Fidelity to overwinter migration strategies and identification of regional foraging hotspots within Subarea 48.1 of Chinstrap penguins (*Pygoscelis antarcticus*)

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3. Project Objectives and Background

During WG-EMM 2021 substantial progress in developing the Risk Assessment for Subarea 48.1 was made, in which a large majority of the data made available to the process had been included (c.f WG-EMM 2019, Table 7). Notably though, WG-EMM 2019 recognized that the inclusion of data into the Risk Assessment relating to adult overwinter migration and fledgling movement strategies from all Pygoscelis spp should be considered a high priority. However these data are hard to acquire; adults moult after breeding (making instrumentation with telemetry devices challenging until very late in the season) and immediate post-fledging mortality rates are high [1]. Nevertheless, prior work to track winter movements of Pygoscelis penguins has shown that Gentoo penguins appear to remain relatively local to their breeding colonies throughout the austral winter [2], while Adélie penguins in the northern Antarctic Peninsula undertake extensive post-breeding migrations [3]. Adult Chinstrap penguins breeding in Subarea 48.1 exhibit more-individualistic strategies, but may be categorized as either far-ranging, with movement into the Pacific or Atlantic sectors of the Southern Ocean, or local and remaining within ~500km of the Antarctic Peninsula [3,4]. Conversely, those from Subarea 48.2 appear to migrate to the South Sandwich Islands over winter (Ratcliffe, pers com).

Importantly, the temporal stability of these alternate migration strategies by individuals is unknown, which in the context of CEMP makes interpreting the available monitoring data challenging; each migration strategy will expose individuals to different environmental conditions, integrating their impacts into overwinter performance in different ways.   Thus, considering the absence of overwinter fishing activity outside the Antarctic Peninsula (excepting the eastern shelf of South Georgia; Figure 1), it is important to understand what conditions overwinter migration strategies within CEMP monitored populations integrate information over. Naturally then, for individuals that express a local migration strategy within Subarea 48.1 it follows that identifying the degree and significance of overlap in relation to the fishery during the austral autumn and winter becomes critical.   In tandem with appropriately contextualizing and interpreting monitoring information for adult birds, improving our understanding of post-fledging movement that coincides with a ramp-up in fishing effort in Subarea 48.1 will help shed further light on the onset of survival bottlenecks and the degree of overlap with fishing operations sensu [1].

Our proposal thus addresses three key knowledge gaps relevant to developing CEMP, its overall objectives and that will directly address data paucity regarded as "high priority" within the Risk Assessment framework in the ongoing development of the krill management strategy:

1) Identification of and individual fidelity to overwinter migration strategies

2) Local overwinter habitat selection

3) Post-fledging habitat selection

Overall, on account of the lead-time for equipment manufacture and supply as well as logistical organization for Antarctic field seasons, the project will run from October 2022 – November 2025 incorporating three overwinter seasons.

4. Consistency with one or more priorities for the CEMP special fund

Our project will directly address priorities (ii), (iii) and (iv) of the CEMP special fund:

(ii) Our study will further expand our knowledge of two poorly understood aspects of Chinstrap penguin at-sea behaviour; site fidelity of individual chinstrap penguins to overwinter foraging locations and post-fledgling movement.

(iii) Our proposal provides an umbrella under which data from projects across multiple sites, which can be drawn together, analysed using an agreed methodology and brought into CCAMLR in a standardized format for further integration.

(iv) Finally, by providing insight into the temporal stability of migration strategies of adult penguins, we will improve interpretation of CEMP indices that integrate information on overwinter conditions.

We will enhance both the spatial and temporal coverage of the CEMP program with data on key life history stages that impact CEMP monitoring indices and will provide important context for interpreting those indices in light of CEMP objectives. Our proposal will provide data acknowledged as representing a "High Priority" for appropriate completion of the Risk Assessment, an integral component to the development of the krill fishery management approach.

