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Domain 1 Marine Protected Area Preliminary Proposal PART A-1: Priority Areas for Conservation

Delegations of Argentina and Chile

EN

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Abstract:

This document contributes to the planning process for the designation of a Domain 1 MPA led by Argentina and Chile. The process has resulted in the compilation, analysis, integration and display of a large amount of information, not only contributing to the best science available but also providing a platform for the sharing and visualization of information, highlighting the multinational approach in all stages of the decision making process. In particular, this paper describes the identification of Priority Areas for Conservation (PAC) in Domain 1 - as introduced during the last EMM meeting (WG-EMM-17/23)-, which included exhaustive analyses of hundreds of spatial data layers, extensive calibration of Marxan parameters and consideration of multiple alternative spatial configurations. To assist in the MPA planning process and future management, Domain 1 was thought in terms of three ecoregions (Northwestern and Southwestern Antarctic Peninsula and South Orkney Islands) that differ not only in their morphology, geology and ecology, but also in their current management and resilience to climate change.

The identification of PAC constitutes the initial step towards the development of a Domain 1 MPA that considers both conservation and rational use of marine resources. PAC can also serve other research and management strategies by providing areas where important benthic and pelagic habitats, processes and species spatially coincide, further improving the decision making process.

In this regard, Argentina and Chile propose the Scientific Committee considers the PAC identified in Domain 1 and its relevance to the MPA planning process and other research and management strategies.

OVERVIEW

This report is aimed to describe the process for the designation of an MPA in Domain 1 led by Argentina and Chile. The entire data collection and decision-making process were done following a multinational approach, on the occasion of two relevant international workshops, intersessional consultations and supplementary analyses (via data sharing mechanisms).

In order to fully describe the process of the draft of MPA proposal, Argentina and Chile will introduce 5 documents:

1- Domain 1 Marine Protected Area Preliminary Proposal. PART A-1: Priority Areas for Conservation

2- Domain 1 Marine Protected Area Preliminary Proposal. PART A-2: MPA Model

3- Domain 1 Marine Protected Area Preliminary Proposal. PART B: Conservation Objectives

4- Domain 1 Marine Protected Area Preliminary Proposal. PART C: Biodiversity Analysis by MPA zones

5- Domain 1 Marine Protected Area Preliminary Proposal. PART D: Simulating nursery areas for Antarctic krill along the western Antarctic Peninsula

Domain 1 Marine Protected Area Preliminary Proposal.

PART A-1: Priority Areas for Conservation

Content

Background of CCAMLR MPAs

Since 2005, CCAMLR has shown increasing interest in the development of Marine Protected Areas (MPA), seeking the advice from the Scientific Committee in accordance with articles II and IX of the Convention. The first workshop on MPA set the establishment of a harmonised regime for the protection of the Antarctic marine environment across the Antarctic Treaty System (ATS) as one of its primary aims, already stating that this may require clarification of the roles and responsibilities of ATCM and CCAMLR in respect of the management of different human activities in the region (SC-CAMLR-XXIV, paragraph 3.52). The development of a system of protected areas was required in order to assist CCAMLR in achieving its broader conservation objectives, obtaining scientific knowledge at a broad-scale: bioregionalisation and also at a fine-scale: subdivision. A few years later, eleven priority areas were identified, and then reviewed and re-scaled into nine large-scale MPA planning domains, to better reflect the scale and location of current and planned research effort, considered to be more helpful at monitoring units (second workshop on MPA in 2011). In 2009, the Convention adopted the first MPA in the South Orkney Islands southern shelf (Conservation Measure 91-03) as a first step towards the development of a representative network of protected areas. Later on, in 2010, to further preserve the significant marine biodiversity of the Convention Area, the Commission endorsed the Scientific Committee's work program to develop a representative system of Antarctic MPAs and one year after, Conservation Measure 91-04 (2011) was adopted, providing a general framework for the establishment of CCAMLR MPAs, including overarching MPA objectives, key elements and limitations of MPA conservation measures, and requirements for management and research and monitoring plans.

Within such a framework, several MPA proposals and advances towards the conservation of marine living resources including rational use have been developed and put forward for the consideration of the CCAMLR Scientific Committee and the Commission. USA and New Zealand presented a joint proposal for MPA in the Ross Sea planning domain. After intense negotiations that lasted over five years, in 2016, CCAMLR finally created the largest MPA in the world, in the Ross Sea region (RSRMPA), thus establishing an important international precedent that once again shows the necessary coexistence of conservation and the rational use of marine resources. In order to continue working towards achieving CCAMLR's objective of creating a representative network of MPAs, other MPA proposals are in discussion at the moment. Australia and France jointly presented a proposal for a representative system of MPAs for the whole East Antarctic planning domain, incorporating input from three consecutive years of work (CCAMLR-XXXIV/30). Germany, on behalf of the European Union, formally presented in 2016 a proposal for the Weddell Sea planning domain (SC-CCAMLR-XXXV/18).

