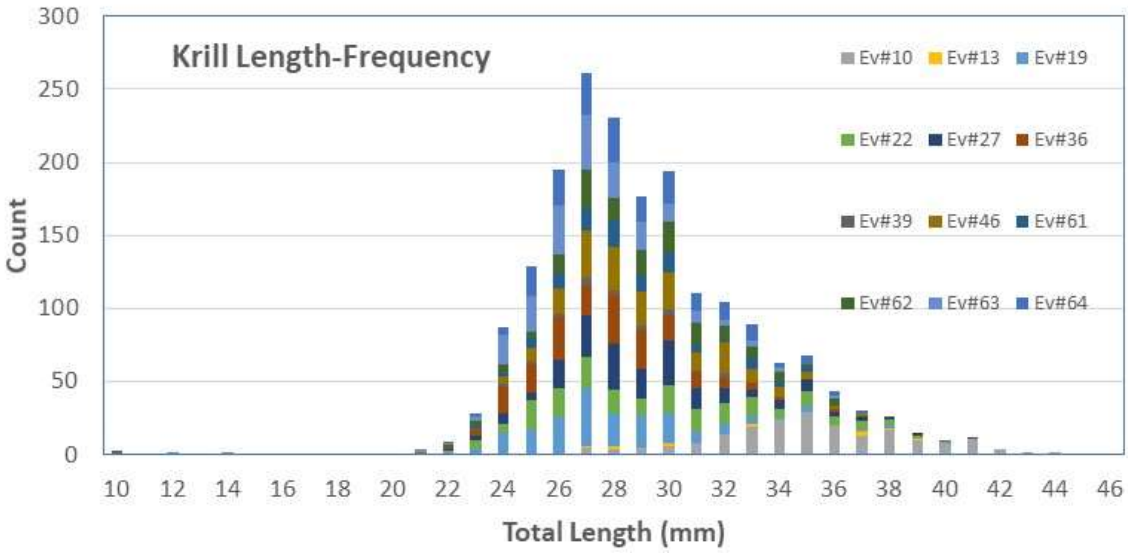

Figure 7. Krill length-frequency from the RMT1 nets conducted during the May survey – note: small krill (10-16 mm TL) are not fully included.

6. Seabird and marine mammal observations

To estimate abundance and distribution of predators within the survey area, seabird and marine mammal observations were conducted concurrently with all daytime acoustic transects, in accordance with standard JNCC Seabirds at Sea Methods (Tasker et al., 1984) and following the Winter Krill Seabird Observation protocol.

Observations were made from the centre of the bridge, as this will be consistent with the methods employed in July when a team of cetacean observers will also be on board.

The most abundant seabird species were blue petrels and diving petrels (a mix of common and South Georgia diving petrels). Humpback and fin whales were the most common cetaceans with 66 humpbacks and 53 fin whales sighted in the ECB and WCB areas. An additional 35 humpback and 17 fin whales were observed during transit around South Georgia, but the only cetacean sighting on passage from the Falklands to South Georgia was a single fin whale (see Tables 7 and 8).

Figure 8. Ryan undertaking seabird and marine mammal observations on the bridge (upper), southern giant petrel (lower left) and cape petrel (lower right).

Table 7. Seabird and marine mammal observations during transects in the Eastern Core Box and Western Core Box.

	ECB		WCB		
Species	**In transect**	**Out transect**	**In transect**	**Out transect**	**Total**
Blue petrel	2531	2344	21	43	**4939**
Diving petrel spp.	1802	2491	246	251	**4790**
Prion spp.	93	111	2	1	**207**
Cape petrel	71	114	2	19	**206**
South Georgia shag	1	0	186	0	**187**
Antarctic tern	55	58	2	11	**126**
Blue petrel/prion spp.	27	94	0	0	**121**
Antarctic fur seal	113	0	7	0	**120**
Black-bellied storm-petrel	55	47	5	11	**118**
Kelp gull	23	67	0	1	**91**
Southern giant petrel	30	23	1	19	**73**
Wandering albatross	13	39	3	15	**70**
Humpback whale	43	19	3	1	**66**
Large cetacean spp.	10	32	11	3	**56**
Fin whale	31	15	7	0	**53**
Southern fulmar	10	28	2	11	**51**
Grey-headed albatross	11	30	4	4	**49**
Gentoo penguin	34	0	14	0	**48**
Kerguelen petrel	5	9	12	9	**35**
King penguin	27	0	0	0	**27**
Northern giant petrel	2	14	1	1	**18**
Southern right whale	4	14	0	0	**18**
Snow petrel	2	12	1	1	**16**
Black-browed albatross	2	6	0	1	**9**
Giant petrel spp.	1	7	0	1	**9**
Light-mantled albatross	0	5	0	1	**6**
Sub-Antarctic skua	0	2	1	1	**4**
Antarctic petrel	0	3	0	0	**3**
Southern royal albatross	1	1	0	1	**3**
White-chinned petrel	1	2	0	0	**3**
Sperm whale	2	0	0	0	**2**
Atlantic petrel	0	1	0	0	**1**
Blue whale	1	0	0	0	**1**
Fairy prion	0	1	0	0	**1**