5. Enhanced capability and methods

Objective #1: Identification of and individual fidelity to overwinter migration strategies (Mar 2023- Nov 2025; 3 seasons)

Light geolocating devices (GLS) are an inexpensive means of collecting coarse-scale movement data on animals. These devices offer sufficient resolution for the purposes of characterizing overwinter migration strategies at the scales described in Hinke et al (2019). Furthermore, individuals can be instrumented before chick-rearing finishes (ensuring only individuals who bred in the colony are included) and followed across multiple years, allowing us to characterize the fidelity of individuals to a particular strategy. Consequently, we will initially instrument a minimum of N=20 individuals in the first season (commencing in February 2023) at each site and supplement with additional instruments for the remaining two seasons to maintain this sample size. Ultimately, the goal is to collect up to 3 consecutive years of movement data for individuals. Each GLS tag has the capacity to record data for up to 4 years, however assuming an annual loss-rate of up to 40% each year (either animals not returning or instrument loss), we request support for an additional 100 GLS tags to be distributed across the study sites to allow replacements.

Objective #2: Local overwinter habitat selection (Mar 2024 – Nov 2025; 2 seasons)

A subset of individuals (if any) who have demonstrated a more "local" (i.e. Subarea 48.1) migration strategy from GLS data will be instrumented with archival Pathtrack Nanofix GPS and CEFAS G5 dive recorders at sites on Ardley, Kopaitic and Deception Islands (N=20 per site; Cape Shireff may be included, contingent upon logistical capacity; Figure 2). Dr Lee and colleagues at KOPRI have conducted a large-scale instrumentation program using similar high resolution tags at Narebski Point. Thus, our study will focus on instrumenting individuals to complement this work and supplement if necessary, to build a comprehensive regional overview. The relatively high return-rate on light geolocating studies (up to

75%; e.g. [3]) and the ease of device retrieval once birds are resighted, suggests we can expect winter movement information from between 10-15 individuals at each site.

Objective #3: Post-fledging movement behaviour (Mar 2023 - 1 season only)

Fledglings from the 4 sites covered in Objective #2 (N=5 per site) as well as Narebski Point that are weigh more than the mean weight recorded for that season (and are thus assumed to represent individuals with increased chances of survival) will be instrumented with Argos-CLS Platform Transmitter Terminal (PTT; either Kiwisat or Telonics) to provide at-sea location information on fledglings.

6. Staff & Budgets

Please see the end of this document for the detailed budget.

In addition to the location-specific tasks outlined below, all Principal Investigators listed in the proposal will contribute to the analysis, preparation and writing of Working Papers and scientific publications.

Principal Investigator	Responsibilities	Time commitments
A Lowther	Project management and administration	4 weeks
	Field and analytical support	
	Involvement in working document and manuscript preparation	
E Johannessen	Field and analytical support	2 weeks
W Oosthuizen	Field and analytical support	2 weeks
N Ratcliffe	Fieldwork / instrumentation (Signy)	1 week
J Hinke	Fieldwork / instrumentation (Cape Shireff)	2 weeks
A Soutullo	Fieldwork / instrumentation (Ardley Island)	1 week
A Machado	Fieldwork / instrumentation (Ardley Island)	2 weeks
WY Lee	Fieldwork / instrumentation (Narebski Point)	2 weeks
C Cárdenas	Fieldwork / instrumentation (Kopaitic Island)	1 week
L Krüger	Fieldwork / instrumentation (Kopaitic Island)	2 weeks
A Barbosa	Fieldwork / instrumentation (Deception Island)	2 weeks

7. Linkages

The two core foci of CCAMLR in Subarea 48.1 and 48.2 are currently spatial conservation management (D1MPA) and the development and rollout of an updated krill fishery management strategy. Both approaches rely on understanding the structure and function of the ecosystem, particularly those components used to monitor it. The harmonization of these streams of work is critical for having an integrated approach to ecosystem based, sustainable management within Area 48. Our proposal in itself does not collect multidisciplinary data, however the linkages to these key CCAMLR foci are clear; developing information on key life history stages of a CEMP monitored species that are poorly understood and represent critical gaps in appropriately informing assessments of risk to the ecosystem from anthropogenic pressure.

