Darwin Plus:
Overseas Territories Environment and Climate Fund

Final Report

*To be completed with reference to the "Writing a Darwin Report" guidance: (http://www.darwininitiative.org.uk/resources-for-projects/reporting-forms). It is expected that this report will be a **maximum** of 20 pages in length, excluding annexes)*

Darwin Project Information

Project reference	DPLUS072
Project title	Developing the risk assessment framework for the Antarctic krill fishery
Territory(ies)	British Antarctic Territory
Lead organisation	British Antarctic Survey
Partner institution (s)	
Darwin Plus Grant value	£132,599
Start/end date of project	1 September 2018 to 31 August 2020
Project leader name	Philip Trathan
Project website/Twitter/blog etc.	
Report author(s) and date	Philip Trathan and Vicky Warwick-Evans; 20 December 2020 August 2020 FR

1 Project Summary

Fisheries in the Southern Ocean are managed under the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), an international body with a Commission that includes 25 Member States, together with the European Union. A further 10 States accede to the Convention, but are not part of the Commission.

This project set out to advise CCAMLR on methods to subdivide catch limits for Antarctic krill (*Euphausia superba*) within the Scotia Sea (Figure 1), especially the Antarctic Peninsula, in order to minimise risks to krill-dependent predators, and develop sustainable fisheries. The krill fishery is the largest fishery in the Southern Ocean; five Members fish for krill and approximately 450,000 t is now harvested annually. We set out to achieve this goal via the implementation of a risk assessment framework, which integrates existing spatial data relating to krill stocks, predator foraging and krill fisheries into data-layers at spatial and temporal scales relevant to ecosystem dynamics.

The Southern Ocean provides critical breeding and foraging habitats for numerous marine predators, many of which rely on Antarctic krill as their main prey source. An ongoing priority for CCAMLR is to set catch limits in a way that minimises the risk to dependent predator populations, whilst also accounting for the needs of the fishery. Currently, concentration of catches occurs at small spatial scales (< 100 km). It is therefore fundamental to determine how catch limits can be spatially and temporally apportioned within and between areas to avoid negative impacts on dependent predator populations. The Scientific Committee has advised the Commission that the program of work is urgent, as previous work has shown that risks to the ecosystem associated with the fishery are increasing, particularly in Subarea 48.1 the Antarctic Peninsula region.

CCAMLR has endorsed the use of a risk assessment framework which integrates spatial data relating to krill stocks, predator foraging and fisheries in order to compute the relative spatial and

temporal risks associated with proposals to subdivide the regional catch limits. However CCAMLR has noted potential limitations to the approach. Thus, the aim of our proposal was to initiate work to address some of these limitations, providing the first implementation of the risk approach within the Scotia Sea region, especially for the Antarctic Peninsula region.

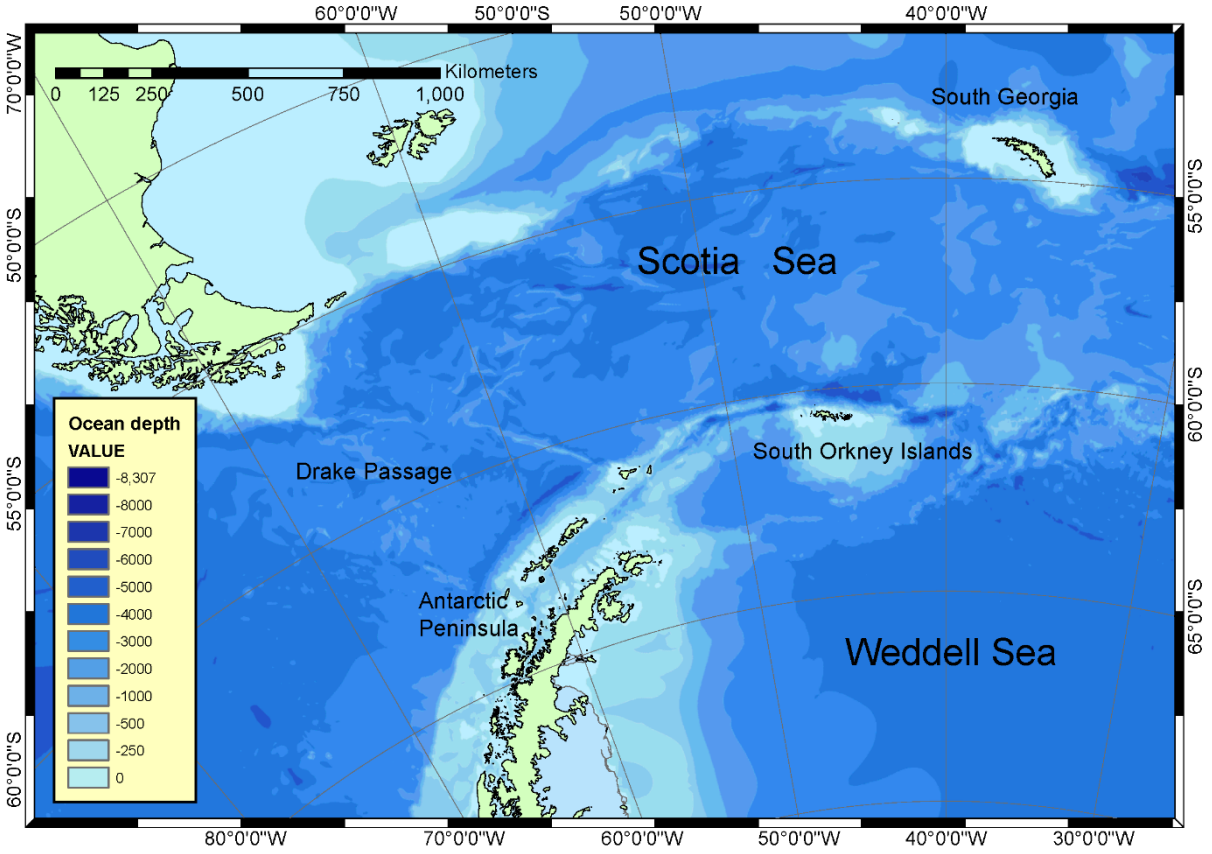

Figure 1. *The Scotia Sea and Antarctic Peninsula, showing the South Shetland Islands, the northern tip of the Antarctic Peninsula, the South Orkney Islands and South Georgia where fishing for Antarctic krill is most concentrated.*

