Darwin Initiative Main & Extra: Final Report

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

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

Submission Deadline: no later than 3 months after agreed end date.

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Darwin Initiative Project Information

Scheme (Main or Extra)	Main
Project reference	DPLUS166
Project title	Improving identification of fish bycatch in the Antarctic krill fishery
Country(ies)	British Antarctic Territory and South Georgia and The South Sandwich Islands
Lead Organisation	British Antarctic Survey
Project partner(s)	Newcastle University, Royal Botanic Garden Edinburgh, MRAG, Government of South Georgia and the South Sandwich Islands, Bangor University.
Darwin Initiative grant value	£ 308,263
Start/end dates of project	01/11/2022 to 16/06/2025
Project Leader name	Philip R Hollyman & Martin A Collins
Project website/blog/social media	*https://www.bas.ac.uk/project/fish-by-catch-in-the-antarctic-krill-fishery/*
Report author(s) and date	Lorena Romero Martínez (BAS), Phil Hollyman (BAS;BU), William Reid (NCU), Martin Collins (BAS), William Goodall-Copestake (RBGE), James Clark (MRAG), Benedict Viney (MRAG), Kate Owen (BAS), Susan Gregory (GSGSSI) 07/08/2025

1 Project Summary

Fish bycatch is a global conservation challenge and a key issue in the Antarctic krill fishery, where non-target fish are regularly caught, often in early life stages (larval and juveniles) that are difficult to identify. This hampers accurate reporting, data collection and the implementation of effective ecosystem-based management.

This project was designed in response to increased concerns reported to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), particularly from scientific findings from the 2021 CCAMLR Working Group on Fish Stock Assessment (WG-FSA) meeting, which highlighted that fish bycatch, particularly of icefish, can exceed targeted fisheries in volume. Data limitations, especially for early life stages, and inconsistent identification prompted the need for better tools and assessments. The primary aim was to improve our understanding of when, where, and which fish species are unintentionally caught during krill harvesting operations. By developing enhanced identification materials for scientific observers on fishing vessels and refining knowledge of fish species distributions across different life stages, the project sought to increase accuracy of identification and reporting of bycatch to support better protection of fish biodiversity and minimise unintended impacts on marine ecosystems.

The project built on existing observer programs and CCAMLR reporting mechanisms. By producing standardised, scalable identification tools and by contributing to a robust baseline dataset, the project supports future environmental assessments and policy development, enabling broader application across the Southern Ocean and beyond.

The biodiversity challenge targeted was the incidental capture of non-target fish species, which can negatively impact vulnerable populations and disrupt marine ecosystem dynamics. The sustainability of the krill fishery is vital for the long-term viability of industries such as aquaculture and the production of nutritional supplements. Ensuring responsible management of this resource safeguards the livelihoods dependent on the resource and contributes to broader food security objectives.

The territories covered in this project are in Area 48 of the CCAMLR Convention area (Figure 1), where krill is actively fished over three sub-areas (48.1 to 48.3) extending from the Antarctic Peninsula and South Shetland Islands (48.1), South Orkney Islands in the Southern Scotia Sea (48.2) and South Georgia in the Northern Scotia Sea (48.3). These areas fall into two UK Overseas Territories (UKOT), South Georgia and the South Sandwich Islands (SGSSI, sub-area 48.3), and British Antarctic Territory (BAT, sub-areas 48.1 and 48.2).

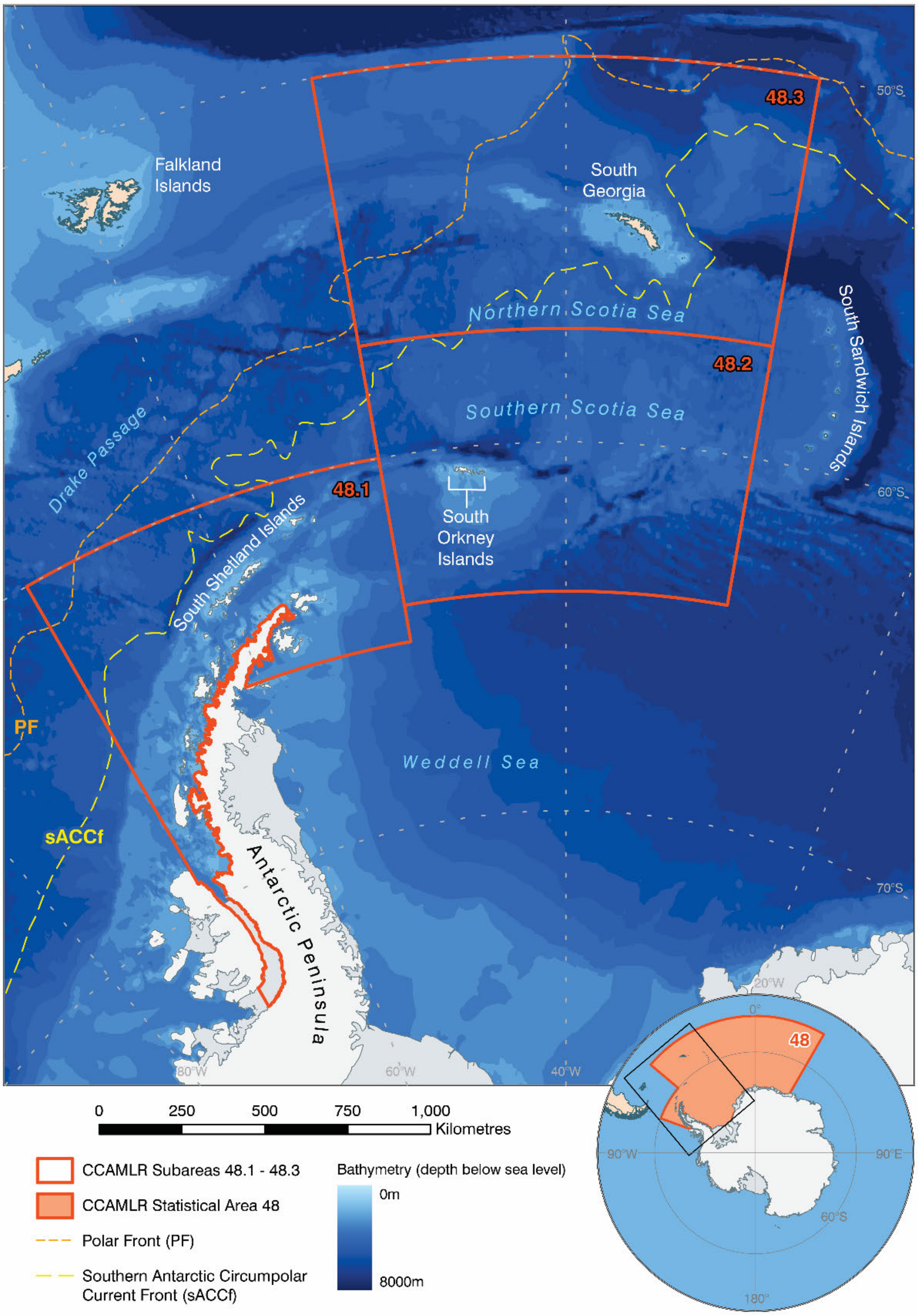

Figure 1: CCAMLR statistical area 48, showing statistical subareas (48.1 to 48.3) where the krill fishery operates. Produced by the Mapping and Geographic Information Centre, British Antarctic Survey, UK. Research and Innovation, 2023.

2 Project Partnerships

During the development of this project, partners were engaged based on both expertise and interest in the proposed work. This resulted in a motivated and committed team with expertise in the necessary areas of research required to successfully complete the project, as well as project partners with responsibility for krill observer provision and training (MRAG) and oversight of the krill fishery at South Georgia (GSGSSI). The issue this project aimed to address is ubiquitous throughout the extent of the fishery for Antarctic krill which extends across two UKOTs (SGSSI and BAT). BAS has a longstanding commitment to undertake science in support of fisheries management for GSGSSI, for which they engage with CCAMLR, presenting research at annual working group meetings (e.g. WG-FSA). It was from these pre-existing commitments that this project was developed. The original team consisted of BAS staff (Hollyman & Collins); MRAG staff (originally Joe Chapman and Steven Young) and GSGSSI staff (Gregory). The two main co-investigators of the project (Reid (Newcastle University) & Goodall-Copestake (Royal Botanic Garden Edinburgh)) provided additional expertise developed from a longstanding interest in the marine science undertaken throughout the region.

The expertise across the team clearly mapped onto each proposed Output. The integrative taxonomy in Output 1 required extensive molecular expertise (Drs Goodall-Copestake and Romero Martínez) along with morphological knowledge of the target species (Drs Hollyman & Reid, Prof. Collins). The review in Output 2 required both a knowledge of existing literature sources (Drs Reid & Hollyman, Prof. Collins) as well as experience of systematic review techniques (Dr Reid). Output 3 required extensive experience of fishery data analysis (Drs Hollyman and Reid) as well as experience of spatiotemporal modelling of said data (Dr Reid). Output 4 required experience of ID guide development (Prof. Collins, Dr Hollyman & the MRAG team). Finally, Output 5 required the access to the scientific observers and the oversight of their training (MRAG). All progress reports from the project were circulated to the wider team for comment and input before final submission, including this final report.

Throughout this project the team has worked well together, maintaining communication through online and in-person meetings. As most project staff only had a proportion of their time dedicated to the project, this sometimes led to work being progressed out of sync with other partners. However, this was mitigated by having a dedicated and skilled PDRA who was involved in the majority of the project outputs.