Table 8. Seabird and marine mammal observations during transits to KEP from the Falklands and during a patrol of South Georgia (close to 1,000 m contour).

	Falklands - KEP		SG patrol		
Species	**In transect**	**Out transect**	**In transect**	**Out transect**	**Total**
Diving petrel spp	1252	1435	307	220	**3214**
Blue petrel	4	11	439	566	**1020**
Prion spp	358	286	24	62	**730**
South Georgia shag	19	147	13	9	**188**
King penguin	44	0	38	0	**82**
Gentoo penguin	27	0	52	0	**79**
Cape petrel	14	25	19	16	**74**
Antarctic tern	13	14	5	22	**54**
Antarctic fur seal	14	0	39	0	**53**
Grey-headed albatross	14	34	0	5	**53**
Wandering albatross	9	21	15	8	**53**
White-chinned petrel	13	39	0	1	**53**
Kerguelen petrel	8	15	13	15	**51**
Black-bellied storm-petrel	7	17	6	16	**46**
Southern giant petrel	12	18	2	8	**40**
Southern fulmar	22	16	0	1	**39**
Humpback whale	0	0	33	2	**35**
Black-browed albatross	8	22	0	0	**30**
Giant petrel spp	2	19	6	2	**29**
Macaroni penguin	2	0	26	0	**28**
Chinstrap penguin	0	0	23	0	**23**
Fin whale	1	0	9	7	**17**
Snow petrel	11	5	1	0	**17**
Southern royal albatross	6	11	0	0	**17**
Northern giant petrel	9	4	1	0	**14**
Atlantic petrel	5	7	0	0	**12**
Large cetacean spp	0	0	7	3	**10**
Soft-plumaged petrel	4	3	0	0	**7**
White-headed petrel	5	2	0	0	**7**
Wilson's storm-petrel	2	3	1	0	**6**
Grey-backed storm-petrel	1	3	0	0	**4**
Kelp gull	0	0	1	3	**4**
Sooty shearwater	1	3	0	0	**4**
Blue petrel/prion spp	0	0	1	2	**3**
Sub-antarctic skua	0	2	1	0	**3**
Antarctic petrel	0	0	1	1	**2**
Cattle egret	0	2	0	0	**2**
Light-mantled albatross	0	0	2	0	**2**
Northern royal albatross	1	1	0	0	**2**
Penguin spp	2	0	0	0	**2**
Grey petrel	0	1	0	0	**1**
Sooty albatross	0	1	0	0	**1**

7. Discussion

All aspects of the survey were successful. In particular the fit of the EK80 echosounder to the *MV Pharos SG*, provides an opportunity to collect scientific acoustic data from more times of year than would otherwise be possible. Preliminary viewing of the acoustic data indicates that the quality is good, although the quality deteriorated when the vessel was head to swell, which caused pitching.

The location of the EK80 display on the rear of the bridge was really useful, as it allowed seabird / whale observers to check the acoustics when feeding aggregations of birds and seals were detected.

The transect length in the ECB and WCB was cut to 35 nautical miles, which allowed two transects to be completed (plus an offshore CTD) during the limited winter daylight. It was the offshore end of the transect that was curtailed, but we saw very little evidence of krill (or krill predators) beyond the 1000 m bathymetric contour. Transects 1-4 of the ECB were repeated (both day and night), which will enable us to assess the acoustic data in a range of conditions and also provide comparative data.

Numerous krill swarms were seen during the transects and the RMT1 was used for target fishing of large surface swarms after dark. The krill catch was dominated by krill of a modal size of 26-20 mm TL, but some smaller krill (10-15 mm TL) were also caught. These smaller krill were not measured as sea, as identification was uncertain, but have been measured after preservation.