2 Project Stakeholders/Partners

The stakeholders for this work are all CCAMLR Member states actively engaged in developing a new management framework for Antarctic krill. This project has helped expedite that process. Other stakeholders include fishing companies, tourist companies and eNGOs that value the natural status of the Antarctic ecosystem. Two UKOTs (GSGSSI and GBAT) are also key stakeholders as the Antarctic krill fishery operates within their areas of interest; our project will therefore also contribute to the UK Blue Belt initiative.

Stakeholder engagement was exceptionally intense over the course of the project. We submitted 6 papers to the 2019 CCAMLR Working Group on Ecosystems and Monitoring and Management (WG-EMM), which was held from 24 June to 6 July 2019 in Concarneau, France. All papers were well received by the CCAMLR community, and provided the basis for important discussions. Most importantly, for the first time in almost 25 years, WG-EMM agreed a clear approach for managing the krill fishery which was detailed in the report of the meeting and considered at the 2019 meeting of the Scientific Committee (21 to 25 October 2019) and subsequently at the 2019 meeting of the Commission (28 October to 1 November 2019). The risk assessment is one of three priority tools in this agreed management strategy.

Discussions were facilitated largely by the outputs we have achieved to-date with this Darwin Plus project, and submitted to CCAMLR. To have reached consensus that the Risk Assessment plays a fundamental part in the management of krill fisheries is a huge step forward for CCAMLR.

Just prior to the 2019 meeting of WG-EMM we jointly coordinated a workshop on krill fishery management for Subareas 48.1 and 48.2 with a US colleague (10 to 14 June, also held in Concarneau). The workshop brought together key stakeholders in krill fisheries management

including expert scientists, industry and eNGOs, to work towards the harmonisation of approaches for krill fisheries management. The meeting was jointly funded by eNGOs and the krill fishing industry; it was a huge success, and we reached agreement on some to the key approaches necessary for successful krill management. The report from this workshop was discussed at the 2019 meeting of WG-EMM, and contributed to the agreement reached at that meeting. We consider that the meeting with stakeholders lay the foundation for subsequently achieving consensus at WG-EMM in 2019.

Our engagement with all stakeholders has arisen from the need to progress the management of the krill fishery. Having a joint workshop including industry, scientists and eNGOs was a significant milestone. Having this funded by a range of stakeholders demonstrated strong positive engagement.

Our work has continued since our last report and our implementation of the risk assessment is now a key deliverable for CCAMLR. In addition, we have been in discussions with the Pew Charitable Trusts (USA) and we are now extending our project work for another 17 months, employing recognised researcher V. Warwick-Evans and recognised researcher F. Perry. The funding support received from Pew is similar in scale to the original support received from Darwin Plus, indicating the strong leveraging Darwin Plus DPLUS072 has achieved. This clearly demonstrates the value of our project to stakeholders.

3 Project Achievements

The key achievement from our project, was the full and open engagement with stakeholders, which contributed to a delivery plan for managing the fishery for krill, agreed by the CCAMLR Commission.

Our work led to and built upon previously unforeseen opportunities that arose over the course of the project. Openness and transparency helped us build trust. The workshop in Concaneau demonstrated the value of our open discussions with all stakeholders. Stakeholders were willing to fund the workshop and have subsequently actively engaged with us in order to help us extend our work beyond the Antarctic Peninsula. The outcomes of the meetings last year have set a precedent for engagement within CCAMLR, allowing a step change in Member collaboration.

Our achievement has been built upon long-term engagement with all stakeholders. We have progressively built a high degree of trust with eNGOs and with the fishing industry through a series of small-scale projects, including through DPLUS09, DPLUS54 and DPLUS072.

Engagement has been long-standing and supported by Darwin Plus over a number of projects.

3.1 Outputs

We have been able to follow our log frame very closely. We have investigated variability in the spatial distribution of the krill fishery over both historical and recent timescales. We have developed four manuscripts that are in submission with peer-reviewed journals. These highlight desirable areas for krill fisheries at spatial and temporal scales in accordance with ecosystem dynamics. It is anticipated that we will submit other papers in the near future.

The first of the studies investigate proxies for the oceanographic flux and movement (import and export) of krill by utilising a fine-scale ocean model to estimate relative water movement rates at spatial scales relevant to predator consumption and fisheries usage (see below, output B).

We have integrated habitat preference models previously developed for *Pygoscelis* penguins (DPLUS009, DPLUS054) and humpback whales, with krill consumption estimates in order to generate spatially and temporally explicit resource demand estimates for key predator groups, including penguins, whales and flying seabirds, at relevant spatial and temporal scales in accordance with predator behaviour. We have combined this with estimates of krill availability

Three papers on this topic were submitted to the 2020 virtual meeting of WG-EMM and two have been refined and submitted to a peer-reviewed journal (see below, output C and output D).

