Darwin Plus:
Overseas Territories Environment and Climate Fund
Annual 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)

Submission Deadline: 30th April 2020

Darwin Plus 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 institutions	
Grant value	Philip Trathan
Start/end dates of project	1 September 2018 to 31 August 2020
Reporting period (e.g. Apr 2019-Mar 2020) and number (e.g. Annual Report 1, 2)	May 2019 - May 2020 AR2
Project Leader name	Philip Trathan
Project website/blog/social media	
Report author(s) and date	Philip Trathan and Vicky Warwick-Evans; 23 June 2020

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, 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 400,000 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 CCAMLR Scientific Committee has advised the Commission that the programme 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.

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 will therefore help expedite the 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 has been exceptional over the past 12 months. We submitted 6 papers to the 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 has also now agreed a clear approach for managing the krill fishery which were detailed in the report of the meeting and considered at the meeting of the Scientific Committee (21 to 25 October 2019) and subsequently at the meeting of the Commission (28 October to 1 November 2019). An extract from the WG-EMM report (https://www.ccamlr.org/en/wg-emm-2019) is given here:

2.18 The Working Group agreed a prioritised, three-part approach to advance a preferred strategy to manage the krill fishery by: (i) developing a stock assessment to estimate precautionary harvest rates (Tables 2 and 3), (ii) developing updated biomass estimates, initially at the subarea scale, but potentially at multiple scales (Tables 4 to 6), (iii) advancing the risk assessment framework to inform the spatial allocation of catch (Tables 7 and 8).

Discussions regarding point three of this action plan were facilitated largely by the outputs we have achieved to-date with this Darwin Plus project, and subsequently submitted to WG-EMM. To have reached consensus that the risk assessment plays a fundamental part in the management framework of krill fisheries is a huge step forward for CCAMLR.

Prior to WG-EMM in 2019 the Project Leader (P.N. Trathan) jointly coordinated a workshop on krill fishery management for Subareas 48.1 and 48.2 with George Watters, 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 eNGO representatives, 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 WG-EMM 2019, 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 2019.

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

a. 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

b. 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

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

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

e. 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

f. 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 also engaged with stakeholders at the regular meetings of the CCAMLR Scientific Committee and Commission. The Commission has now endorsed the management framework proposed by WG-EMM 2019, including the risk assessment. We submitted two papers to the meeting of the Scientific Committee (these are attached to our current report):

g. 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

h. 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 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 annual report on this project has been delayed because the end of the reporting period coincides with an exceptionally busy period in the CCAMLR annual cycle. Thus, despite the limitations set by Covid-19, we have now submitted a further suite of papers to the 2020 virtual meeting of WG-EMM. These papers show our wide engagement across CCAMLR Members and 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

The recognised researcher (V. Warwick-Evans) is 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).

In addition, we have been approached by the Pew Charitable Trusts (USA) and asked to submit a research proposal extending our project work for another 17 months. The development of the contract for this work is almost complete. It is likely to be of similar scale in monetary terms, to the financial support provided by Darwin Plus to DPLUS072. This clearly demonstrates the value of our project to stakeholders.

The key lesson learned from our project, is that full and open engagement with stakeholders is essential as previously unforeseen opportunities can arise that would have been hard to predict. Openness and transparency builds 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 level of trust with eNGOs and with the fishing industry through a series of small-scale projects, including previously through DPLUS09, DPLUS54 and now through DPLUS072.

3. Project progress

3.1 Progress in carrying out project Activities

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 two manuscripts that are nearly ready for submission to 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 these papers in the near future following the 2020 virtual meeting of WG-EMM.

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 section 2: output c).

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 have been 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 section 2: output 2, output 3 and output 4).

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 distance from the coast, distribution of krill consumption by predators and other management boundaries 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.

A paper on this topic has been 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 section 2: output 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 2020, will be undertaken during the rest of this project.

3.2 Progress towards project Outputs

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 meeting of WG-EMM. 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, 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 also be met. Indeed, some papers are already at the level necessary for submission.

3.3 Progress towards the project Outcome

Our work, which includes contributions from a wide range of international collaborators, will allow 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 now 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 Area.

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.

The overall success of the project will best be judged at the time that CM 51-07 is re-negotiated.

We will continue with development of our project under new funding currently under negotiation with the Pew Charitable Trusts (US).

3.4 Monitoring of assumptions

All of the assumptions 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 large number of collaborators.