The acoustic data will be analysed in detail in Cambridge, but the data collected should allow (i) estimates of krill biomass in the ECB to be calculated; (ii) comparison of day and night vertical distribution of krill; (iii) determination of spatial overlap between krill and krill predators; and (iv) investigations of the interactions between foraging whales and krill swarms.

A preliminary review of the seabird data and comparison with data collected during the austral winters of 2010 and 2011 (Black, 2011) suggest a greater abundance of blue petrels and diving petrels in the ECB area on this survey compared to 2010 and 2011. It is possible that this is a consequence of population increase following the rat eradication. It would be useful to do some similar comparative transects on the south side of the island, as this area was always rat-free. There was also a dramatic increase in the numbers of fin and humpback whales seen in comparison with 2010 and 2011.

Overall the *MV Pharos SG* has proved to be a really useful platform for science and the officers and crew were exceptionally supportive of the project and a key part of the success of the first survey. The vessel is also very efficient in fuel consumption (Appendix III).

8. Acknowledgements

This report details the first of six winter krill project field campaigns. A small BAS project team were supported by enthusiastic and dedicated colleagues including the crew of the *MV Pharos SG*, observers, officers from the Government of South Georgia and the South Sandwich Islands (GSGSSI), and land-based support from wintering staff at BAS King Edward Point (KEP) research base.

We are hugely grateful to the crew of the *MV Pharos SG*. From Captain and Officers through to deck crew, catering staff and engineers, all were enthusiastic, interested and keen to support the science being undertaken. Their support has been integral to the success of this first deployment.

We are also grateful to Government Officers from GSGSSI, for their support in planning the surveys and participation in training for acoustic instrument calibration and data collection.

9. References

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Appendix I: Event log

Each individual event was assigned an event number. Gear is assigned as Conductivity Temperature Depth 'CTD' profiler, acoustic survey 'Transect', or 1m^2 mouth opening plankton net 'Net'. Note that seabird and marine mammal observations occurred concurrently with daytime acoustic transects only. Times presented are local (UTC -2). Lat and Lon refer to latitude and longitude respectively. Further details of plankton trawls can be found in the KEP plankton trawl database.

Event	Gear	Location	Type	Date	Start time (local)	Start Lat	Start Long	End time (local)	End Lat	End Long
1	CTD	CBE	Test	10/05/2022	16:35:00	-54.2631	-36.4276	16:51:00	-54.2654	-36.4298
2	Transect	ECB1	Night	10/05/2022	18:17:00	-54.0950	-36.2567	22:19:00	-53.7613	-35.4345
3	Transect	ECB2	Night	10/05/2022	23:29:00	-53.8502	-35.3505	03:12:00	-54.1733	-36.1833
4	Net	ECB1	Coastal	11/05/2022	07:03:00	-54.0917	-36.2617	07:36:00	-54.0950	-36.2483
5	CTD	ECB1	Coastal	11/05/2022	08:00:00	-54.0952	-36.2600	08:15:00	-54.0945	-36.2632
6	Transect	ECB1	Day	11/05/2022	08:21:00	-54.0937	-36.2600	12:00:00	-53.7633	-35.4367
7	CTD	ECB1/2	Offshore	11/05/2022	12:23:00	-53.7967	-35.4017	12:38:00	-53.7917	-36.4050
8	Transect	ECB2	Day	11/05/2022	13:14:00	-53.8500	-35.3483	16:48:00	-54.1717	-36.1733
9	CTD	ECB2	Coastal	11/05/2022	16:51:00	-54.1717	-36.1750	17:06:00	-54.1700	-36.1750
10	Net	ECB2	Coastal -Target	11/05/2022	17:43:00	-54.1400	-36.0767	18:19:00	-54.1433	-36.1100
11	Transect	ECB3	Night	11/05/2022	19:12:00	-54.2650	-36.0733	22:43:00	-53.9390	-35.2457
12	Transect	ECB4	Night	11/05/2022	23:27:00	-54.0230	-35.1552	03:06:00	-54.3500	-35.9617
13	Net	ECB3	Coastal	12/05/2022	06:51:00	-54.2650	-36.0817	07:26:00	-54.2750	-36.0500
14	CTD	ECB3	Coastal	12/05/2022	07:42:00	-54.2650	-36.0667	07:52:00	-54.2650	-36.0683
15	Transect	ECB3	Day	12/05/2022	08:04:00	-54.2642	-36.0700	11:39:00	-53.9400	-35.2467
16	CTD	ECB3/4	Offshore	12/05/2022	12:04:00	-53.9767	-35.2017	12:19:00	-53.9750	-35.2017
17	Transect	ECB4	Day	12/05/2022	12:56:00	-54.0200	-35.1550	17:07:00	-54.3483	-35.9617
18	CTD	ECB4	Coastal	12/05/2022	17:12:00	-54.3600	-35.9650	17:25:00	-54.3600	-35.9617
19	Net	ECB4	Coastal - Target	12/05/2022	17:51:00	-54.3517	-35.9483	18:27:00	-54.3483	-35.9817
20	Transect	ECB5	Night	12/05/2022	18:58:00	-54.4008	-35.9100	22:34:00	-54.0755	-35.0900
21	Transect	ECB6	Night	12/05/2022	23:25:00	-54.1593	-34.9867	03:21:00	-54.4933	-35.8083
22	Net	ECB5	Coastal	13/05/2022	06:41:00	-54.4033	-35.8950	07:17:00	-54.3950	-35.9300