The project team will continue to work together to develop and submit further peer reviewed manuscripts stemming from Outputs 2 and 3, along with further CCAMLR working group papers with the final outputs of the project. We are also discussing options for follow on projects based on the molecular analyses undertaken for Output 1, led by Dr Romero Martínez.

3 Project Achievements

3.1 Outputs

Output 1: Identification of which life history stages of which fish species are present in SGSSI and BAT waters and potentially caught by the krill fishery

The accurate identification of fish bycatch was central to achieving Output 1. To address this challenge, we developed a genetic identification toolbox enabling DNA barcoding of fish species found as bycatch. This approach complemented traditional morphological identification by experts, creating an integrative taxonomy framework.

To genetically underpin taxonomic designations available for all fish life history stages, we analysed samples collected by fishery observers between 2021 and 2024, as well as specimens from the British Antarctic Survey (BAS) biological archive (Outputs 1.1 & 1.2). This included species previously reported as bycatch but not necessarily caught during the project's timeframe. Additionally, we expanded our collaboration with the Natural History Museum (NHM), London, to obtain further specimens, especially those not represented in observer samples or in the BAS biological Archives.

The genetic toolbox developed and tested during the project included 20 PCR primers for the amplification of the mitochondrial gene *cox*1 and 44 primers targeting the mitochondrial control region (see Annex 5.1 for details). This toolbox enabled the genetic identification of 81 fish species in 51 genera and 23 families (Outputs 1.1 – 1.3).

Results from the integrative taxonomy analysis have been presented at two scientific conferences, FSBI 2023 and ICES 2024, with the latter awarding the project Best poster presentation at the ICES Annual Science Conference in September 2024 (Annex 5.2 and https://www.ices.dk/news-and-events/news-archive/news/Pages/ASC24awards.aspx). The award recognized that this work had broader implications and scope beyond the aims of the original project. Furthermore, two scientific papers summarising key findings from this work were submitted to the CCAMLR WG-FSA in 2023 and 2024, contributing directly to ongoing discussions on bycatch management and ecosystem-based fisheries management (Annexes 5.3 and 5.4).

A major outcome of this work is a peer review manuscript currently in review, which was submitted to the Journal *Polar Biology* on the 3rd of July, 2025 (Annex 5.5). This paper was not in the original log framework.

All the genetic data generated through this work were submitted to the open-access database GenBank, under the Bioproject PRJNA1270765, with accession numbers: PQ686535-45, PQ727374-PQ736688, PQ728912-86, PQ736524-PQ736688, PQ742065-PQ742162, and PQ672629-PQ672777 (Output 1.4). The dataset was made publicly available on 30 June 2025. The associated metadata have been deposited in the BAS Polar Data Centre, and accessible from June 30 2025 at https://doi.org/10.5285/9c459656-5fe4-44f7-860f-da287111016c (Output 1.4). In addition, a physical DNA bank has been established, storing both tissue samples and successfully extracted DNA. These materials have been archived under BAS logistics case number 22903 (Output 1.4).

Output 2: Baseline information assembled for fish life history stages caught as bycatch during krill fishery operations.

The systematic review has been completed (Output 2.1), and a scientific paper is in preparation. Preliminary findings were included in a CCAMLR WG-FSA paper (Annex 5.4), presented at two scientific conferences (Annex 5.6 & 5.7) as well as the GSGSSI Marine Protected Area 5-year review symposium (Annex 5.8). The review aimed to synthesise biological data on the top 20 bycatch species in krill fisheries within the maritime zones of South Georgia, and the British Antarctic Territories (CCAMLR areas 48.1, 48.2 and 48.3) (log framework 2.1.1). Due to regional variation in bycatch, the final review included 29 species, rather than the planned 20.

Peer-reviewed literature was searched via Web of Science (April–July 2023) using Boolean operators combining species names (and synonyms) with biological terms (e.g., fecund*, larv*, matur*, etc.). For example: “Champsocephalus gunnari” AND “fecund*”. The search yielded 1,435 references; after removing 921 duplicates, 514 abstracts were screened in Rayyan (log framework 2.1.2). Of these, 89 papers were fully reviewed. A backward citation search was also conducted to capture missing key literature, though this step took longer than expected. Locating older studies (1970s–1980s) proved difficult due to discontinued journals, journal name changes, and lack of digitisation. Efforts to retrieve these included contacting libraries, publishers, authors, and colleagues, with partial success (log framework 2.1.3).

Data extracted included location, habitat, seasonal occurrence of early life stages, and life history parameters. Annex 5.9 details the subset of data that will be used in the manuscript (log framework 2.1.4). We extended the scope of the review to include adult stages to gain a more complete set of biological traits for each species. For 9 of the 29 species, no life history data were found for the areas where they are caught. For at least two species, no peer-reviewed literature was found at all. Even when data existed for one area, it was often absent in others. To prioritise research needs, a preliminary traffic light system was developed to highlight species requiring urgent attention.

Results are being disseminated through multiple channels. Key findings on larval and juvenile timings have been integrated into an identification guide (Output 4), presented at conferences and in CCAMLR working group papers (log framework 2.1.5). A peer-reviewed manuscript is underway (partial completion of log framework 3.2.2). We are looking at alternative ways to disseminate the results and make them more available to end users beyond the scientific community. The Scientific Committee on Antarctic Research (SCAR) SCARFISH working group on Biology and Life Histories (BLH) is using the basis of our review to extend it to other regions and species using a refined search strategy based on the lessons learnt during this work. The review will be led by the coleaders of the working group which includes Dr Reid. An abstract will be submitted to the 23rd FishBase and SeaLifeBase Symposium (2–3 September 2025), highlighting the importance of integrating life history data into FishBase to broaden accessibility (Annex 5.10).

Output 3: Statistical analysis of CCAMLR bycatch and BAS larval and juvenile fish data and assessment of overlap between fish life history stages and krill fishing operations

The statistical analysis of the bycatch data has been the most challenging element of the project. CCAMLR released data collected by the fisheries observers (SISO) and vessel collected data (C1), which covered the years from the early 1980s to 2024 (log framework 3.1.1). We struggled with reconciling the two data sets because the sampling was undertaken in such different ways but we also had challenges working with the data set separately. This has been recognised by CCAMLR as an ongoing issue (see below). Over the time period covered by the data collection the observer coverage on vessels and the way the samples have been collected has changed dramatically. From 2010, observers have been taking a standard 25 kg krill sample every haul which is searched for fish (adults, juveniles and larvae). The C1 fish bycatch data is generated by the vessel by removing fish from the krill catch during the quality control process.

The two data sets were difficult to compare because they examine different components of the catch. The 25 kg SISO sample generally represents smaller individuals and is often a single sample from the fishing haul, there is no minimum sampling requirement, but observers are aim for one sample per day. In contrast, the C1 data is generated by removing fish from the sorting conveyor belt, resulting in larger fish being found and smaller individuals being missed. Due to the differences in sampling regime and reasoning, it is not possible to simply combine these two data sources.

The exploratory analysis required to understand these data (Output 3.1) indicated that there was very different fish diversity but also size distribution between the two data sets (Annex 5.11). This began to highlight a series of problems for any subsequent analyses. Firstly, the two data sets are not easily comparable and represent different sections of the fish communities. Secondly, we had no way of standardising effort for the C1 data because we did not know how long or thorough the removal fish was during the catch sorting process. Thirdly, we found inconsistencies with the way observers were reporting bycatch and no bycatch. Some observers reported each individual fish within the bycatch while others aggregated the bycatch at a species level to give a total count and weights. Uncertainty still remains around whether all observers were reporting ‘no bycatch’ in a consistent way. We found approximately 30 different ways in which observers made a comment in relation to no bycatch found. Identifying which observer observations had no bycatch is important because we need to add zeros into the data set for the data analysis. Fourthly, we do not know to what extent the SISO data was representative of the whole catch, meaning that we could not reliably scale the 25 kg sample to that of the full catch. As an example, the average krill catch per vessel per haul between 2010 and 2023 was 16.75 tonnes (maximum 130 tonnes), but the bycatch sampling is only 25 kg, giving a subsampling rate of just 0.15%. When expanded to daily catch rates, bycatch sampling is even lower as vessels routinely report daily catches over 1000 tonnes, giving a subsampling rate of < 0.0025%. The ongoing issues around bycatch sampling have been identified by CCAMLR and are not unique to this project. We additionally undertook some training in order to deal with some of the temporal and spatial issues we were facing by trying to analyse these data in a Bayesian context and in response to recommendations around using Generalised Additive Model (GAM) approaches for analysing fisheries and bycatch data by CCAMLR Working Groups on Statistics, Assessments and Modelling (WG-SAM-2024) and Working

Group on Fish Stock Assessment and Incidental Mortality Associated with Fishing (WG-FSA-IMAF-2024). CCAMLR have now paused undertaking their own bycatch analysis until they get better handle on scaling up SISO data to the catch or a given area as well as the coverage of C1 data collection. At the most recent CCAMLR meetings, it was recommended that a questionnaire be sent to all krill vessels to better understand the data collection for both data sources (SC-CCAMLR-43, 2024 – Annex 7).

The exploratory analyses have been valuable. There are interesting observations that can be made based on the descriptive analyses undertaken; plots which highlight spatial differences in the catch composition across the different statistical areas; and give an indication of whether sampling effort is enough to estimate fish diversity in the area (Annex 5.11). The analysis is not as in-depth as previously expected but it is still valuable as it may help inform how future bycatch sampling is undertaken to help with any scaling of catch. It also uncovers differences in the fish bycatch communities through traditional distance-based methods as well as Generalised Linear Latent Variable Models (GLLVM), which will hopefully allow us to understand the influence of environmental and fishery-related variables in the fish bycatch composition. However, given the broader issues we have with raw data, we haven't been able to progress our analyses to a satisfactory conclusion.