The main objective of establishing a system of Marine Protected Areas (MPAs) in the Southern oceans is to preserve biodiversity. This is achieved by maintaining a healthy ecosystem, and therefore, specific objectives include the protection of benthic and pelagic habitats, ecosystemic processes and the feeding and reproduction areas of key marine species. These ecosystems are important in several ways, including its biogeochemical cycles, their contribution to food security as well as maintaining unique biological biodiversity (Murphy et al. 2013). However, individual MPA should complement each other based on the differential conservation objectives and threats present on each of CCAMLR's Planning Domains.

Domain 1 MPA Background

Climate Change in Domain 1

One of the most productive areas of the Southern oceans is the Southwest Atlantic sector, from the Antarctic Peninsula to the Antarctic Convergence and Scotia Arc, including the South Georgias and South Sandwich Islands. The Antarctic Peninsula is one of the areas that has experienced the most evident effects of global warming (Ducklow et al. 2013). Here, the surface air temperature has increased an average of 3- 4°C and, in particular, the average winter temperatures increased 6°C from 1950 to 2005 (Meredith and King 2005, Turner et al. 2009). During the same period, an increase in the average sea surface temperature was recorded in more than 1°C during summer (Meredith and King, 2005).

Because of the warming experienced in the region, there have been changes in the dynamics of sea ice; their average extension declined by 40% and duration of ice cover was reduced by 80 days (Ducklow *et al*. 2013; Stammerjohn *et al*. 2003, 2008a, 2008b, 2012). It has also decreased the frequency of occurrence of cold years and increased melting of glaciers, while the collapse of several ice shelves has increased in some areas of the WAP (Skvarca *et al*. 1999, Cook *et al*. 2016). Recent evidence shows that this situation is not only produced by atmospheric warming as it was originally thought, but also by the warming of deep ocean waters associated with the intrusion of the ACC onto the WAP shelf (Cook *et al.* 2016). Other consequences that have been observed include changes in atmospheric circulation, increased wind speed, and increased frequency of cloudiness and snowfall and precipitation (Thomas *et al.* 2008).

A surprising aspect of regional climate change is the magnitude of the impact caused by a relatively small change in temperature. The rise of a few degrees of air temperature produces the increase in ocean temperature and can cause large hydrologic changes that affect both the physical environment and the organisms. Increasing freshwater input from melting glaciers has contributed to the seasonal change in species diversity of phytoplankton and, thus, the marine zooplankton (Moline *et al*. 2008, McClintock *et al.* 2008). In addition, the decline in winter sea ice modifies the variety and regional composition of phytoplankton, which favors the proliferation of salps in detriment of krill. Krill recruitment has been linked to years of heavy sea ice during the winter (Fraser and Hoffman 2003), and it has been proposed that both the decrease in the extent and the duration of ice during the winter are the cause of the decline in krill abundance in the Antarctic Peninsula region (Atkinson *et al.* 2004, Flores *et al.* 2012). In addition, based on experimental evidence, it has been suggested that krill eggs might be sensible to increased concentrations of pCO_2 under projected scenarios (Kawaguchi *et al.* 2011). The effect of multiple stressors and their synergistic effects might become significant threats to krill populations in the Southern Ocean (Kawaguchi *et al.* 2013). Because of the key role that krill plays in the Antarctic ecosystem, negative effects produced by climate change may cascade to the trophic web and hence to the entire ecosystem. Alternatively, these changes also affect top predators; either by the loss or gain of critical habitat such as the territory used during reproduction and/or by modifying food webs, having a direct impact on birds and mammals feeding habits. Either way, the reduction of the sea ice is likely to affect the reproductive success of ice-dependant species, noting that species that do not depend on sea ice could benefit (Forcada 2007, Flores *et al.* 2012).

The reported actual and projected changes in the area, and the responses they induce in the ecosystem, are of profound importance (Meredith *et al.* 2017). In agreement with Conservation Measure 91-04, the development of conservation strategies for the marine living resources, particularly the designation of a representative system of MPAs, is of particular importance for maintaining the ability to adapt in the face of climate change.

Human activities in Domain 1

While climate change effects are of particular importance for the conservation of the Antarctic marine living resources, other activities need to be taken into account when designing conservation strategies. In Domain 1 several human activities contemplated within the Antarctic Treaty System take place simultaneously. Krill fishing and tourism, along with logistic/scientific activities, need to be considered in the decision making process in order to increase the efficacy in the application of the conservation strategies.

Krill Fishery activity began in 1961 but it became more active by the 1970s. As the fishery industry developed, its fishing location switched from the Indian Ocean to the Atlantic Ocean sector, where it focussed almost entirely since the early 1990s. In the past 10 years and most likely due to the decrease of sea ice extension, the spatial distribution of the fishery has been moving to the south, and nowadays it is mainly concentrated i) on the region of the Bransfield Strait/Mar de la Flota off the Antarctic Peninsula, ii) to the northwest of Coronation Island, and iii) to the north of South Georgias Islands (CCAMLR Krill Fishery Report 2015). In this area, krill fishery activity is regulated by CCAMLR through Conservation Measures 51-01 and 51-07, in which precautionary limits and trigger levels are established as 'decision rules' to determine what proportion of the stock can be fished while still achieving the Convention objectives.