23	CTD	ECB5	Coastal	13/05/2022	07:31:00	-54.4017	-35.9100	07:39:00	-54.4017	-35.9083
24	Transect	ECB5	Day	13/05/2022	07:52:00	-54.4003	-35.9093	11:35:00	-54.0750	-35.0883
25	Transect	ECB3	Day	13/05/2022	12:48:00	-53.9433	-35.2500	16:50:00	-54.2650	-36.0700
26	CTD	ECB3	Coastal	13/05/2022	16:54:00	-54.2650	-36.0750	17:03:00	-54.2667	-36.0750
27	Net	ECB3	Coastal - Target	13/05/2022	18:13:00	-54.1583	-36.1983	18:49:00	-54.1750	-36.1850
28	Transect	ECB1	Night	13/05/2022	19:33:00	-54.0933	-36.2567	23:06:00	-53.7633	-35.4383
29	Transect	ECB2	Night	13/05/2022	23:54:00	-53.8517	-35.3533	03:32:00	-54.1700	-36.1767
30	Net	ECB1	Coastal	14/05/2022	06:43:00	-54.0917	-36.2483	07:17:00	-54.0933	-36.2800
31	CTD	ECB1	Coastal	14/05/2022	07:30:00	-54.0950	-36.2617	07:46:00	-54.0950	-36.2617
32	Transect	ECB1	Day	14/05/2022	07:56:00	-54.0943	-36.2578	11:43:00	-53.7633	-35.4375
33	Transect	ECB2	Day	14/05/2022	12:58:00	-53.8500	-35.3500	16:39:00	-54.1717	-36.1750
34	CTD	ECB2	Coastal	14/05/2022	16:46:00	-54.1733	-36.1817	17:01:00	-54.1733	-36.1950
35	Net	ECB2	Coastal - Target	14/05/2022	18:04:00	-54.1683	-36.0200	18:39:00	-54.1617	-36.0383
36	Net	ECB2	Coastal - Target	14/05/2022	18:51:00	-54.1617	-36.0350	19:10:00	-54.1700	-36.0250
37	Transect	ECB3	Night	14/05/2022	20:03:00	-54.2642	-36.0767	21:25:00	-54.1450	-35.7617
38	Transect	ECB4	Night	14/05/2022	22:50:00	-54.0089	-35.6133	00:45:00	-54.3500	-35.9567
39	Net	ECB3	Coastal	15/05/2022	06:38:00	-54.2650	-36.0667	07:14:00	-54.2750	-36.0383
40	CTD	ECB3	Coastal	15/05/2022	07:33:00	-54.2650	-36.0683	07:44:00	-54.2667	-36.0683
41	Transect	ECB3	Day	15/05/2022	08:03:00	-54.2650	-36.0683	11:38:00	-53.9400	-35.2483
42	CTD	ECB3	Offshore	15/05/2022	11:58:00	-53.9633	-35.2133	12:22:00	-53.9583	-35.2183
43	Transect	ECB4	Day	15/05/2022	13:04:00	-54.0217	-35.1550	16:46:00	-54.3500	-35.9600
44	CTD	ECB4	Coastal	15/05/2022	16:49:00	-54.3500	-35.9650	17:02:00	-54.3517	-35.9517
45	Net	ECB4	Coastal -Target	15/05/2022	18:39:00	-54.2050	-36.1117	18:59:00	-54.2083	-36.0933
46	Net	ECB4	Coastal - Target	15/05/2022	19:09:00	-54.2083	-36.0917	19:29:00	-54.2050	-36.1117
47	Net	CBE	KEP non-target	16/05/2022	06:17:00	-54.2717	-36.4467	06:53:00	-54.2900	-36.4433
48	Net	CBE	KEP non-target	16/05/2022	06:57:00	-54.2917	-36.4417	07:32:00	-54.3067	-36.4183
49	CTD	CBE	KEP Routine	16/05/2022	07:43:00	-54.3083	-36.4100	07:58:00	-54.3067	-36.4100
50	CTD	BoI	KEP Routine	19/05/2022	16:08:00	-54.0200	-37.3900	16:27:00	-54.0333	-37.3933
51	Net	BoI	KEP non-target	19/05/2022	17:20:00	-54.0483	-37.4267	17:56:00	-54.0333	-37.4017
52	Net	BoI	KEP non-target	19/05/2022	17:59:00	-54.0317	-37.4050	18:34:00	-54.0183	-37.4017
53	Transect	WCB4.1	Night	19/05/2022	20:31:00	-53.8695	-37.7280	00:02:00	-53.2983	-37.9167