Output 4: Updated species identification materials for fisheries observers, vessel operators and other end users.

In parallel with the genetic identification of fish species, all specimens subsampled for DNA were also morphologically identified using standard taxonomic keys (Efremenko 1983; Kellermann 1989; Gon and Heemstra 1990; Collins and Xavier 2022). A high-quality photographic record was created for each specimen, and this visual material was linked to the corresponding genetic data. Both the image and associated metadata were submitted to the BAS Polar Data Centre as part of the project's data outputs.

This photographic material formed the foundation for the development of an easy-to-use, ecologically informed identification guide, with a focus on larval and juvenile fish (Output 4.1). In addition to high-resolution photographs and detailed descriptions of key morphological features, the guide includes species distribution maps and spatial occurrence heatmaps, broken down by size class for each fish species. Initially, the outputs of the spatiotemporal modelling were going to be used to generate predictive distribution maps. Given the difficulties with Output 3 detailed above, these were replaced with presence maps for each species, generated from both the SISO and C1 data, along with fish size and sub-area stratified monthly density plots generated from SISO data, to give observers an indication of when and where and when different sizes of individual species have been seen previously (Annex 5.12). The guide is intended to be a living document, so as new information and imagery are generated, they can be added to the guide in future years.

Drafts of the guide have been presented to CCAMLR WG-FSA and shared in poster format at scientific conferences (Annex 5.2 & 5.4). Additionally, feedback on the first draft was gathered from both current and former fishery observers (see Annex 5.13). Their insights have been instrumental in refining the guide, particularly in improving the clarity, usability, and relevance of the material for end users in the field. The guide will be deployed on selected vessels during the 2025/26 season and a report will then be presented to CCAMLR WG-FSA in 2026.

Output 5: Training event for identification materials end users.

An introduction to the identification materials was delivered by Dr. Romero Martínez in April 2025 as part of the MRAG deployment training for new fisheries observers (Output 5.1). During this session, a draft version of the identification guide was presented (Annex 5.14), and the identification process was explained in collaboration with MRAG partner Benedict Viney.

Once the guide is finalised, it will be distributed to fisheries observers and vessels operating in the region. In addition, tailored training sessions will be provided to ensure that end users are equipped to apply the material effectively in the field.

References:

SC-CCAMLR-43. Report of the forty-third meeting of the scientific committee of CCAMLR. 2024. Hobart, Australia, 540 pp.

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3.2 Outcome

We believe this project has achieved the originally stated outcome of:

Improved understanding of where, when and which fish are caught as bycatch in the krill fisheries, translating into improved species monitoring practice for the benefit of SGSSI and BAT

Whilst the original outputs have changed in certain unexpected ways (see section 3.1), the core outcome has remained at the centre of the project. The indicators outlined in the log framework (0.1 & 0.2) have both been achieved through the activities listed in detail in section 3.1 of this report. These can both be verified with several of the annexes attached to this report. There are several means of verification to support the completion of indicator 0.1 (Annex 5.3 & 5.4) are the CCAMLR papers submitted in 2023 and 2024 which have been shared with both GSGSSI and BAT outlining the annual progression of the project. The project was also presented by Dr Reid at the GSGSSI Marine Protected Area 5-year symposium which engaged a wide range of stakeholders with interests in fisheries management at South Georgia (Annex 5.8).

Annex 5.5 is a peer reviewed paper submitted to Polar Biology which has also been shared with GSGSSI and BAT and has Susan Gregory as a co-author (project partner, GSGSSI) and Annex 5.12 is the ID guide that includes information generated during Outputs 1, 2, 3 and 4. Indicator 0.2 can be verified by the generation of an observer bycatch ID guide (Output 4 – Annex 5.12) and the presentation of this guide at the most recent krill observer training event, run by MRAG (Annex 5.14). We anticipate that the improved ID guides will result in more accurate data collection in future krill fishery operations, although this will only be verifiable once the guides have been in use for several seasons. The guide contains spatiotemporal observations of bycatch across SGSSI (sub-area 48.3) and BAT (sub-areas 48.1 & 48.2) waters, and is underpinned by the integrated taxonomy undertaken for Output 1.

3.3 Monitoring of assumptions

Throughout this project, important assumptions that were originally identified in the log frame were monitored. These will be listed and discussed in turn.

Outcome assumption: Data generated at an appropriate resolution to understand spatial and temporal as well as species level differences for bycatch to allow for informed management

This assumption relates to the data required for the planned spatiotemporal modelling from Output 3. As previously discussed, whilst the fishery data are present at a haul-by-haul resolution, the discrepancy between the two major data sources and questions around the observer reporting limited our ability to undertake the originally planned analyses. These analyses were to be used to understand what variables may be associated with spatial and temporal fish bycatch along with integrating information from the systematic review gain an understanding of risk of capture (Output 3.2). Even though the original modelling has not been possible, we are now in the process of a community-based analyses, which will help to inform fisheries managers at CCAMLR of spatial and temporal differences in the bycatch communities within the krill fishery, as opposed to individual bycatch species. We anticipate the submission of a peer reviewed paper in the next few months along with the submission of a working group paper to CCAMLR WG-FSA 2025 that may also include recommendations on how to improve bycatching reporting based on the issues we have found with analysing these data (Annex 5.11).

Output 1 assumption: New samples successfully shipped to UK in good enough condition for integrative taxonomy.

This assumption related to the condition of samples collected during the project, and whether they would be in good enough condition to undertake integrative taxonomy. Samples were collected for this project over several seasons of the Antarctic krill fishery (2021 - 2024). Alongside this, the pre-existing sample collections held by the British Antarctic Survey were utilised to increase the coverage of species. These samples allowed the identification of 81 separate species. Whilst not every specimen was in good enough condition to generate images for the morphological identification section of the ID guide, it was possible to extract molecular samples. In general, there were multiples of each species, allowing for the selection of the best specimens for image capture. Where this was not possible, existing imagery from previous ID guides was used as a placeholder. Due to the inconsistent nature of the fish sampling (i.e. low chance of sample collection during the SISO 25 kg krill sub-sample) some species which were well represented in the bycatch data, were not found during the 4-years of sampling. As the guide is a ‘living document’, any missing images and/or samples can be added in future years if collection is possible.

Output 2: Sufficient baseline information is available for collation.

This assumption related to the systematic review of life history parameters, and whether there would be enough existing information to extract for the 20 species of interest. Due to differences in bycatch composition between the three sub-areas, the original 20 species were increased to 29. For 9 of the species, no life history data were found for the areas where they are caught. For at least two species, no peer-reviewed literature was found at all (Annex 5.7). Even when data existed for one area, it was often absent in others. This was a major finding from the review, highlighting the scarcity of life history information of fish species in this region, even ones routinely caught as bycatch in a major international fishery. This finding has formed the backbone of a review project by the newly formed SCARFISH working group on Biology and Life Histories (BLH), extending our work to other regions and species using a refined search strategy based on the lessons learnt because of this work (Annex 5.10).

Output 3: Bycatch data is released by CCAMLR after a data request.

These data were released by CCAMLR in January 2024 with no issue.

Output 4: Genetic analysis has successfully improved species assignments in the original (morphology only) identification materials.

This assumption related to several instances where morphological identification is extremely difficult, and where previous molecular work has revealed incorrect species assignments. Accordingly, we believed the molecular work undertaken in Output 1 would successfully improve species assignments. Bioinformatic analysis of COX-I sequences has help to clarify ambiguous identifications of Nototheniidae and Myctophidae larvae and juveniles across all seasons and sub-areas. Table 1 (reproduced from Annex 5.5), highlights that 13 of the 25 main observer sampled species from Output 1 had at least one instance of misidentification. We hope that the improved materials in the ID guide will help to mitigate this is future seasons.

Table 1. Comparison of genetic and observers’ identifications of fish specimens collected as bycatch. Observers recorded identification for species of Channichthyidae (a), Nototheniidae (b) and Myctophidae (c). Bold values show agreement with genetic identification, red values show disagreement.

a)

	Genetic ID (n=144)								
Species code	ANI	SSI	SGI	KIF	WIC	FIC	JIC	PMA	TIC

Observers ID	ANI	39								
	SSI		17				2			
	SGI			16						
	KIF				14					
	WIC	3	1	4	2	12				
	FIC		5		2		7			
	JIC		1	3				4	1	
	PMA			7					3	
	TIC								1	0

b)

		Genetic ID (n=71)							
	Species code	NOL	NOG	NOD	TRH	TRL	TRW	TLO	ANS
Observers ID	NOL	33	1			2			
	NOG	2	8		1				
	NOD			5					
	TRH				6				
	TRL					3	1		
	TRW					1	1		
	TLO							0	
	ANS								7

c)

		Genetic ID (n=66)							
	Species code	ELN	ELC	KRA	PRM	PRT	PRP	GYN	GYR
Observers ID	ELN	22	2						
	ELC	9	6		1				
	KRA			10					
	PRM				1				
	PRT					1			
	PRP			3			0		
	GYN							10	
	GYR								1

Output 5: All observers will be able to attend training sessions given international travel restrictions due to the COVID-19 pandemic.

COVID-19 restrictions were no longer in place when the training was undertaken.