We have integrated existing and novel data-layers and applied the risk assessment framework, focussing primarily on Subarea 48.1, at a variety of spatial scales that we identified based on bathymetry, predator distribution, current flow, and distance from the shelf-edge, and at temporal scales according to predator life-history and movement constraints. This will now allow us to identify the relative risks when the framework is applied at various spatial and temporal scales, and enable the identification of an appropriate scale at which to apportion the catch limit. We have focussed on Subarea 48.1 as this is where the fishery is most constrained by catch limits and where it operates in close proximity to the breeding colonies of dependent predators, especially penguins. We have completed three scenarios and can now rapidly complete various others, including those agreed by the 2020 virtual meeting of WG-EMM.

Various papers on this topic were submitted to the 2020 virtual meeting of WG-EMM and will be refined for submission to a peer-reviewed journal in the near future, once final comments from collaborators (and WG-EMM) have been incorporated (see below, outputs 1, 2, 3, 4 and 5).

Our initial scenarios allow us to demonstrate how we will utilise the risk assessment to identify the areas of increased risk to predator populations or krill that will allow CCAMLR to focus research and monitoring in those areas. Our risk framework allows for the addition of new information by other Members as it becomes available. Our outputs include a series of maps that detail the data layers included in the risk assessment as well as tables of risk indices and catch-limit proportions under different krill fishing scenarios. Extension of these methods to include other scenarios, including those identified by WG-EMM, will be undertaken during the extension of this project, funded by Pew.

Papers submitted to WG-EMM 2019 (these were attached to our previous half year report):

i. Developing layers for a Risk Assessment for Subarea 48.1 using data from at-sea sightings
V. Warwick-Evans, L. Dalla Rosa, E. Secchi, E. Seyboth, N. Kelly and P.N. Trathan

ii. Developing a Risk Assessment for Subarea 48.1 using tracking data
V. Warwick-Evans, A. Friedlaender, J.T. Hinke, N. Kokubun, J.H. Kim and P.N. Trathan

iii. Considerations about managing the krill fishery at small spatial and temporal scales
P.N. Trathan, V. Warwick-Evans and E. Young

iv. Report from the Workshop on Krill-fishery Management for Subareas 48.1 and 48.2
G. Watters and P. Trathan

v. Towards the development of Marine Important Bird and Biodiversity Areas (mIBAs) for penguins in Antarctica – an update on progress
J. Handley, M.-M. Rouyer, L. Pearmain, V. Warwick-Evans, P. Trathan and M.P. Dias

vi. Advances are urgently needed in providing regular estimates of krill stock status based on the available data
S. Hill, J. Hinke, N. Ratcliffe, P. Trathan and G. Watters

In addition to engagement with stakeholders at the two meetings outlined above, we have also engaged with stakeholders at meetings of the CCAMLR Scientific Committee and Commission. The Commission has now endorsed the management framework proposed by WG-EMM. We submitted two papers to the meeting of the Scientific Committee in 2019 *(these were attached to a previous report):*

vii. Report from the Workshop on Krill-fishery Management for Subareas 48.1 and 48.2 (Concarneau, France, 10 to 14 June 2019)

G. Watters and P. Trathan

viii. Report from the Workshop on Krill-fishery Management for Subareas 48.1 and 48.2

P.N. Trathan, G. Watters, N. Bransome, S. Davie, P.E. Skogrand, R. Werner, A. Kavanagh, C. Johnson and J. Arata (On behalf of the Workshop Organising Committee)

Our final report on this project has been delayed because the reporting period coincides with an exceptionally busy period in the CCAMLR annual cycle. Despite the limitations set by Covid-19, we have now submitted a further suite of papers to the 2020 virtual meeting of WG-EMM, as

well as the 2020 virtual meetings of the Working Group on Fish Stock Assessment and the Scientific Committee. These papers show our wide engagement across stakeholders, including with scientists from Australia, Brazil, Japan, Korea, the UK and the USA as well as with BirdLife International; they include:

1. Using mesoscale survey results to produce regularly updated estimates of krill biomass at the subarea scale

   S.L. Hill, S. Fielding, P.N. Trathan, V. Warwick-Evans

2. Spatial distribution and density of procellariiform seabirds within the northern Antarctic Peninsula marine ecosystem

   V. Warwick-Evans, J. Santora, J. Waggitt, P.N. Trathan

3. Spatially-explicit estimates of consumption of Antarctic krill by a suite of seabird and marine mammal predators in the north-west Antarctic Peninsula*V. Warwick-Evans, N. Kelly, L. Dalla Rosa, A. Friedlaender, J. Hinke, J.-H. Kim, N. Kokubun, J. Santora, E. Secchi, E. Seyboth, P.N. Trathan*

4. Estimating the distribution of Antarctic krill for the northern Antarctic Peninsula

   V. Warwick-Evans, S. Fielding, C. Reiss, G. Watters, P.N. Trathan

5. Using the Risk Assessment Framework to spread the catch limit in Subarea 48.1

   V. Warwick-Evans, J. Hinke, N. Kelly, C. Reiss, G. Watters, D. Welsford, P.N. Trathan

6. Performance indicators of Antarctic krill dependant predators highlight the complexity of ecosystem-based fishery management at South Georgia

   P.N. Trathan, S. Fielding, P. Hollyman, E. Murphy, V. Warwick-Evans, M. Collins

7. Habitat models to describe the interaction between female Antarctic fur seals (*Arctocephalus gazella*) and the licensed krill fishery in CCAMLR Subarea 48.3, South Atlantic in winter

   C. Bamford, V. Warwick-Evans, I. Staniland, J. Jackson, P.N. Trathan

8. Marine Important Bird and Biodiversity Areas for penguins in Antarctica, proxies for conservation action

   J. Handley, M.-M. Rouyer, E. Pearmain, V. Warwick-Evans, P.N. Trathan, M. Dias

9. Planned updates for the krill fishery management Risk Assessment framework.

   P.N. Trathan, V. Warwick-Evans, S. Fielding, E.J. Murphy, (UK); N. Kelly, D. Welsford, (Australia); L. Dalla Rosa, E. Secchi, E. Seyboth, (Brazil); B.A. Krafft, (Norway);J. Hinke, C. Reiss and G. Watters (USA)

The recognised researcher (V. Warwick-Evans) was wholly supported by Darwin Plus DPLUS072; her contribution to all papers is therefore supported by Darwin Plus. This is identified as part of the acknowledgments for the major project outputs (outputs 2, 3, 4, 5 and 6).