The multi-site dataset generated from this proposal will be made available to all CCAMLR and its Members that aim to make scientific use of it, as well as to SCAR through its recently established AntICON Scientific Research Program. Our study will also establish a basis for which future studies can be compared, enabling the development of a new time series data on overwinter foraging behaviour. Thus, our proposal links to core CCAMLR foci in the region and CEMP's overall objectives, as well as other Antarctic research groups active within Member states.

8. Contribution to CEMP infrastructure

Our proposals´ contribution to CEMP infrastructure is simple: we will develop a coordinated, multi-site, multi-Member data collection and analysis pipeline to begin the development of a time series dataset for a key CEMP-monitored species that will provide environmental context to CEMP indices. The data collected during this proposal will address directly relative priority highlighted in Table 7 of WG-EMM 2019. The Risk Assessment component of the new krill management strategy presented in WG-EMM-2021/27 is likely to require updating at regular intervals. As such, once completed, our study builds on prior CEMP Fund tracking studies and to further develop a framework to assimilate data directly into future updates of the Risk Assessment processes.

Citations

1. Hinke JT, Watters GM, Reiss CS, Santora JA, Santos MM. Acute bottlenecks to the survival of juvenile Pygoscelis penguins occur immediately after fledging. Biology letters. 2020;16: 20200645.

2. Korczak-Abshire M, Hinke JT, Milinevsky G, Juáres MA, Watters GM. Coastal regions of the northern Antarctic Peninsula are key for gentoo populations. Biology letters. 2021;17: 20200708.

3. Hinke JT, Polito MJ, Goebel ME, Jarvis S, Reiss CS, Thorrold SR, et al. Spatial and isotopic niche partitioning during winter in chinstrap and Adélie penguins from the South Shetland Islands. Ecosphere. 2015;6: 1–32.

4. Hinke JT, Santos MM, Korczak-Abshire M, Milinevsky G, Watters GM. Individual variation in migratory movements of chinstrap penguins leads to widespread occupancy of ice-free winter habitats over the continental shelf and deep ocean basins of the Southern Ocean. PloS one. 2019;14: e0226207.