The pathway to change from the original application holds true, it stated:

The research project addresses key questions in krill fisheries management related to the interactions between early life history stages of fish and the fisheries, and the development of improved mechanisms for identifying fish bycatch to enhance reporting to CCAMLR. The research is timely because the krill fisheries are expanding yet there are key gaps in our understanding of early life history stages of bycatch species of fish, and fish are currently not *covered in krill risk assessment management. The project team will use archived and new fish samples (underpinned by morphological and molecular analyses) and data from existing sources to understand the spatiotemporal dimensions to fish bycatch in the krill fisheries, understand what, when and where the risk to bycatch occurs and develop tools for improved monitoring into the future. The results will be published in peer-reviewed scientific literature, presented to CCAMLR working groups and GSGSSI through existing marine science management meetings and stakeholder events. The longevity of the project will be maintained through the development of improved fish bycatch guides and new training materials for fisheries observers. The results are expected to feed into CCAMLR and GSGSSI management of the krill fisheries.*

We feel that the achievements of the project, outlined and evidenced in section 3.1 highlight that this pathway to change does indeed hold true. We have improved the mechanisms for identifying bycatch through the generation of a new ID guide, using newly collected and archived samples from the krill fishery. Within this guide are figures highlighting the spatial and temporal catches of each species, stratified by fish size. These results have formed the basis of two CCAMLR working group papers (Annexes 5.3 and 5.4), several conference presentations (Annexes 5.2, 5.6, 5.7, 5.8), one submitted peer reviewed paper (Annex 5.5) and at least two further papers (e.g. Annex 5.11).

One major change in the Antarctic krill fishery generally is the manner in which it is managed by CCAMLR. When the original application was developed, the spatial distribution of effort within the fishery was managed by a Conservation Measure (CM) 51-07. This CCAMLR management measure designated specific catch limits within sub-areas 48.1, 48.2 and 48.3. CM 51-07 has historically been considered precautionary due to the low overall exploitation rate of the target species (620,000 tonnes catch vs. 60.3 million tonnes of krill biomass). However, it resulted in spatially constrained fishing within each sub-area in the locations of highest krill abundance, leading to potentially damaging overlap with higher predator populations (Ratcliffe et al., 2021; Ryan et al., 2023). During the development of this application there was a large international effort to generate a new management framework, as CM 51-07 was set to expire. This management would split the catch of the fishery into fine scale areas with the spatial extent and catch limits informed by the spatial overlap with populations of krill dependant predators (Warwick-Evans et al., 2022). A future ambition of this project was to feed into this management approach, potentially providing the spatiotemporal model outputs of larval and juvenile fish as an extra layer of information for the spatial overlap approach (log framework 3.2). Unfortunately, at the 2024 CCAMLR meetings CM 51-07 expired and no agreements were made regarding the new management approach (SC-CCAMLR-43, 2024). This means that there is now no spatial management in place and the full allowable catch within a single year (620,000 tonnes) could, potentially, be taken from a single location. This is obviously of concern from a conservation standpoint and we hope that outputs of this project highlight the issues with the current data collection within the fishery, as well as providing new materials to improve the accuracy of the collected data. With the formation of the SCARFISH group, the project team hope to expand the work started in this project, collaborating with the international community to further improve the management of the Antarctic krill fishery.

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WG-FSA-IMAF-2024. Report of the Working Group on Fish Stock Assessment and Incidental Mortality Associated with Fishing. Hobart, Australia, 30 September - 11 October 2024. 168 pp. Available here: https://meetings.ccamlr.org/system/files/meeting-reports/e-sc-43-a7.pdf

WG-SAM-2024. Report of the CCAMLR Working Group on Statistics, Assessments and Modelling Leeuwarden, The Netherlands, 24 - 28 June 2024. 48 pp. Available here: https://meetings.ccamlr.org/system/files/meeting-reports/e-sc-43-a5.pdf

3.4 Impact

The original impact statement for the project was as follows:

The ecosystem-based management and conservation of biodiversity within SGSSI and BAT waters is enhanced by an improvement in the precision of reporting of Antarctic krill fishery bycatch.

We feel that this project has already delivered impact in line with the original statement, with the capacity to increase this impact over time. It has contributed to the improved management of the krill fishery through the development of a new ID guide (Output 4, Annex 5.12), the dissemination of findings at CCAMLR WG-FSA, a key stakeholder (Annexes 5.3 & 5) and the production of a scientific paper (Annex 5.5), with the ambition for at least two more from existing project data (e.g. Annex 5.11). The new ID guide, which has already been introduced to fishery observers (Annex 5.14) should improve the accuracy of bycatch data reporting within the fishery in future seasons. The working group (WG-FSA) and scientific papers have and will continue to contribute towards the improved ecosystem-based management of the krill fishery, through direct engagement with the regional fisheries management organisation responsible for the krill fishery (CCAMLR) as well as the wider scientific community through groups like SCARFISH (see section 4.4). One of the papers currently in development (Annex 5.11) will contain recommendations for improving the disparity between the C1 and SISO data sources on board krill vessels, with the aim of making our originally proposed spatiotemporal modelling a possibility with data from future fishing seasons.

4 Contribution to Darwin Initiative Programme Objectives

4.1 Project support to the Conventions, Treaties or Agreements

During the development of this project, there were key international conventions and research programs to which we anticipated the project would contribute. The main one of these being CCAMLR, a regional fisheries management and conservation body responsible for the Antarctic and sub-Antarctic. The UK is an original signatory to CCAMLR, GSGSSI operates fisheries within the CCAMLR area and BAT is fully contained within the CCAMLR area. CCAMLR has an ecosystem-based approach to management as outlined in article II of the CCAMLR convention (https://www.ccamlr.org/en/organisation/camlr-convention-text#II). Ultimately, the convention states that populations of both target (e.g. Antarctic krill) and bycatch (e.g. larval/juvenile fish) need to be maintained, as do their ecological relationships. Without core information on the life history and biology of exploited species, it is not possible to manage them to the ideals outlined in the CCAMLR convention text.

Our work in this project has generated information which has helped and will continue to help the UK support the ecosystem-based management of the Antarctic Krill fishery within CCAMLR. Output 2 has highlighted large knowledge gaps around key biological and life history information for many of the species caught as bycatch within the krill fishery. This gives researchers clear, urgent targets for future work to fill these knowledge gaps through collaborative international networks such as SCARFISH. Output 3 has highlighted several issues with the current data collected within the fishery, these issues are currently being written into a scientific manuscript with clear recommendations for improvement that will be submitted as a peer reviewed paper, and to a CCAMLR working group (Annex 5.11). Output 4 has generated an ID guide (Annex 5.12) with aims to improve the accuracy of bycatch identification going forward. This will help with the future quantification of bycatch within the fishery.

When this project was developed, a core piece of the regulations managing the krill fishery was CCAMLR conservation measure 51-07. This has now expired, the repercussions are not yet fully understood but are likely to change the dynamics of the fishery over the coming years (more information on this can be found in section 3.3). This only increases the importance of the work undertaken during this project. There will be a strong desire within much of the international community to develop and propose new management, and the ability to collect more accurate data and fill known research gaps should make this job easier.

This project was designed with the Darwin Plus R10 objectives in mind: to increase the area of coverage, effectiveness and condition of protected areas in pursuit of global targets, and the implementation of National Biodiversity or Environment Action Plans. The research contributed towards research needs in Themes 2, 6 and 7 of GSGSSI's Research and Monitoring Plan and MPA objectives covering biodiversity and sustainable fisheries management. The Government of the British Antarctic Territory (GBAT) also have strategic goals to protect the environment such as: 'To develop a better understanding of the BAT environment' and 'To identify rare flora and fauna and/or special areas across the BAT and development of protection and conservation measures' which work undertaken during this project has directly supported.

The outputs from this project and directly address the GSGSSI's Research and Monitoring Plan 2020-21, and the 2019 Krill Fisheries Management Plan. This in turn contributes to the UK and GSGSSI commitments to CCAMLR. In the initial proposal we anticipated the results would feed directly into the GSGSSI MPA independent review and the project was presented (by invitation) at their 5-year MPA review symposium by Dr Reid (Annex 5.8).

4.2 Project support for multidimensional poverty reduction

Due to the nature of the two overseas territories covered by this project (GSGSSI and BAT), the work undertaken here has not contributed to multidimensional poverty reduction. This is due to the fact that neither GSGSSI or BAT have any resident populations, aside from BAS and GSGSSI staff temporarily resident on specific scientific bases.

4.3 Gender Equality and Social Inclusion (GESI)

As stated in section 4.2, this project does not engage with communities within the overseas territories, and can therefore only comment on the project team itself.

Communication between team members has been effective throughout, with the intention of giving all team members the chance to participate. The team is comprised of 33 % women, with 25 % of the project partners (BAS and GSGSSI) led by women. Authorship of outputs is also done collaboratively with opportunities for all team members (as well as external collaborators) to participate with all completed working group and peer reviewed manuscripts led by Dr Romero Martínez.

GESI Scale	Description	Put X where you think your project is on the scale
Not yet sensitive	The GESI context may have been considered but the project isn't quite meeting the requirements of a 'sensitive' approach	

GESI Scale	Description	Put X where you think your project is on the scale
Sensitive	The GESI context has been considered and project activities take this into account in their design and implementation. The project addresses basic needs and vulnerabilities of women and marginalised groups and the project will not contribute to or create further inequalities.	X
Empowering	The project has all the characteristics of a ‘sensitive’ approach whilst also increasing equal access to assets, resources and capabilities for women and marginalised groups	
Transformative	The project has all the characteristics of an ‘empowering’ approach whilst also addressing unequal power relationships and seeking institutional and societal change	

4.4 Transfer of knowledge

The project partners have and continue to seek opportunities to transfer the knowledge developed in this project to the wider scientific community. Primarily this has been done through the production of working group (Annexes 5.3 and 5.4) and peer reviewed (Annex 5.5) papers, and the presentation of work at conferences (Annexes 5.2, 5.6, 5.7 & 5.8) and CCAMLR working groups. In the original log framework only one peer reviewed paper was indicated, based on the proposed spatiotemporal analysis of bycatch data (Output 3.2). Whilst we have not yet been able to produce a paper based on Output 3 (see section 3.1), we have been able to produce and submit an additional peer reviewed paper based on Output 1, led by our PDRA, Dr Romero Martínez. We also have two further peer reviewed papers in development based on Outputs 2 (Annexes 5.9 & 5.10) and 3 (Annex 5.11). However, the paper from Output 3 will be more descriptive of the data, investigating bycatch community composition, outlining the issues faced and making recommendations for future sampling.