Each of the outputs that we identified in our original project proposal is now well advanced, with a number of papers ready for submission to peer-reviewed journals, and a suite of papers submitted to the 2020 virtual meetings of CCAMLR. We have followed our log frame working with a team of international collaborators to deliver against all of our outputs.

The only output remaining to be addressed (under our log frame), is the submission of peer-reviewed papers to scientific journals. However, the suit of papers submitted to the 2020 virtual meeting of WG-EMM are sufficiently advanced, that we feel this commitment will be met. Indeed, some papers are already at the level necessary for submission; thus, outputs 2, 3 and 6 are now in review with peer reviewed journals.

A. The aspirations and challenges of implementing ecosystem-based fisheries management for Antarctic krill within the complex, variable and changing ecosystem at South Georgia.

   Trathan, P.N., Fielding, S., Hollyman, P., Murphy, E.J., Warwick-Evans, V., Collins, M.A. (In Review). ICES Journal of Marine Systems.

B. Ecosystem-based management of the Antarctic krill fishery - the 'devils are in the detail' at small spatial and temporal scales.

   Trathan, P.N., Warwick-Evans, V., Young, E.F., Friedlaender, A., Kim, J.H., Kokubun, N. (In Review). Journal of Marine Systems.

C. Multi-scale assessment of distribution and density of procellariiform seabirds within the northern Antarctic Peninsula marine ecosystem.

   Warwick-Evans, V., Santora, J.A., Waggitt, J.J., Trathan, P.N. (In Review). ICES Journal of Marine Science.

D. Using seabird and whale distribution models to estimate spatial consumption of krill to inform fishery management.

   Warwick-Evans, V., Kelly, N., Dalla Rosa, L., Friedlaender, A., Hinke, J.T., Kim, J.H., Kokubun, N., Santora, J.A., Secchi, E.R., Seyboth, E., Trathan, P.N. (In Review). Ecosphere.

Other papers will be submitted in due course, and will also contain acknowledgement to Darwin Plus DPLUS072.

3.2 Outcome

Our work, which includes contributions from a wide range of international collaborators, allows us to identify the relevant spatial and temporal scales for management of the krill fishery based on the development of a risk assessment. We have submitted this work to CCAMLR and will pursue this in order to apportion catch limits at sustainable levels.

We have engaged widely across the CCAMLR community, including with the proponents of the proposed CCAMLR Domain 1 Marine Protected Areas.

The CCAMLR Conservation Measure governing the spatial allocation of the krill catch limit (Conservation Measure 51-07) will be reviewed in November 2021. We anticipate that it will continue in some revised form that accounts for dependent predators at appropriate spatial and temporal scales.

Having the 2020 meeting of the CCAMLR Scientific Committee subscribe to our work plan for the coming year (output 9) demonstrates that this work is now mainstream CCAMLR. However, the overall success of the project will best be judged at the time that CM 51-07 is re-negotiated in November 2021.

We will continue with development of our project under new funding now agreed with the Pew Charitable Trusts (US). We consider that the project set out to achieve certain outcomes and these were all fulfilled.

A key indicator of the success of our project, is the extension now funded by Pew (see above).

3.3 Monitoring of assumptions

Happily, all of the assumptions that we made during the development of our proposal have turned out to be correct. CCAMLR has endorsed the risk assessment approach and this is now under development through international collaboration. Our project DPLUS072 contributes to this and has been the focus of work by a number of collaborators.

A key issue throughout project delivery was the availability of data from our collaborators. However, we managed this by keeping close contact with all parties to ensure we were able to access the data we needed.

A key indicator that we achieved our goals is the number of papers we submitted to CCAMLR, of which some are now being submitted to the peer-reviewed literature.

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

The Antarctic Peninsula and South Shetland Islands lie within the British Antarctic Territory; they are probably the most rapidly warming part of the Southern Ocean. Developing fisheries management strategies that have the capacity to provide robust advice within the context of climate change projections is therefore of regional and global significance. The PL for the project (P.N. Trathan) therefore initiated a paper that has been submitted to the 2020 virtual meetings of both WG-EMM, WG-FSA, and the Scientific Committee. Though not directly linked to the outputs of this project, the paper demonstrates the broader context that surrounds the DPLUS072 project and issues that need to be considered as part of the development of the Risk Assessment. We also submitted a paper to the Scientific Committee that built on this work to ensure climate change stays on the CCAMLR agenda. These papers are:

I. The United Nations' Intergovernmental Panel on Climate Change's (IPCC) Special Report on the Ocean and Cryosphere in a Changing Climate: what does CCAMLR need to know?

R. Cavanagh, P.N. Trathan, S. Grant, S.L. Hill, P. Hollyman, B. Krafft, J. Melbourne-Thomas, M. Meredith, M. Muelbert, E. Murphy, M. Sommerkorn, J. Turner.

II. Identifying and integrating relevant scientific research outputs on climate change into the work of the Scientific Committee and its Working Groups. SC-CAMLR-39/03.

Delegations of the United Kingdom, Argentina, Australia, Belgium, Norway and Sweden

The Government of the British Antarctic Territory (GBAT) has key goals for management of the Antarctic environment (https://britishantarcticterritory.org.uk/research/environmental-protection/) that include, to: Develop a better understanding of the BAT environment, and Identify future environmental challenges, including climate change, and development of mitigation measures. Our project DPLUS072 directly relate to these challenges. Developing international collaborative work to address GBAT objectives will help enhance these objectives, especially in the context of multi-lateral environmental agreements, such as CCAMLR.