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

The Antarctic Peninsula lies within the British Antarctic Territory (BAT); it is 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 (Trathan) initiated a paper that has been submitted to WG-EMM 2020. Though not directly linked to the outputs of this project, the paper demonstrates the broader context that surrounds the project and issues that need to be considered as part of the development of the risk assessment. This paper is:

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.

The Government of BAT (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: Consideration of gender equality issues

Our work is implemented and directed by the recognised researcher (V. Warwick-Evans) and the project PL (Trathan). 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. 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 project. 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 are being 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 WG-EMM, there will be no formal report agreed by consensus, as in previous years; however, there is likely to be a Chair's report which will become available towards the end of the calendar year, after this project terminates. The Scientific Committee meets after this project, DPLUS072, terminates, but should hopefully be available in due course.

7. Lessons learnt

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 solely UK-centric project. This is because the Antarctic Peninsula although part of BAT, is also managed internationally through CCAMLR and the Antarctic Treaty System. As such collaboration and transparency have been 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 a single 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; however, Covid-19 has hindered this during 2020, so we have made extensive use of email, Skype and Zoom. Sll of these communication media have allowed us to continue despite major international problems with travel.

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

We have updated our log frame (attached) 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 meeting of WG-EMM. 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, co-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 section 2: output d, output g and output h).

Part of the anticipated co-funding identified in the original proposal did not materialise, as the CEMP Fund rules changed to no longer allow for salary contributions. During our project implementation the shortfall was not a problem as our analyses and output were readily accepted by our collaborators. Further, we have submitted grant proposals to the Antarctic WildLife Research Fund to prolong our project after the project officially ends. As identified above, the Pew Charitable Trusts (US) have also invited us to bid for funds to continue the project until 31 December 2021.

9. Other comments on progress not covered elsewhere

We have delivered a suit of papers to the 2020 virtual meeting of WG-EMM. We will report at the end of the project about how well these papers were received and therefore on further progress made.

10. Sustainability and legacy

Our project contributes to evidence-based management of Antarctic krill fisheries – a stated priority for CCAMLR and a major focus of discussions within the CCAMLR community over the past two years. Our work has been promoted during CCAMLR Working Group, Scientific Committee and Commission meetings. It has been well received by the CCAMLR community, and will be a major focus during the 2020 virtual WG-EMM meetings in July. The meeting reports provide evidence that this has been an important topic for CCAMLR. Additionally, although WG-EMM has been cancelled this year, e-group discussions will proceed, focussing on priority topics. The risk assessment is one of only three topics being discussed this year, again highlighting the importance of our project within the community, and its impact for management.

Our planned exit strategy is still valid and it is highly likely that the outputs from our project will be used for future management of the krill fishery. We have discussed our outputs with US-AMLR (the US Antarctic Programme) and AAD (The Australian Antarctic Division) and our collaborators agree that the progress to date is promising, and that the outputs should be used for management. The project will be discussed

with the wider community during the upcoming WG-EMM discussions, and it is likely that the recommendations as a result of these meetings will be to implement the outcome of our risk assessment into the krill management framework.

On implementation of the risk assessment, CCAMLR will be able to demonstrate a community-led ecosystem-based management strategy for krill.

11. Darwin identity

The Darwin initiative has been acknowledged in all of our major manuscripts, both for the virtual 2020 meeting of WG-EMM and for submission to peer reviewed journals. We submitted an abstract to present this work, including to promote the Darwin Initiative, at the World Seabird Conference which was scheduled to be held in Hobart in October 2020. However, this meeting has been postponed due to the global pandemic of Covid-19. We hope to present the work next year, during which we will publicise Darwin Plus. We have given talks within our institution, and at other institutions, during which the Darwin Plus logo was displayed.

12. Safeguarding

The British Antarctic Survey is a well-respected UK scientific research organisation, with many safeguarding procedures in place, including those of the parent bodies that include NERC and UKRI. There is zero tolerance of bullying, harassment, sexual exploitation and abuse, and a clear code of conduct for all staff. There are many official procedures to report and investigate any untoward behaviour, and these are taken seriously, and infringements can be reported to higher management in a protected manner, should they occur. The excellent reputation of BAS provides evidence that those involved in this project were protected at all times.