Over the last year, the SCARFISH group has formed and the work undertaken during this project directly feeds into several of the SCARFISH working groups, including: Genomics + Physiology + Pathology, Biogeography, Modelling and Management tools and Biology and Life History (BLH). Many of the project team (PRH, LRM, MC & WR) are involved with at least one of these working groups and the BLH group is also being co-led by one of the project co-investigators, Dr Will Reid. Through this network, we will continue the transfer of knowledge developed during this project into the future, helping to shape research in this field over the coming years.

[redacted]

4.5 Capacity building

The main area of capacity building within this project was the focus of Output 5. The indicator from this Output was:

All krill observers employed by MRAG ahead of fishing activities in 2025 trained to use updated identification materials in March 2025.

This training was held slightly later than originally planned, but Dr Romero Martínez presented the guide and how to use it at this event (Annex 5.14).

As stated in section 4.2, there are no permanent residents in SGSSI or BAT within whom capacity could be built. The members of GSGSSI engaged with the management of the fishery are not directly involved at the point where our developed materials could be applied.

5 Monitoring and evaluation

Throughout the length of the project meetings were held with all team members which helped to monitor and assess possible risks. The frequency of full team meetings changed throughout the project, at periods they were on a monthly basis or less, and during busy periods (e.g. over the summer of 2024) they were held on a fortnightly basis. Additionally, the PL (Dr Hollyman and latterly Prof. Collins) and PDRA (Dr Romero Martínez) met on a fortnightly basis to ensure progress was made.

Throughout the project, more substantive visits by team members were undertaken to progress specific sections of work. Dr Romero Martínez visited both Newcastle University and Edinburgh to work with Drs Reid and Goodall-Copestake respectively for a week at a time which helped to progress Outputs 1 and 2 early in the project. The results of these meetings were fed back to the full team at group meetings. Most recently (May 2025), Dr Hollyman visited Dr Reid in Newcastle to progress Output 2 and Output 3.

Two in-person full team meetings were also held during the course of the project, one in June 2023 (BAS Cambridge) and one in January 2024 (Newcastle University, Annex 5.15). These meetings were instrumental in making team decisions about the forward direction of the project and updating the wider project team on the current status of the work.

Moreover, all the information and data generated by the different outputs has synthesised in a shared folder accessible to collaborators.

6 Lessons learnt

Throughout this project there have been several important lessons learned, all of which have been managed and/or mitigated in some way to ensure the successful completion of the project.

In terms of project management, one issue faced at several points was staff turnover and changing affiliations of core team members. During the development of the bid, two staff members were engaged and included in the bid from MRAG (Joe Chapman and Steven Young). Between the submission of the final proposal and the start of the project, Steven left MRAG and was replaced by Jordan Moss. Over the subsequent 18 months, both Joe Chapman and Jordan also left MRAG, being replaced by Dr James Clark and Benedict Viney. The changing staff makeup of the MRAG team had no lasting impact on the project as all new team members were engaged and helpful with the delivery of the project. However, Joe Chapman was planning to help with both Outputs 2 and 3, and he also had key intellectual input to the development of the project, so it was unfortunate that he moved on. Drs Will Goodall-Copestake and Phil Hollyman both changed institutes during the project, thankfully it was possible to officially make this change for both parties through a change request. In the case of Dr Hollyman, this entailed making Prof. Martin Collins the Co-PL to ensure a smooth ending to the project which was ultimately being led by BAS. Kate Owen (a replacement for Phil Hollyman within BAS) was also added to the project using a small amount of the staff time allocated to Dr Hollyman to ensure the strong links with the South Georgia science team were maintained and make use of Kate's extensive experience. None of these staff changes had a long-lasting impact on the project, but all came with a large administrative burden in the form of multiple change requests and collaboration agreements between partners. It is not possible to plan for these types of changes within a project, but in future we would set aside more time for the administration surrounding changes such as these.

Output 1. In the early stages of the project, there were initial unsuccessful attempts to amplify the control region of sampled fish species. This was resolved by holding a meeting where we discussed the most efficient approach to overcome the technical difficulties of amplifying the targeted region. It was considered that amplifying longer control region fragments followed by use of MinIon NGS sequencing technology would be both time and cost efficient compared to standard Sanger sequencing. This was only applicable for the barcoding sequencing of the control region, due to the high variability observed between fish species in this region. Thus, to enhance the probability of amplification, primers were designed based on the location of conserved sequence blocks (CSBs) within the control region. However, this would amplify >1000bp which under standard sequencing methods would be costly and time consuming. Hence, it was considered beneficial for the project to purchase a MinIon sequencer. This approach did not result in any overspend in the budget and enhance our ability to complete Output 1.

Output 2. The systematic review took longer than originally expected. Through the process, we worked as a team to complete this task. A key lesson learned from the exercise was that the time allocated to the task was less than required. We had a protocol which the team followed in order to extract information/ data. We were also too strict in some of the criteria which were subsequently relaxed meaning that we had to review some papers multiple times to extract the information. These did not have an impact on the budget nor the subsequent Outputs.

Output 3. The statistical modelling of the data set has proved challenging as detailed in several previous sections (e.g. 3.1). There are several important issues with the data, which have been recognised by CCAMLR, leading to a request for information from active krill vessels developed at the WG-FSA last year. Whilst initially we had planned to undertake spatiotemporal modelling of the data at a species level, we have changed focus to a more descriptive analysis of the bycatch data with analysis of variation in bycatch communities between years and sub-areas (Annex 5.11 – see section 3.1, Output 3 for detailed breakdown). One lesson learned from this experience is to not assume data are of a consistent quality to allow analyses like the ones we had planned. Initial exploration of the data was promising when we received it, but when we began the analysis in earnest (slightly later than initially expected due to delays with Output 2), we discovered one problem after another. We are still exploring ways to analyse these data. A further lesson learned in relation to this Output was the dedicated time required, this would have been far more effective had we employed a dedicated staff member to work on this aspect of the project full time.

7 Actions taken in response to Annual Report reviews

There were several key points of feedback contained in the reviews from the annual reports from years 1 and 2.

From annual report 1, the feedback centred around the lack of supporting information associated with the report.

'*No evidence was provided with the AR. Please consider whether evidence is available to support every statement made in the report. In particular, MoV will be highly likely to generate outputs that can be provided. Please do not, however, put any extra effort into generating evidence. Think of evidence as illustrative. Some examples of material might be: meeting minutes; agreements, contracts, MoU; lab protocols; field manuals; training manuals; slide decks; posters; photos (of equipment, meetings, fieldwork, labs, samples, anything); species assessments; management plans; drafts of articles and reports; internal reports; policy recommendations; databases (perhaps screenshots); maps; data record sheets; risk assessments*.'

This was easily rectified at the both the following half year and annual report. A whole range of supporting evidence was provided with these subsequent reports to address this concern.

From the second annual report, there was also one main comment that needed addressing:

"*It would be useful if the project could briefly address engagement with international partners*

The exit strategy relies largely on the dissemination of project outputs to partners and the wider stakeholder and scientific community. Project partners include BAS, MRAG and GSGSSI which ensures uptake of project outputs by relevant UK entities. The UK partners have a high degree of ownership of the project and therefore the exit strategy is appropriate and likely to be successful.

CCAMLR is the international coordinating body in the region, and could potentially serve to catalyse interest and uptake of project outputs among international partners. Other than the *dissemination of project outputs to CCAMLR, there is no discussion in the application or the AR of more active engagement with partners with a view to encouraging broader exploitation of the resources developed by the project. While this aspect is beyond the scope of the Outcome and Impact statements, it would be useful if the next AR could briefly address the issue of engagement with international partners and their interest in project outputs.*"

Over the project as a whole there has been extensive contact with international groups to this end. However, this was not well reflected in the last annual report.

Firstly, the presentation of project outputs at the ICES annual science conference (Annexes 5.2 & 5.7) generated substantial conversation with several other research teams with similar interests. Specifically, the Australian Antarctic Division (AAD), who have an extensive krill focussed research team. This conversation led to a funding application to the Antarctic Wildlife Research Fund to continue some aspects of this work (led by Dr Romero Martínez), in collaboration with Dr Leonie Suter from the AAD earlier this year.

The work was also presented at two CCAMLR WG-FSA meetings (Annexes 5.4 and 5.4), where it generated discussions with several international research teams that have an interest in krill fishery management as well as the development of ID guides for fishery observers. At the meeting in 2023 when we presented a project update, we asked for engagement in the form of samples of species we were missing. Whilst this initially generated interest, we ran into difficulties around shipping samples. The aim is to present final project outputs at the WG-FSA meeting in 2025 (bycatch diversity and distribution based on Annex 5.11) and the full ID guide in 2026, following a trial use in the fishery over the next season.

The work has also generated a lot of interest in a newly formed international research group focussed on fish, stemming from the Scientific Committee on Antarctic Research (SCAR) called SCARFISH. There outputs of this project are of interest to several working groups within SCARFISH and as detailed in sections 3.1 and 4.4, they will feed into the development of future work through this international network.