5 OPTIONAL: Gender equality

Our work is implemented and directed by the recognised researcher (V. Warwick-Evans) and the project PL. The recognised researcher is supported in full by DPLUS072, while the PL is partially supported by the project. We therefore have a balanced gender ratio, but with the majority of salary support directed towards the female gender. The key outputs from the project to date (see section 2: outputs 2, 3, 4, 5 and 6) are mostly led by the female recognised researcher. We have engaged widely with the international community, including with many female researchers.

We believe that we have fully engaged with gender equality issues.

6 Sustainability and Legacy

Our project is ongoing, supported by the Pew Charitable Trusts. On the assumption that CCAMLR agrees to the final conclusions of this work in November 2021, then the work is likely to be an ongoing as part of CCAMLR's work programme.

7 Lessons learned

Our project set clear and specific objectives related to the management of Antarctic krill, one of the last under-exploited fisheries in the world. Given the potential future contribution to human food security, and the need to manage within a multi-lateral environmental agreement, our objectives had to be very clearly articulated, achievable and transparent. We also had to ensure that we worked internationally and that we didn't deliver a very UK-centric project. This is because the Antarctic Peninsula includes a UKOT, but it is also managed internationally through CCAMLR and the Antarctic Treaty System. As such collaboration and transparency are vital.

Our project has focussed on developing multi-lateral outputs, which include scientists from a range of CCAMLR Members, including Members with different conservation and management objectives. Building the trust of such a diverse group was key. Our major output (see section 2: output 5) includes three Members with a keen interest in krill management; our work is the first time that these Members have worked collaboratively to deliver an output.

Working within multi-lateral environmental agreements takes time and energy, but has paid dividends. Working to include the concerns of our collaborators has been vital. Developing trust and transparency has been the bedrock for this project. Travel to liaise with collaborators was important; Covid-19 hindered this in part.

7.1 Monitoring and evaluation

Our primary means of monitoring and evaluation is through engagement at CCAMLR meetings and with the CCAMLR Working Groups. It is through the interactions with CCAMLR and the wider scientific community that we are able to validate our approach.

The official meeting reports from CCAMLR therefore provide a key means of independently evaluating our approach. Consequently, report text from WG-EMM and the Scientific Committee provide a key means for demonstrating that our Outputs and Activities do actually contribute to the project Outcome.

The meeting report for WG-EMM-2019 can be found at (https://www.ccamlr.org/en/wg-emm-2019), and that for the Scientific Committee at (https://www.ccamlr.org/en/sc-camlr-38). These web pages also include a list of papers submitted to the various meetings. The key paragraphs for WG-EMM-2019 are 2.60 to 2.64 and for the Scientific Committee are 3.30 to 3.33.

The CCAMLR meetings for 2020 were held in virtual form, given the difficulty with international travel following the global pandemic of Covid-19. Though we have submitted a number of papers to the 2020 virtual meeting of EMM, there will be no formal report agreed by consensus, as in previous years.

7.2 Actions taken in response to annual report reviews

We updated our log frame (attached to a previous report) in response to feedback from our DPLUS072 AR1R report. We have identified where reports of the impacts of our work can be found, providing evidence to support claims of progress.

We have engaged extensively with partners, evidenced by the suit of papers that we have submitted to the 2020 virtual meetings of CCAMLR. We have engaged with a large number of scientists from Australia, Brazil, Japan, Korea, the UK and the USA. The recognised researcher (Warwick-Evans) visited Australia, funded by BAS, to consider statistical approaches. We have engaged in Skype and Zoom meetings and have engaged extensively through email. Since the development of the global pandemic of Covid-19, these forms of exchange have proved extremely useful. During 2019, we met with many collaborators at regular CCAMLR meetings, and at a specially convened meeting funded by eNGOs and the fishing industry (see above, output d, output g and output h).

The anticipated co-funding through a proposal outlined in the original proposal did not materialise, as the CEMP Fund rules changed to not allow salary contributions. During implementation the shortfall was not a problem as our analyses and output were readily accepted by our collaborators. As identified above, the Pew Charitable Trusts (US) have now agreed to provide support to continue the project until 31 December 2021.

8 Darwin Identity

The Darwin Plus logo was displayed prominently in all talks we gave, including at CCAMLR meetings. Darwin Plus support was also acknowledged in all papers, as well as in papers submitted to peer-reviewed journals.

9 Finance and administration

9.1 Project expenditure

Project spend (indicative) since last annual report	2019/20 Grant (£)	2019/20 Total actual Darwin Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs				
Consultancy costs				
Overhead Costs				
Travel and subsistence				
Operating Costs				
Capital items				
Others				
TOTAL				

Staff employed (Name and position)	Cost (£)
Victoria Warwick-Evans - Researcher	
TOTAL	

Consultancy – description and breakdown of costs	Other items – cost (£)
TOTAL	

Capital items – description	Capital items – cost (£)
TOTAL	

Other items – description	Other items – cost (£)
Purchase of a replacement laptop – due to the failure of the "motherboard" on the original high spec laptop, a replacement laptop was required to finish the work. A change request form was submitted in Oct 2019 to ask if the funds could be moved from the T&S budget, which was going to be underspent, to cover the purchase of the replacement laptop. This was agreed in writing.	
TOTAL	

9.2 Additional funds or in-kind contributions secured

Source of funding for project lifetime	Total (£)

TOTAL	

Source of funding for additional work after project lifetime	Total (£)
Pew Charitable Trusts	
TOTAL	

9.3 Value for Money

Our project demonstrates great value for money, in as much as it has helped CCAMLR to realign itself on a more scientifically-based management approach for the krill fishery. That this is now adopted as the primary method for management across 25 Member states plus the European Union speaks to the influence this Darwin Plus project has had. Furthermore, the fact that Pew have provided funds (approximately equal to those bid for under DPLUS072) to continue the work underlines just how valuable this work is to the CCAMLR community.