WG-EMM 2019. Report of the Working Group on Ecosystem Monitoring and Management. Concarneau, France, 24 June-5 July 2019.
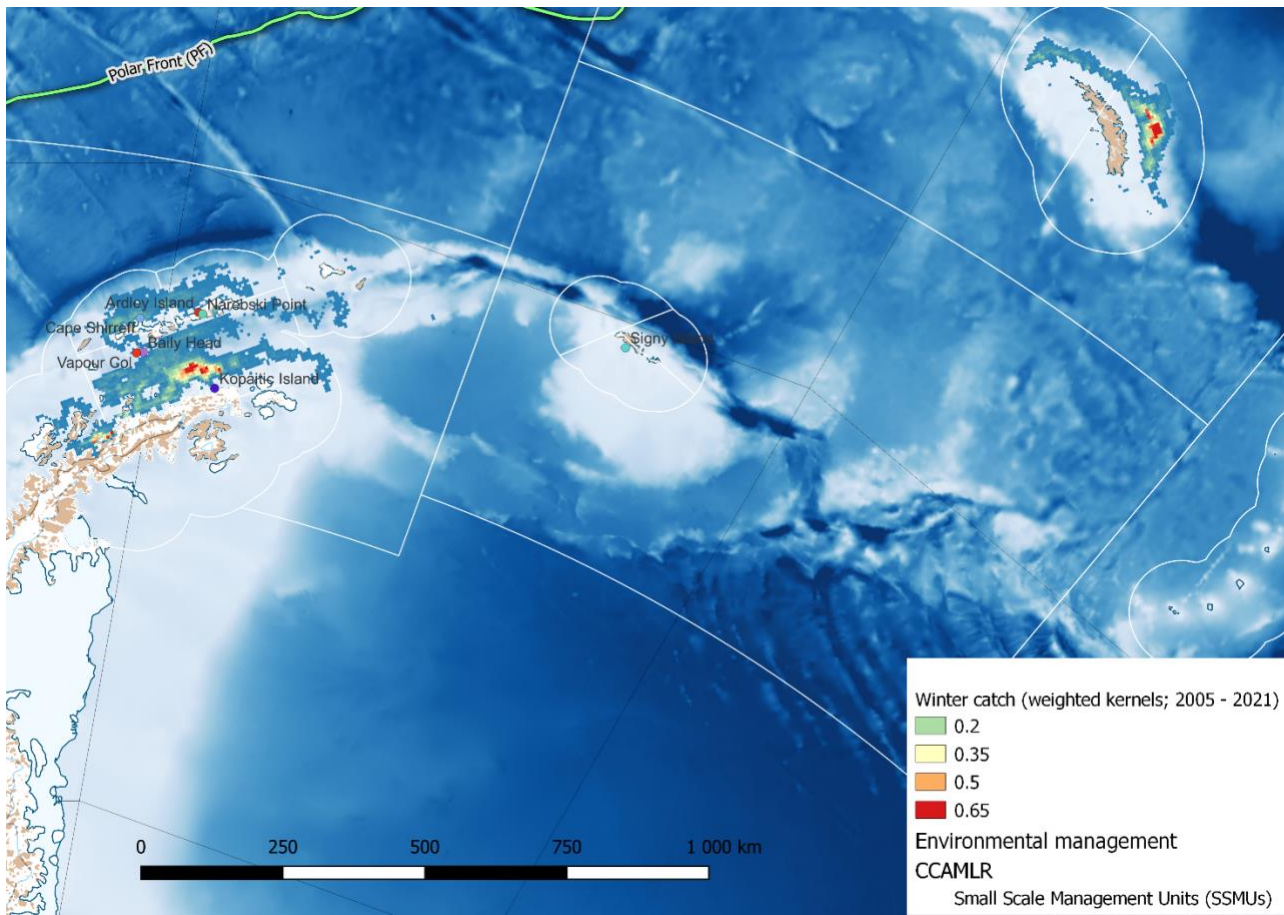
Figure 1. Overview of winter fishing activities across Area 48, and the study sites relevant to Objective #1. Light geolocating devices will be deployed on individual breeding chinstrap penguins at each location for multiple years, to identify alternate overwinter migration strategies and the degree of individual fidelity to them.
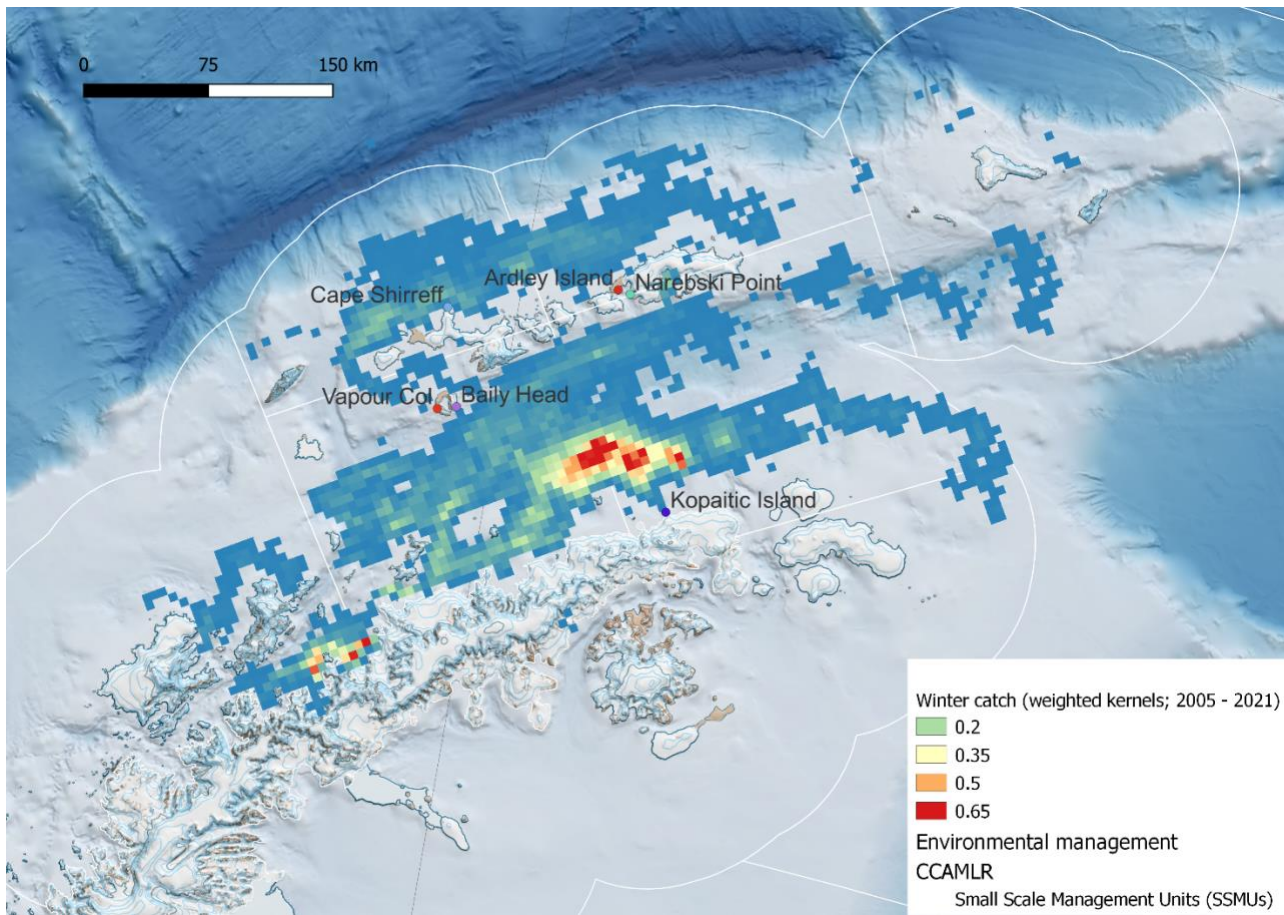
Figure 2. Locations of proposed study sites in Subarea 48.1 related to Objectives #2 and #3 in the proposal. Kernels weighted by tonnage of krill catch from 2005 – 2021 between April and November are shown. Study locations are chosen as a function of ease of access for instrumentation and retrieval (proximity to research stations) to capture trends between colonies and across the environmental gradients of the Bransfield Strait as well as the Drake Passage, and to encompass the general areas in which the fishery has been operating during the winter over the preceding 16 years. Research relevant already underway, led by Dr's Lee and Soutullo (Narebksi Point and Ardley Island) will be supplemented / complemented with instrumentation and logistical support where needed.

DETAILED BUDGET:

Note that the budget will not be spent in a single year, but costings for equipment will be spread over the project.

Item	N	Cost/N	Total (€)	Notes
Light Geolocating Tags (MigrateTech Intigeo)	220	120	26400	6 sites @ N=20/site, plus 100 additional replacements : includes shipping costs
Pathtrack nanotech GPS / TDR tags	100	620	62000	5 sites @ N=20/site : includes shipping
Kiwisat K2G Argos PTT + data transmission	25	2100	52500	5 sites @ N=5/site : includes shipping and related Argos data retrieval costs
Attachment and programming equipment	5	200	1000	tape, glue, cable ties, leg rings, programming interfaces for GLS
Flights (Punta Arenas / KGI)	12	1400	16800	additional staff to assist instrumenting / recapturing animals
TOTAL (€)			**158700**	

Should the CEMP Special Fund be unable to support the entire project, additional funding for Objective #3 (line item Kiwisat K2G Argos PTT + data transmission) can be sought through other means.