8 Risk Management

Only one risk has been an issue over the last 12 months, the issues with the bycatch data detailed in section 3.1 which have made spatiotemporal modelling unfeasible (Output 3). We had identified this as a potential risk during the initial log framework as an assumption associated with the Outcome. This issue with the data was not initially apparent as we were building our modelling approach off of existing approaches to generating scaled bycatch data from CCAMLR (WG-FSA-IMAF-2024). Whilst there were initial issues identified withing the CCAMLR secretariat working group papers related to the harmonisation of SISO and C1 data, these were only deemed insurmountable at the most recent CCAMLR meeting (SC-CCAMLR-43, 2024 – Annex 7). This led to a request for information from active fishing vessels to help clarify this issue. Given the scale of the issue, it is unlikely that historical data will be useable in the format we had hoped, even with the improved understanding of C1 and SISO data from vessels. One main reason for this is that is the unknown coverage of C1 sampling (as this is not recorded) and the relatively low sampling effort of observers when compared to krill catch (See section 3.1 Output 3 for more detail).

As an alternative to this proposed spatiotemporal work, over the last few months we have proceeded with a descriptive analysis of the bycatch data, detailing the spatial and temporal changes in bycatch composition. We are also undertaking community-based analyses of the bycatch community, investigating differences between sub-areas and years using traditional distance-based approaches and if possible, a Generalised Linear Latent Variable modelling framework (Annex 5.11).

9 Scalability and Durability

We are confident that this project will have a lasting impact on the management of, and data collection within, the Antarctic krill fishery. Through the development of multiple working group and scientific publications, the approach and findings of this work will be available to the wider scientific community as well as fishery managers, informing future work and management. The integrative taxonomy approach undertaken here is detailed in the paper currently under review (Annex 5.5), assuming it is eventually published it will be available to fishery managers globally who may be facing similar issues of bycatch quantification and misidentification, allowing them to copy the approach used here. All genetic outputs are also available in open access databases (e.g. Gen-Bank), making them accessible to the wider scientific community. These data as well as the results of the review (Output 2) are already feeding into international scientific collaborations through platforms like SCARFISH (see sections 3 and 4 for details).

The ID guide (Annex 5.12) will be deployed on vessels within the Antarctic krill fishery next season through MRAG as a trial, and it will be submitted to CCAMLR for approval at the FSA working group in 2026 (incorporating feedback from the trial). If the working group approves the document, there is then the possibility to translate the guide into several languages for use on vessels throughout the fishery. Currently, only observers familiar with English would be able to utilise it. Even if it is only utilised by English speaking observers, the guide would still be used throughout all sub-areas where the fishery operates, but translation to other languages would enable its use on all vessels within the fishery. As it is a living document, it should stay relevant and useful for years to come as new images and information can be added when they become available.

10 Darwin Initiative identity

Any time work resulting from this project has been presented at conferences (Annexes 5.2, 5.6 & 5.7), symposia (Annexes 5.2 & 5.8), working groups (Annexes 5.4 & 5.4) and in submitted papers (Annex 5.5) we have taken the opportunity acknowledge the Darwin plus programme, either through the inclusion of the logo on all presentation materials or directly in the funding statements and acknowledgements within the text. In all instances, the Darwin funding associated with this project has been identified as distinct, as it was the only source of funding for this work. The Darwin Plus programme will also be acknowledged in any future outputs that contain data generated during this project.

GSGSSI and BAT are fully aware of the Darwin Plus programme and their contribution to this project, having either been involved throughout, or provided letters of support during bid development.

11 Safeguarding

[redacted]

[redacted]

12 Finance and administration

Project costs from 2024/25 as well as the finances from April – June are presented here to cover the full period since the last annual report.

12.1 Project expenditure

Project spend (indicative) since last Annual Report	2024/25 Grant (£)	2024/25 Total actual Darwin Initiative Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs (see below)	[redacted]			
Consultancy costs				
Overhead Costs				
Travel and subsistence				

	[redacted]			
Operating Costs	[redacted]			
Capital items (see below)	[redacted]			
Others (see below)	[redacted]			
TOTAL	£116,016	£104,359.77		

Staff employed (Name and position)	**Cost (£)**
Lorena Romero Martinez	[redacted]
Philip Hollyman	
Will Reid	
Will Goodall-Copestake	
James Clark	
Benedict Viney	
Kate Owen	
TOTAL	

Other items – description	**Other items – cost (£)**

Software (for molecular work) Consumables for lab work	[redacted]
TOTAL	

Project spend (indicative) since last Annual Report	**2025/26 Grant (£)**	**2025/26 Total actual Darwin Initiative Costs (£)**	**Variance %**	**Comments (please explain significant variances)**
Staff costs (see below)	[redacted]			
Consultancy costs				
Overhead Costs				
Travel and subsistence				
Operating Costs				
Capital items (see below)				
Others (see below)				
TOTAL	**£23,464.24**	**£21,050.26**		

Staff employed (Name and position)	**Cost (£)**
Lorena Romero Martinez	[redacted]
Philip Hollyman	
Will Reid	
Will Goodall-Copestake	
James Clark	
Benedict Viney	
Kate Owen	
TOTAL	

Other items – description	Other items – cost (£)
Financial audit costs	[redacted]
TOTAL	

12.2 Additional funds or in-kind contributions secured

Matched funding leveraged by the partners to deliver the project	Total (£)
British Antarctic Survey	[redacted]
Newcastle University	
Scottish Association for Marine Science	
GSGSSI	
TOTAL	

Total additional finance mobilised for new activities occurring outside of the project, building on evidence, best practices and the project	Total (£)
TOTAL	

12.3 Value for Money

This project brought together a multidisciplinary team with a proven track record of working together in the area of study. With BAS as the lead institute, the project was able to leverage considerable experience working in GSGSSI and BAT waters, along with extensive sample collections of fish and larval fish that were utilised at no cost to the project. With MRAG and GSGSSI as project partners, the collection of samples by fisheries observers was also organised at no cost to the project. Use of commercial fishing vessels as sampling platforms allowed multiple locations to be sampled at once and negated the requirement for expensive scientific ship time. Shipment of samples to the UK was undertaken using BAS logistics at no extra cost.

The staff costs associated with the project covered the cost of a full time PDRA (Lorena Romero Martinez) who was 100% on the project for the full duration. The initial recruitment process also utilised the resources within BAS. The remaining staff costs covered partial salary for a further seven staff who brought key skills and knowledge to the project.

Early in the project, the approach to molecular analyses was changed by purchasing a MinION unity that allowed in-house sequencing. This resulted in reduced molecular costs over the whole project.

Virtual team meetings were used to keep more regular contact and engage proactively with stakeholders in lieu of costly in-person meetings.

The project has resulted in two working group (WG-FSA) papers (with a minimum of two more planned), one submitted peer reviewed paper (with two more planned), several conference presentations, multiple publicly available resources and an ID guide for fishery observers. The work undertaken in this project is already forming the basis of future scientific funding proposals and is feeding into international scientific groups.

13 Other comments on progress not covered elsewhere

14 OPTIONAL: Outstanding achievements of your project (300-400 words maximum). This section may be used for publicity purposes.

I agree for the Biodiversity Challenge Funds to edit and use the following for various promotional purposes (please leave this line in to indicate your agreement to use any material you provide here).

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)**
				Yes / No
				Yes / No
				Yes / No
				Yes / No
				Yes / No

Annex 1 Report of progress and achievements against logframe for the life of the project

Project summary	Progress and achievements
Impact The ecosystem-based management and conservation of biodiversity within SGSSI and BAT waters is enhanced by an improvement in the precision of reporting of Antarctic krill fishery bycatch.	This project has contributed to the improved management of the krill fishery through the development of a new ID guide, the dissemination of findings in working group and scientific papers and conference presentations. The new ID guide will improve the accuracy of data reporting within the fishery in future seasons, improving bycatch data reporting. The working group and scientific papers have and will continue to contribute towards the improved ecosystem-based management of the krill fishery, through direct engagement with the regional fisheries management organisation responsible for the krill fishery (CCAMLR) as well as the wider scientific community through groups like SCARFISH.
Outcome Improved understanding of where, when and which fish are caught as bycatch in the krill fisheries, translating into improved species monitoring practice for the benefit of SGSSI and BAT	Through Outputs 1, 2, 3 and 4, this project has utilised several different approaches to achieve this outcome. The integrative taxonomy from Output 1 provides detailed information on the fish species found as bycatch in GSGSSI and BAT waters during krill fishery operations. Output 3 has provided spatial and temporal information on the historical catches of these bycatch species, using all available data sources and stratifying results by size category for individual species. The results of Outputs 1, 2 and 3 have informed the creation of a bycatch ID guide (Output 4) which will result in improved species monitoring withing GSGSSI and BAT waters.
Outcome indicator 0.1 Baseline assessment of fish bycatch in the krill fishery occurring in SGSSI and BAT waters completed by October 2024	The baseline assessment of fish bycatch has been undertaken using several different methods such as integrative taxonomy (Output 1), systematic literature reviews (Output 2) and analysis of fishery generated data (Output 3). Providing a range of accessible outputs (e.g. data repositories, ID guides and papers) for GSGSSI and BAT.
Outcome indicator 0.2 Fisheries observers better informed on bycatch identification by March 2025	A preliminary introduction to the identification materials (Output 4) was delivered by Dr. Romero Martínez in April 2025 as part of the MRAG deployment training for new fisheries observers (Output 5). This guide will be tested in the field during the next fishery season and presented to CCAMLR in 2026.
Output 1 Identification of which life history stages of which fish species are present in SGSSI and BAT waters and potentially caught by the krill fishery	