Krill is one of the last remaining under-exploited marine stocks anywhere in the world ocean. Ensuring that management is scientifically based is key, if it is to contribute towards global food security. Krill also form part of a complex foodweb within an area of the planet that is warming rapidly. Having a scientific foundation is vital.

Annex 1 Project's full current logframe as presented in the application form (unless changes have been agreed)

Please insert your project's logframe (if your project has a logframe), including indicators, means of verification and assumptions. N.B. if your application's logframe is presented in a different format in your application, please transpose into the below template. Please feel free to contact Darwin-Projects@ltsi.co.uk if you have any questions regarding this.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
Impact: Impact: The Antarctic krill fishery is managed sustainably, by helping ensure that the fishery has minimal impacts on both stock and on key krill dependent predators, yet remains economically attractive.			
Outcome: A spatially and temporally scaled risk assessment to aid CCAMLR in managing a sustainable krill fishery by advising on the distribution of catch limits, taking into account the risks to predators and the desirability of areas for the krill fishery.	0.1 Positive engagement at the CCAMLR Working Group meetings 0.2 and subsequent adoption of the results or methodology within CCAMLR's management of the krill fishery, or in Domain 1 Planning for Marine Protected Areas.	0.1 That CCAMLR Conservation Measure 51-07 (the current spatial distribution of krill catch within Area 48) is continued, but in a revised format, taking into account results from the risk assessment, including accounting for dependent predators at appropriate spatial and temporal scales.	That ongoing discussions within CCAMLR continue along the lines anticipated with regard to the krill risk assessment and MPAs. We will revise our plans after each Commission meeting (held each October) in order to account for potential changes in direction.
Output 1: Identify areas which are desirable to the krill fishery.	1.1 Analysis of historical catch data from which we can identify desirable areas for krill fisheries by the end of 2018. 1.2 Submission of a Working Paper to the CCAMLR Working Group on Ecosystem Monitoring and Management in June 2019.	1.1 Classification of near shore habitats, shelf edge habitats and off shore habitats to determine preferred areas and whether these change over time. 1.2 Report text from CCAMLR Scientific Committee in 2019.	That krill fisheries target particular features, and are not random in their distribution.
Output 2: Produce a spatially and temporally scaled krill model which takes account of flux and movement of krill.	2.1 Analysis of oceanographic flow fields in an existing oceanographic model to determine preferred movement pathways and retention areas by June 2019. 2.2 Submission of a Working Paper to the CCAMLR Working Group on Ecosystem Monitoring and Management in June 2020.	2.1 Analyses of the impacts of tides on foraging and on transport pathways. 2.2 Report text from CCAMLR Scientific Committee in 2020.	That it is possible to identify krill flux using an oceanographic model.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
Output 3: Spatially and temporally explicit consumption estimates for key predator groups.	3.1 Production of maps highlighting the key areas for predator consumption by June 2019. 3.2 Submission of a Working Paper to the CCAMLR Working Group on Ecosystem Monitoring and Management in June 2019.	3.1 Identification of areas used by multiple predator species, particular focus on cetaceans and penguins as the taxa with most available data. 3.2 Report text from CCAMLR Scientific Committee in 2019.	That we are able to obtain distribution data from flying seabirds. We are already in possession of distribution data for the other species, and are almost certainly able to obtain seabird data from the literature if collaborators are unable to share their data.
Output 4: Maps and tables of results describing the levels of risk to krill dependent predators under scenarios where management occurs at a variety of spatial and temporal scales.	4.1 A report containing the final results will be submitted as a Working Paper to the CCAMLR Working Group on Ecosystem Monitoring and Management in June 2020.	4.1 Report text from CCAMLR Scientific Committee in 2020.	That the previous outputs are completed successfully.
Output 5: Peer-reviewed papers submitted for publication.	5.1 Individual papers will be submitted for publication by the end of the project.	5.1 Papers in scientific journals.	Normal submission and editorial control by journal editors.

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 Use habitat models to investigate variability in the spatial distribution of the krill fishery in relation to bathymetry, sea ice cover, proximity to the shelf break and fine-scale water movement, over both historical (1981/82 to 2016/17) and recent timescales (2009/10 to 2016/17).

1.2 Write up the model for submission to WG-EMM-19.

2.1 Investigate proxies for the oceanographic flux and movement (import and export) of krill by utilising a fine-scale ocean model to estimate relative water movement rates at spatial scales relevant to predator consumption and fisheries usage.

2.2 Write up results for submission to WG-EMM-20.

3.1 Integrate habitat preference models previously developed for *Pygoscelis* penguins (DPLUS009, DPLUS054) and humpback whales, with krill consumption estimates in order to generate spatially and temporally explicit resource demand estimates for key predator groups, including penguins, whales and flying seabirds, at relevant spatial and temporal scales in accordance with predator behaviour.

3.2 Write up the results for submission to WG-EMM-19.

4.1 Integrate existing and novel data-layers and apply the risk assessment framework to identify the areas of increased risk to predator populations or krill. We will apply the risk assessment framework at a variety of spatial scales which we will identify based on bathymetry, predator distribution, current flow, and distance from the shelf-edge, and at temporal scales according to predator life-history and movement constraints. This will allow us to identify the relative risks when the framework is applied at various spatial and temporal scales, and enable the identification of an appropriate scale at which to apportion the catch limit. We will focus initially on Subarea 48.1 as this is where the fisheries is most constrained by catch limits and where it operates in close proximity to the breeding colonies of dependent predators, especially penguins. We will present the methodologies utilised in the production of the data layers allowing for the addition of new information by other Members. We will also present a series of maps and tables which detail the data layers to be included in the risk assessment and the risk indices and catch-limit proportions under different krill fishing scenarios.