13. Project expenditure

Table 1: Project expenditure <u>during the reporting period</u> (1 April 2019 – 31 March 2020)

Project spend (indicative) in this financial year	**2019/20 D+ Grant (£)**	**2019/20 Total actual D+ Costs (£)**	**Variance %**	**Comments (please explain significant variances)**
Staff costs				
Consultancy costs				
Overhead Costs				
Travel and subsistence				
Operating Costs				
Capital items				
Others (Please specify)				
TOTAL				

Annex 1: Report of progress and achievements against Logical Framework for Financial Year 2019-2020 – <u>if applicable</u>

Project summary	Measurable Indicators	Progress and Achievements April 2019 - March 2020	Actions required/planned for next period
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 work was discussed and endorsed by WG-EMM in 2019 and is being discussed again at the virtual WG-EMM meeting in 2020, with the aim of incorporating the results into the krill fishery management framework. This is a considerable step towards achieving the project impact.	
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 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	We have had positive engagement at previous CCAMLR Working Group meetings, and the project topic has been identified as one of only 3 priority areas for discussion at the virtual meetings to be held in July 2020. Discussion with the US and Australian Antarctic programmes has indicated that they are keen to implement the risk assessment into the krill management framework and are co-authors on our key outputs.	Discussions at virtual WG-EMM in July. Submission of papers for peer review. We have begun engagement with scientists from Argentina and Chile in relation to Domain 1 Planning for Marine Protected Areas; further engagement will take place after WG-EMM in July 2020.
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 WG-EMM in June 2019.	This work was reported to WG-EMM 2019 and further progress will be reported to WG-EMM 2020.	
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		We have created a layer in the risk assessment which accounts for the	This work is complete.

Project summary	Measurable Indicators	Progress and Achievements April 2019 - March 2020	Actions required/planned for next period
shelf break and fine-scale water movement, over both historical (1981/82 to 2016/17) and recent timescales (2009/10 to 2016/17).		desirability of different areas to the krill fishery.	
1.2 Write up the model for submission to WG-EMM-19.		The work was reported to WG-EMM 2019 with further work for WG-EMM 2020.	This work is complete
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. 2.2 Submission of a Working Paper to the CCAMLR WG-EMM.	The work was reported to WG-EMM 2019 and a paper is ready for submission to a peer-reviewed journal. This work is complete	
Activity 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.		We considered different oceanographic gateways that may bring krill to the preferred fishing locations in the Bransfield Strait.	This work is complete.
Activity 2.2. Write up results for submission to WG-EMM in 2019.		This work was delivered to WG-EMM in 2019	A paper for the peer-reviewed literature is ready for submission to the journal Ecological Indicators.
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 WG-EMM in June 2019.	We have written a paper detailing the distribution of flying seabirds which has been submitted to WG-EMM 2020, and which is in review at ICES Journal of Marine Science. We have written a paper estimating the consumption of krill by whales, penguins and flying seabirds and submitted this to WG-EMM 2020 and is about to be submitted to the journal Diversity and Distribution.	
Activity 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		This has been completed	

Project summary	Measurable Indicators	Progress and Achievements April 2019 - March 2020	Actions required/planned for next period
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.			
Activity 3.2. Write up the results for submission to WG-EMM in 2019.		This has been completed	
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 to WG-EMM in June 2020.	We have applied the risk assessment to Subarea 48.1. We have tested 3 spatial scales to date, but will be able to rapidly add more scales in the very near future. We have identified the relative risks to the ecosystem at each of these three scales, and have the code to implement this at multiple spatial scales. We have written this up for a paper to WG-EMM in 2020.	
Activity 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.		This has been completed.	

Project summary	Measurable Indicators	Progress and Achievements April 2019 - March 2020	Actions required/planned for next period
Output 5: Peer-reviewed papers submitted for publication.	5.1 Individual papers will be submitted for publication by the end of the project.	We have one paper in review, and two papers ready to be submitted. We are waiting on the results of discussion from WG-EMM 2020 to finalise the final risk assessment but this will also be written up for publication in peer-reviewed journals in the coming months. We have recently acquired more data on the winter distribution of krill in Subarea 48.1 and will write up this paper for peer review after the new data has been incorporated into the analysis.	
5.1 All of the outputs will be written up for submission to peer reviewed journals.		The papers should all be completed by the end of the project, depending upon the responses we receive at WG-EMM in 2020.	

Annex 2: Project's full current logframe as presented in the application form (unless changes have been agreed) - <u>if applicable</u>

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: 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.	0.2 Positive engagement at the CCAMLR Working Group meetings 0.3 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 XXX.	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.

	2.2 Submission of a Working Paper to the CCAMLR Working Group on Ecosystem Monitoring and Management in June 2020.		
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.

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.	N
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.	