54	Transect	WCB4.2	Night	20/05/2022	00:40:00	-53.2833	-37.7817	04:16:00	-53.8550	-37.5933
55	Net	WCB4.1	Coastal	20/05/2022	06:38:00	-53.8683	-37.6867	07:13:00	-53.8683	-37.7217
56	CTD	WCB4.1	Coastal	20/05/2022	07:23:00	-53.8717	-37.7283	07:31:00	-53.8700	-37.7300
57	Transect	WCB4.1	Day	20/05/2022	08:16:00	-53.8693	-37.7300	11:44:00	-53.2990	-37.9167
58	CTD	WCB4.1	Offshore	20/05/2022	12:00:00	-53.2917	-37.8683	12:21:00	-53.2900	-37.8733
59	Transect	WCB4.2	Day	20/05/2022	12:58:00	-53.2833	-37.7833	16:58:00	-53.8533	-37.5917
60	CTD	WCB4.2	Coastal	20/05/2022	17:03:00	-53.8567	-37.6117	17:11:00	-53.8533	-37.5933
61	Net	WCB4.1/2	Coastal - Target	20/05/2022	18:13:00	-53.8683	-37.6267	18:34:00	-53.8633	-37.6417
62	Net	WCB4.1/2	Coastal - Target	20/05/2022	18:42:00	-53.8617	-37.6250	19:02:00	-53.8667	-37.6250
63	Net	WCB4.1/2	Coastal - Target	20/05/2022	19:30:00	-53.8250	-37.6783	19:51:00	-53.8300	-37.6600
64	Net	ECB	Offshore - Target	21/05/2022	17:03:00	-54.2450	-35.2900	17:24:00	-54.2567	-35.2783
65	Transect	Offshore to Stromness	Night	22/05/2022	21:33:00	-53.7000	-35.7500	01:40:00	-54.1333	-36.5917
66	CTD	Husvik	Calibration	23/05/2022	08:30:00	-54.1767	-36.6800	08:33:00	-54.1767	-36.6800

Appendix II: Penguin Tagging Details

Tag Type	Tagging Location	Date Tagged	Number Tagged	Notes
Wildlife Computers SPOT-367A PTT	Maiviken	10/5/2022	4	Transmit 250 times / day; off 0500-0700 and 1500 – 1800 due to limited satellite passes.
Wildlife Computers SPOT-367A PTT	Bird Island	10/5/2022	4	Transmit 250 times / day; off 0500-0700 and 1500 – 1800 due to limited satellite passes.
GPS Logging Tags	Bird Island	11/5/2022	4	Need to download data to base station.

Appendix III Fuel Consumption Reports

Period	Activity	Distance (nm)	Fuel Used (m3)	Notes
10/5 – 16/5/2022	ECB Transects	938	24.5	
19/5 – 20/5/2022	WCB Transects, Bay of Isles plankton	249	5.9	Included passage from KEP to Bay of Isles