5.1 All of the outputs will be written up for submission to peer reviewed journals.

Annex 2 Report of progress and achievements against final project logframe for the life of the project (if your project has a logframe)

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
Impact: The Antarctic krill fishery is managed sustainably, by helping ensure that the fishery has minimal impacts on both stock and on key krill dependent predators, yet remains economically attractive.		The Antarctic Peninsula is one on the fastest warming parts of our planet, yet it is an important feeding location for large numbers of marine predators, including penguins, other seabirds, seals, and recovering populations of baleen whales, all of which depend upon Antarctic krill. Krill is also the target of the largest fishery in the Southern Ocean, so sustainable management is vital. This project contributes to sustainable management so that different ecosystem components are not inadvertently or disproportionally adversely affected, hence helping to maintain the local biodiversity, as well as that which uses the area on a seasonal basis.
Outcome: A spatially and temporally scaled risk assessment to aid CCAMLR in managing a sustainable krill fishery by advising on the distribution of catch limits, taking into account the risks to predators and the desirability of areas for the krill fishery.	0.1 Positive engagement at the CCAMLR Working Group meetings 0.2 and subsequent adoption of the results or methodology within CCAMLR's management of the krill fishery, or in Domain 1 Planning for Marine Protected Areas.	Verification for our output indicators can be found in the 2019 report of the CCAMLR Commission (https://www.ccamlr.org/en/system/files/e-cc-38_1.pdf) in paragraphs 5.17 to 5.18, copied below: 5.17 The Commission endorsed the advancement of the krill fishery management strategy agreed by the Scientific Committee (SC-CAMLR-38, paragraphs 3.18 to 3.45) that comprised three key priority elements: (i) a stock assessment to estimate precautionary harvest rates (ii) regular updates of biomass estimates, initially at the subarea scale, but potentially at multiple scales (iii) a risk assessment framework to inform the spatial allocation of catch. 5.18 The Commission noted the importance of the successful development of a krill fishery management strategy and its appreciation to all parties involved. The Commission agreed that there was a need to expedite development of the three elements in paragraph 5.17 because of the expiration of CM 51-07 at the end of the 2020/21 season, and that this would require, inter alia, focus topics during future working group meetings, and collaboration between Members and with bodies such as the SCAR Krill Action Group (SKAG) and ARK.

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
Output 1: Identify areas which are desirable to the krill fishery.	1.1 Analysis of historical catch data from which we can identify desirable areas for krill fisheries by the end of 2018. 1.2 Submission of a Working Paper to the CCAMLR Working Group on Ecosystem Monitoring and Management in June 2019.	Papers submitted to CCAMLR show that these outputs were delivered: see outputs c and f, also 5 and 6 (see above).
1.1 Use habitat models to investigate variability in the spatial distribution of the krill fishery in relation to bathymetry, sea ice cover, proximity to the shelf break and fine-scale water movement, over both historical (1981/82 to 2016/17) and recent timescales (2009/10 to 2016/17). 1.2 Write up the model for submission to WG-EMM-19.		Papers submitted to CCAMLR show that these outputs were delivered: see outputs c and f, also 5 and 6 (see above).
Output 2: Produce a spatially and temporally scaled krill model which takes account of flux and movement of krill.	2.1 Analysis of oceanographic flow fields in an existing oceanographic model to determine preferred movement pathways and retention areas by June 2019. 2.2 Submission of a Working Paper to the CCAMLR Working Group on Ecosystem Monitoring and Management in June 2020.	Papers submitted to CCAMLR show that these outputs were delivered: see outputs c, also 1, 4 and 6 (see above).
2.1 Investigate proxies for the oceanographic flux and movement (import and export) of krill by utilising a fine-scale ocean model to estimate relative water movement rates at spatial scales relevant to predator consumption and fisheries usage. 2.2 Write up results for submission to WG-EMM-20.		Papers submitted to CCAMLR show that these outputs were delivered: see outputs c, also 1, 4 and 6 (see above).
Output 3: Spatially and temporally explicit consumption estimates for key predator groups.	3.1 Production of maps highlighting the key areas for predator consumption by June 2019.	Papers submitted to CCAMLR show that these outputs were delivered: see outputs a, b, c and e, also 2, 3, 7 and 8 (see above).

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
	3.2 Submission of a Working Paper to the CCAMLR Working Group on Ecosystem Monitoring and Management in June 2019.	
Output 4: Maps and tables of results describing the levels of risk to krill dependent predators under scenarios where management occurs at a variety of spatial and temporal scales.	4.1 A report containing the final results will be submitted as a Working Paper to the CCAMLR Working Group on Ecosystem Monitoring and Management in June 2020.	Papers submitted to CCAMLR show that these outputs were delivered: see output 5 (see above).
4.1 Integrate existing and novel data-layers and apply the risk assessment framework to identify the areas of increased risk to predator populations or krill. We will apply the risk assessment framework at a variety of spatial scales which we will identify based on bathymetry, predator distribution, current flow, and distance from the shelf-edge, and at temporal scales according to predator life-history and movement constraints. This will allow us to identify the relative risks when the framework is applied at various spatial and temporal scales, and enable the identification of an appropriate scale at which to apportion the catch limit. We will focus initially on Subarea 48.1 as this is where the fisheries is most constrained by catch limits and where it operates in close proximity to the breeding colonies of dependent predators, especially penguins. We will present the methodologies utilised in the production of the data layers allowing for the addition of new information by other Members. We will also present a series of maps and tables which detail the data layers to be included in the risk assessment and the risk indices and catch-limit proportions under different krill fishing scenarios.		Papers submitted to CCAMLR show that these outputs were delivered: see output 5 (see above).
Output 5: Peer-reviewed papers submitted for publication.	5.1 Individual papers will be submitted for publication by the end of the project.	
5.1 All of the outputs will be written up for submission to peer reviewed journals.		The following papers are in review and acknowledge Darwin Plus DPLUS 072:

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
		Trathan, P.N., Fielding, S., Hollyman, P., Murphy, E.J., Warwick-Evans, V., Collins, M.A. (In Review) The aspirations and challenges of implementing ecosystem-based fisheries management for Antarctic krill within the complex, variable and changing ecosystem at South Georgia. ICES Journal of Marine Systems. Trathan, P.N., Warwick-Evans, V., Young, E.F., Friedlaender, A., Kim, J.H., Kokubun, N. (In Review) Ecosystem-based management of the Antarctic krill fishery - the 'devils are in the detail' at small spatial and temporal scales. Journal of Marine Systems. Warwick-Evans, V., Santora, J.A., Waggitt, J.J., Trathan, P.N.(In Review) Multi-scale assessment of distribution and density of procellariiform seabirds within the northern Antarctic Peninsula marine ecosystem. ICES Journal of Marine Science. Warwick-Evans, V., Kelly, N., Dalla Rosa, L., Friedlaender, A., Hinke, J.T., Kim, J.H., Kokubun, N., Santora, J.A., Secchi, E.R., Seyboth, E., Trathan, P.N. (In Review) Using seabird and whale distribution models to estimate spatial consumption of krill to inform fishery management. Ecosphere. Other papers will be submitted in due course, and will also contain acknowledgement to Darwin Plus DPLUS072.

Annex 3 Standard Measures

Code	Description	Totals (plus additional detail as required)
Training Measures		
1	Number of (i) students from the UKOTs; and (ii) other students to receive training (including PhD, masters and other training and receiving a qualification or certificate)	0
2	Number of (i) people in UKOTs; and (ii) other people receiving other forms of long-term (>1yr) training not leading to formal qualification	0
3a	Number of (i) people in UKOTs; and (ii) other people receiving other forms of short-term education/training (i.e. not categories 1-5 above)	i. 0 ii. 1 Warwick-Evans received training.
3b	Number of training weeks (i) in UKOTs; (ii) outside UKOTs not leading to formal qualification	i. 0 ii. 1 Warwick-Evans received training in Australia on cetacean abundance estimation.
4	Number of types of training materials produced. Were these materials made available for use by UKOTs?	0
5	Number of UKOT citizens who have increased capacity to manage natural resources as a result of the project	0
Research Measures		
9	Number of species/habitat management plans/ strategies (or action plans) produced for/by Governments, public authorities or other implementing agencies in the UKOTs	1
10	Number of formal documents produced to assist work in UKOTs related to species identification, classification and recording.	19 Working Papers
11a	Number of papers published or accepted for publication in peer reviewed journals written by (i) UKOT authors; and (ii) other authors	i. 0 ii. 4
11b	Number of papers published or accepted for publication elsewhere written by (i) UKOT authors; and (ii) other authors	i. 0 ii. 0
12b	Number of computer-based databases enhanced (containing species/genetic information). Were these databases made available for use by UKOTs?	1 GitHub (in preparation)
13a	Number of species reference collections established. Were these collections handed over to UKOTs?	0

Code	Description	Totals (plus additional detail as required)
13b	Number of species reference collections enhanced. Were these collections handed over to UKOTs?	0
Dissemination Measures		
14a	Number of conferences/seminars/workshops/stakeholder meetings organised to present/disseminate findings from UKOT's Darwin project work	0
14b	Number of conferences/seminars/ workshops/stakeholder meetings attended at which findings from the Darwin Plus project work will be presented/ disseminated	2019 - 4 2020 - 4
Physical Measures		
20	Estimated value (£s) of physical assets handed over to UKOT(s)	0
21	Number of permanent educational/training/research facilities or organisation established in UKOTs	0
22	Number of permanent field plots established in UKOTs	0
23	Value of resources raised from other sources (e.g., in addition to Darwin funding) for project work	

Annex 4 Publications

Type * (e.g. journals, manual, CDs)	Detail (title, author, year)	Nationality of lead author	Nationality of institution of lead author	Gender of lead author	Publishers (name, city)	Available from (e.g. weblink, contact address, annex etc)
CCAMLR papers	Outputs i to viii. Outputs 1 to 9. Outputs I to II.					Available from CCAMLR Secretariat on request, or from the PI or recognised researcher.
Peer-reviewed papers	Outputs A to D.					Will be published with open access availability.

Annex 5 Darwin Contacts

Ref No	DPLUS072
Project Title	Developing the risk assessment framework for the Antarctic krill fishery
Project Leader Details	
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Checklist for submission

	Check
Is the report less than 10MB? If so, please email to Darwin-Projects@ltsi.co.uk putting the project number in the Subject line.	Y
Is your report more than 10MB? If so, please discuss with Darwin-Projects@ltsi.co.uk about the best way to deliver the report, putting the project number in the Subject line.	NA
Have you included means of verification? You need not submit every project document, but the main outputs and a selection of the others would strengthen the report.	Y
Do you have hard copies of material you want to submit with the report? If so, please make this clear in the covering email and ensure all material is marked with the project number. However, we would expect that most material will now be electronic.	N
Have you involved your partners in preparation of the report and named the main contributors	NA
Have you completed the Project Expenditure table fully?	Y
Do not include claim forms or other communications with this report.	