Output indicator 1.1 Genetically underpinned taxonomic designations available for all fish life history stages stored in BAS archives for specimens collected in GSGSSI and BAT waters by July 2023	Genetically underpinned taxonomic designations are available for all fish life history stages sourced from the BAS archives both in Cambridge and at King Edward Point. This included species previously reported as bycatch but not necessarily caught during the project's timeframe. Additionally, we expanded our collaboration with the Natural History Museum (NHM), London, to obtain further specimens, especially those not represented in observer samples or in the BAS biological Archives.
Output indicator 1.2 Genetically underpinned taxonomic designations available for newly acquired samples collected by observers in the krill fishery by October 2024	Genetically underpinned taxonomic designations are available for all fish life history stages returned to BAS Cambridge by fishery observers between 2021 and 2024.
Output indicator 1.3 Resource archives are established to ensure post-project longevity of collected materials and data by December 2024	A physical DNA bank has been established, storing both tissue samples and successfully extracted DNA. These materials have been archived under BAS logistics case number 22903.
Output indicator 1.4 Data generated submitted to publicly accessible databases by December 2024	All the genetic data generated through this work were submitted to the open-access database GenBank, under the Bioproject PRJNA1270765, with accession numbers: PQ686535-45, PQ727374-PQ736688, PQ728912-86, PQ736524-PQ736688, PQ742065-PQ742162, and PQ672629-PQ672777. The dataset will be publicly available from 30 June 2025. The associated metadata have been deposited in the BAS Polar Data Centre, and it will also be accessible from June 30 2025 at https://doi.org/10.5285/9c459656-5fe4-44f7-860f-da287111016c. In addition,
Output 2. Baseline information assembled for fish life history stages caught as bycatch during krill fishery operations	
Output indicator 2.1. Baseline information on life history stages of 20 fish species caught in GSGSSI and BAT waters established via a systematic review, completed by September 2024.	A systematic review has been completed, synthesizing biological data on the top 29 bycatch species in krill fisheries within the maritime zones of South Georgia, the South Sandwich Islands, and the British Antarctic Territories (CCAMLR areas 48.1, 48.2 & 48.3). Due to regional variation in bycatch, the final review included 29 species, rather than the planned 20. Data extracted included location, habitat, seasonal occurrence of early life stages, and life history parameters. We extended the scope of the review to include adult stages to gain a more complete set of biological traits for

	each species. For 9 of the 29 species, no life history data were found for the areas where they are caught. To prioritise research needs, a preliminary traffic light system was developed to highlight species requiring urgent attention.
Output 3. Statistical analysis of CCAMLR bycatch and BAS larval and juvenile fish data and assessment of overlap between fish life history stages and krill fishing operations	
Output indicator 3.1 Location characteristics and fisheries operational variables assessed to understand fish bycatch and abundance in space and time from CCAMLR and BAS data, completed by August 2024.	The statistical analysis of the bycatch data has been the most challenging element of the project. The format of the data released by CCAMLR was not conducive to the planned spatiotemporal statistical analysis. As an alternative, a range of descriptive and community-based analyses have been undertaken to understand the variation if bycatch through space and time. These highlight spatial differences in the catch composition across the different statistical areas and give an indication of whether sampling effort is enough to estimate fish diversity in the bycatch. The analysis is not going to have a predictive output as previously envisaged, but it does provide valuable information that may help inform how future bycatch sampling is undertaken.
Output indicator 3.2 Statistical analysis results and archived and current samples integrated into baseline information and assessment made of life history stage overlap with the krill fisheries that indicates risk of capture, completed by September 2024.	This output indicator was contingent on the predictive outputs of indicator 3.1. In lieu of this, observational data from the fishery has been used to produce spatial maps of individual species, which have been also used for in the ID guide, along with spatially stratified temporal abundance plots to help observers identify bycatch species.
Output 4. Updated species identification materials for fisheries observers, vessel operators and other end users	
Output indicator 4.1 Morphological and genetics results from output 1 used to update identification materials prior to MRAG observer training in 2025	And ID guide has been produced, synthesizing information from Outputs 1, 2 and 3. While it has been designed as a standalone reference, there is potential for it to be incorporated into a broader identification guide for fisheries operating in CCAMLR Area 48. Additionally, feedback on the first draft was gathered from both current and former fishery observers. Their insights have been instrumental in refining the guide, particularly in improving the clarity, usability, and relevance of the material for end users in the field.

Output 5. Training event for identification materials end users	
Output indicator 5.1 All krill observers employed by MRAG ahead of fishing activities in 2025 trained to use updated identification materials in March 2025.	A preliminary introduction to the identification materials was delivered by Dr. Romero Martínez in April 2025 as part of the MRAG deployment training for new fisheries observers. During this session, a draft version of the identification guide was presented (Annex 5.14), and the identification process was explained in collaboration with MRAG partner Benedict Viney.

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

Project summary	SMART Indicators	Means of verification	Important Assumptions
Impact: The ecosystem-based management and conservation of biodiversity within SGSSI and BAT waters is enhanced by an improvement in the precision of reporting of Antarctic krill fishery bycatch.			
Outcome: Improved understanding of where, when and which fish are caught as bycatch in the krill fisheries, translating into improved species monitoring practice for the benefit of SGSSI and BAT	0.1 Baseline assessment of fish bycatch in the krill fishery occurring in SGSSI and BAT waters completed by October 2024 0.2 Fisheries observers better informed on bycatch identification by March 2025	0.1 Results fed to GBAT/GSGSSI for annual stakeholder meeting review 0.1.1 Results communicated to GSGSSI and GBAT via CCAMLR working group papers and Darwin Plus reports 0.1.2 Results undergo peer review as part of scientific publication process 0.2 Implementation of new fish bycatch identification materials by MRAG, which will be used by fisheries observers in BAT and SGSSI waters	Data generated at an appropriate resolution to understand spatial and temporal as well as species level differences for bycatch to allow for informed management As data are collected on a haul-by-haul basis within the fishery, we don't anticipate this will be a large issue.
Output 1 Identification of which life history stages of which fish species are present in SGSSI and BAT waters and potentially caught by the krill fishery	1.1 Genetically underpinned taxonomic designations available for all fish life history stages stored in BAS archives for specimens collected in GSGSSI and BAT waters by July 2023 1.2 Genetically underpinned taxonomic designations available for newly acquired samples collected by observers in the krill fishery by October 2024 1.3 Resource archives are established to ensure post-project	1.1, 1.2 and 1.3 Database of metadata and morphological data lodged in BAS Polar Data Centre for samples that have been identified to species 1.1, 1.2 and 1.3 Physical DNA bank established for successfully extracted DNA samples 1.1, 1.2 and 1.3 Database of DNA sequences established for all successfully sequenced samples 1.1 and 1.2 Submitted working group paper containing details on the diversity of finfish bycatch to	New samples successfully shipped to UK in good enough condition for integrative taxonomy. There are several options available for sample preservation including conventional freezing, blast freezing and ethanol. We are confident that with the breadth of sample collection options and preservation methods we will obtain enough samples in good condition.

	longevity of collected materials and data by December 2024 1.4 Data generated submitted to publicly accessible databases by December 2024	CCAMLR working group in September 2024 (WG-FSA) 1.4 Species abundances submitted to GBIF 1.4 DNA sequence data submitted to GenBank 1.4 All specimen images and metadata submitted to the Polar Data Centre	
Output 2 Baseline information assembled for fish life history stages caught as bycatch during krill fishery operations.	2.1 Baseline information on life history stages of 20 fish species caught in GSGSSI and BAT waters established via a systematic review, completed by September 2024.	2.1 Submitted working group paper containing the results of the systematic review to GSGSSI and CCAMLR working groups in June and September 2024	**Sufficient baseline information is available for collation.** This relies on the depth of the existing literature. As studies of fish ecology in this region have been conducted for several decades we anticipate that sufficient data should exist, if not for all species, then at least for the most abundant bycatch species.
Output 3 Statistical analysis of CCAMLR bycatch and BAS larval and juvenile fish data and assessment of overlap between fish life history stages and krill fishing operations	3.1 Location characteristics and fisheries operational variables assessed to understand fish bycatch and abundance in space and time from CCAMLR and BAS data, completed by August 2024. 3.2 Statistical analysis results and archived and current samples integrated into baseline information and assessment made of life history stage overlap with the krill fisheries that indicates risk of capture, completed by September 2024.	3.1 Submitted working group paper containing the results of statistical analysis to GSGSSI and CCAMLR working groups in September 2024 or June 2025. 3.2 Submitted open access peer reviewed scientific paper (by March 2025)	Bycatch data is released by CCAMLR after a data request. Should any CCAMLR member state refuse to release its data, we will simply run the same analysis with a reduced data set (CCAMLR will still release the data of all countries that do agree). As vessels tend to all operate in similar areas we don't anticipate any issues with this.
Output 4 Updated species identification materials for fisheries observers,	4.1 Morphological and genetics results from output 1 used to update	4.1 Identification materials freely available via the Polar Data Centre	**Genetic analysis has successfully improved species assignments in**

vessel operators and other end users	identification materials prior to MRAG observer training in 2025	4.1.1 Submitted working group paper containing details of the identification materials submitted to CCAMLR working group in June 2025 (WG-EMM)	**the original (morphology only) identification materials.** We are aware of several instances where morphological identification is extremely difficult, and where previous molecular work has revealed incorrect species assignments. Accordingly, we believe the molecular work proposed in output 1 will successfully improve species assignments.
Output 5 Training event for identification materials end users	5.1 All krill observers employed by MRAG ahead of fishing activities in 2025 trained to use updated identification materials in March 2025.	5.1 Training attendance list compiled by MRAG 5.2 Checklist of learning outcomes completed by krill observers 5.3 Training summary report completed by June 2025.	**All observers will be able to attend training sessions given international travel restrictions due to the COVID-19 pandemic.** Should travel to MRAG be unfeasible, the training will be moved to a virtual format

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)

1.1 Collation and cataloguing of all currently archived fish and larval fish samples held at BAS by Dr Hollyman, Prof. Collins and the PDRA.

1.1.1 Training of PDRA in morphological identification of available fish material by Dr Hollyman and Prof. Collins.

1.1.2 Development of mitochondrial DNA genetic identification toolbox for fish bycatch species by Dr Goodall-Copestake with training for PDRA.

1.1.3 DNA extraction from tissue sub-samples by PDRA and Dr Goodall-Copestake also providing training as required.

1.1.4 Amplification, cleaning, sequencing and quality editing of mitochondrial DNA by PDRA and Dr Goodall-Copestake (providing training as required).

1.1.5 DNA sequence database cross referencing and species assignment by PDRA and Dr Goodall-Copestake (providing training as required).

1.1.6 Collation of sample morphological and meta- data, formatting and submission for archiving in the Polar Data Centre by PDRA, Dr Hollyman, Dr Goodall-Copestake.

1.2 Collection of new fish and larval fish samples by observers within the krill fishery, observers to be briefed via MRAG.

1.2.1 Collation and cataloguing of all newly collected fish samples from the krill fishery by PDRA and KEP Biologist.

1.2.2 All unidentified specimens identified to the finest taxonomic level by Dr Hollyman and the PDRA.

1.2.3 Trialling of double staining using alcian blue and alizarin red as a tool to aid identification by PDRA and Dr Hollyman.

1.2.4 Photographs of all available specimens from 1.1 and 1.2 will be taken for activity 4.1 by PDRA and Dr Hollyman.

1.2.5 DNA extraction of samples by PDRA and Dr Goodall-Copestake.

1.2.6 Mitochondrial DNA amplification-cleaning-sequencing-editing by PDRA and Dr Goodall-Copestake.

1.2.7 DNA sequence database cross referencing and species assignment by PDRA and Dr Goodall-Copestake.

1.2.8 Collation of sample images (from 1.2.4), morphological and meta- data, formatting and submission for archiving in the Polar Data Centre by PDRA, Dr Hollyman, Dr Whitelaw and Dr Goodall-Copestake.

1.3 Samples used in activities 1.1.4 and 1.2.6 will be archived to produce a DNA bank by PDRA and Dr Goodall-Copestake.

1.4 Genetic data and metadata formatted for Genbank, and species identification and metadata formatted for GBIF by PDRA and Dr Goodall-Copestake.

1.4.1 Genetic data submitted to Genbank by PDRA and Dr Goodall-Copestake.

1.4.2 Species distribution data submitted to GBIF by PDRA and Dr Hollyman.

1.4.3 Submission of data collated in 1.2.8 submitted to the Polar Data Centre by Dr Whitelaw and the PDRA

1.5 Paper on fish bycatch diversity prepared for CCAMLR working groups by Dr Hollyman, Dr Goodall-Copestake, Prof. Collins and PDRA.

1.5.1 Papers submitted to and presented at WG-EMM (Y3) and WG-FSA (Y3) by Dr Hollyman.

2.1 Systematic review of all available literature (grey and peer-reviewed) focussed on early life history stages of known bycatch species within the krill fishery in order to make a baseline assessment of information by Dr Reid, Dr Hollyman and PDRA.

2.1.1 Define objectives and write protocol for systematic review by Dr Reid, Dr Hollyman and PDRA.

2.1.2 Search for scientific papers using a series of bibliographic databases by PDRA.

2.1.3 Collate relevant scientific papers and read by Dr Reid, Dr Hollyman and PDRA.

2.1.4 Extract information on larval hatching timings, larval duration, growth rates and spatial distribution of larvae and juvenile fish and create database to store data by Dr Reid, Dr Hollyman and PDRA.

2.1.5 Write review for CCAMLR working group (WG-FSA) by Dr Reid, Dr Hollyman and PDRA.

3.1 Statistical modelling of fish bycatch and fish larval data from CCAMLR and BAS archives by Dr Reid, Dr Hollyman and PDRA

3.1.1 Request fish bycatch and associated metadata data from CCAMLR by Dr Hollyman. 3.1.2 Extract fish larval and juvenile data from BAS databases by Dr Phil Hollyman and PDRA. 3.1.3 Undertake spatial and temporal modelling of CCAMLR fish bycatch data and BAS larval and juvenile data in association with other key variables including sea surface temperature, fishing depth, seafloor depth, season, time of day and catch location by Dr Reid. 3.1.4 Write CCAMLR working group paper Dr Reid, Dr Hollyman, Dr Young, Mr Chapman and PDRA. 3.2 Integrate data generated during Output 1 into the systematic review database generated during activity 2.1 by PDRA. 3.2.1 Use results of modelling exercise and systematic review to assess overlap of timings and life history stage of fish with krill fisheries operation to understand which species are at risk of being caught, when and at what stage by Dr Reid, Dr Hollyman, Prof. Collins and MRAG. 3.2.2 Write peer reviewed publication, Dr Reid assisted by all other team members. 4.1 Production of identification materials for fisheries observers. PDRA, assisted by all other team members 4.1.1 Visual identification aids developed by synthesising the information generated from all previous activities. These identification materials will cover the various early life history stages of each available fish, the location and month when fish may be found and subtleties of distinguishing between similar species that are often confused. PDRA, assisted by all other team members. 4.2 Paper summarising newly developed identification materials prepared for CCAMLR working groups by PDRA assisted by all investigators. 4.2.1 Papers submitted to and presented at WG-FSA (Y3) by PDRA and Dr Hollyman. 5.1 Deliver training on newly developed identification guides to observers at annual pre-season observer training at MRAG London. by Dr Young, Mr Chapman and Dr Hollyman 5.1.1 Production of training summary report by MRAG.

Table 1 Project Standard Indicators

Please see the Standard Indicator Guidance for more information on how to report in this section, including appropriate disaggregation. N.B. The annual total is not cumulative. For each year, only include the results achieved in that year. The total achieved should be the sum of the annual totals.

DI Indicator number	Name of indicator	If this links directly to a project indicator(s), please note the indicator number here	Units	Disaggregation	Year 1 Total	Year 2 Total	Year 3 Total	Total achieved	Total planned
DPLUS-C09	1.3 Resource archives are established to ensure post-project longevity of collected materials and data.	Species reference collections made	Number			2		2	2
DPLUS-C16	1.4 Data generated submitted to publicly accessible databases by December 2024	Number of records added to accessible databases	Number				3	3	3
DPLUS-C17	3.1 Location characteristics and fisheries operational variables assessed to understand fish bycatch and abundance in space and time from CCAMLR and BAS data	Number of unique papers submitted to peer reviewed journals	Number			1	2	3	5

Table 2 Publications

Title	Type (e.g. journals, manual, CDs)	Detail (authors, year)	Gender of Lead Author	Nationality of Lead Author	Publishers (name, city)	Available from (e.g. weblink or publisher if not available online)
Improving identification of fish bycatch in the Antarctic krill fishery	CCAMLR WG-FSA-2023/4. Working group paper.	M.L.Romero Martínez, P.R. Hollyman, W.D.K. Reid, W.P. Goodall-Copestake, J. Moir Clark & M.A. Collins. 2023	Female	British/Ecuadorian	CCAMLR, Hobart.	CCAMLR, Hobart. Annex 5.3 of this report.
An integrative taxonomy approach for the identification of fish bycatch in the Antarctic krill fishery	CCAMLR WG-FSA-IMAF-2024/13. Working group paper.	M.L.Romero Martínez, W.D.K. Reid, M.A. Collins., W.P. Goodall-Copestake, J.M Clark, B. Viney & P.R. Hollyman. 2024	Female	British/Ecuadorian	CCAMLR, Hobart.	CCAMLR, Hobart. Annex 5.4 of this report.
What’s Inside the Net? Insights into Fish Bycatch Diversity in the Antarctic Krill Fishery	Journal submission	M.L. Romero Martínez, W.D.K. Reid, M.A. Collins, K.L. Treviño Cuellar, W.P. Goodall-Copestake, J.M. Clark, B. Viney, S. Gregory, K. Owen and P.R. Hollyman. 2025.	Female	British/Ecuadorian	Submitted to Polar Biology.	Open access online following final acceptance.

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 **correct template** (checking fund, scheme, type of report (i.e. Annual or Final), and year) and **deleted the blue guidance text** before submission?	X
Is the report less than 10MB? If so, please email to BCF-Reports@niras.com putting the project number in the Subject line.	X
Is your report more than 10MB? If so, please consider the best way to submit. One zipped file, or a download option, is recommended. We can work with most online options and will be in touch if we have a problem accessing material. If unsure, please discuss with BCF-Reports@niras.com about the best way to deliver the report, putting the project number in the Subject line.	X
If you are submitting photos for publicity purposes, **do these meet the outlined requirements** (see section 14)?	X
Have you included means of verification? You should not submit every project document, but the main outputs and a selection of the others would strengthen the report.	X
Have you provided an updated risk register? If you have an existing risk register you should provide an updated version alongside your report. If your project was funded prior to this being a requirement, you are encouraged to develop a risk register.	X
Have you involved your partners in preparation of the report and named the main contributors	X
Have you completed the Project Expenditure table fully?	X
Do not include claim forms or other communications with this report.	