Domain 1 MPA Process

All data use in this process comes from a variable range of sources that not only comprise data from CCAMLR domains but also from the wider community, including public global databases such as the Global Seafloor Geomorphology dataset (www. bluehabitats.org), KrillBase (Atkinson *et al.* 2017), and the U.S. National Snow and Ice Data Center (NSIDC), among many others.

Spatial data layers that were included in the analyses were provided on the basis of cooperation among Members and in agreement with experts on the occasion of several international workshops, intersessional consultations and supplementary analyses (via data sharing mechanisms). They represent the best science available gathered through the entire MPA process up to March 2017.

Main outcomes of the I International Workshop for Domain 1 (Valparaiso-Chile, 2012)

- Data compilation and agreed list of conservation objectives to be included in the analysis.
- A definition of the cost-layer to be included.
- A recommendation on the analysis and software to be used for aide on identifying priority areas for conservation.

  The report of the meeting (WG-EMM-12/69) can be found in the Domain 1 e-group.

Data sharing: Before the Second International Workshop, and in line with WG-EMM recommendation in which members are encouraged to develop different preliminary activities in their own countries (WG-EMM-14, paragraph 3.25), the data files were shared through a CCAMLR e-group. Examples of these activities include national workshops carried out by Argentina, Chile, the USA and the UK and aimed to (i) compile new data, (ii) discuss different conservation objectives, (iii) analyse penguins' habitat modeling and, (iv) identify high priority areas for conservation within Domain 1. All data is available at https://groups.ccamlr.org/d1pg/

Main outcomes of the II international Workshop (Buenos Aires, Argentina, 2015)

- Compilation and review of all available data for Domain 1.
- Review of target levels for each conservation object.
- Compilation and review of all available data on human activities.
- Discussion of parameters involved in estimating the cost layer related to human activities.

This information is available on the Report of the Second International Workshop for Domain 1 (WG-EMM-15/42), which can be found on the Domain 1 planning e-group.

At that time, two objectives of the workshop remained incomplete:

- (1) Development and analysis of alternative MPA scenarios using Marxan.
- (2) Developing of a Draft Proposal with the identification of preliminary areas for consideration of SC-CAMLR.

Data review and data sharing (before WG-EMM 2016 held in Bologna, Italy)

• Domain 1 MPA GIS database, including layers for Conservation Objectives and Marxan Costs were uploaded for all Members consideration within the Domain 1 planning e-group at https://groups.ccamlr.org/d1pg/.
• Domain 1 MPA Marxan database, including input files for running Marxan, were uploaded in the Domain 1 Planning e-group (https://groups.ccamlr.org/d1pg/).

Informal workshop on Domain 1 MPA (Bologna-Italy 9th July 2016)

In order to show the progress made from 2015 to 2016, and to fulfil the multinational commitments made at the II International Workshop, an informal workshop was held with the following objectives:

- To introduce alternative/possible scenarios according to what had been discussed during the II International Workshop.
- To introduce and integrate different analyses, views and experiences performed by other Members into the Domain 1 MPA designation process.

Regarding these objectives, there were three presentations introduced and discussed at the workshop, all of which complemented each other. The first presentation, introduced by Argentina, described the technical progress on Marxan analysis, following the agreement made during the previous year at the international workshop in Buenos Aires. The second presentation was introduced by the UK and described Marxan outcomes when only specific benthic conservation features were considered. The third presentation, by Adrian Dahood from the U.S., introduced the use of ecosystem modelling (Ecopath), which incorporated trophic relationships into the MPA planning process for the Western Antarctic Peninsula Region. Data and information for these analyses was available at Domain 1 Planning e-group.

The general agreements of the Informal workshop were:

Related to technical progress, several discussions were held and aimed to seek advice on the next stages of analysis.

1) Advice on target protection levels: several scenarios testing conservation targets levels were run in order to show how this parameter influences the selection of priority areas for conservation.

During the Informal Workshop, it was agreed that medium target protection levels were going to be used in final Marxan analysis as they better represent the protection sought within Domain 1 MPA.

2) Advice on fishery cost layer: several other scenarios testing the influence of the krill fishery cost layer were presented at the Informal Workshop. It was shown that the variable selected to represent the krill fishery and its range had a strong influence in the selection of priority areas for conservation. It was agreed to seek for the WG-EMM-16 advice on this matter.

During the EMM 16, advice specifically related to the fishery cost layer was sought, to better represent its spatial and temporal variability, including the utility to further split krill fishing time period matching predators-prey seasonality, for instance, during breeding and non-breeding distributions. The Working Group agreed on the use of a 3-year period for the most recent krill fishing activity (current krill fishing pattern), extending it to 10-year periods prior to current fishing pattern (historical krill fishing patterns) (WG-EMM-16, paragraph 3.19).

3) Overlap between Domain 1 and 3: it was agreed to extend data layers from Domain 1 into a 30km buffer zone through Domain 3, and to run Marxan analyses to identify priority areas for conservation within the buffer to help validate the analyses done within the Weddell Sea MPA process.

Until the MPA data sharing CCAMLR website reaches in its final version, Domain 1 MPA data and other relevant information (WG-EMM documents) are shared through Domain 1 MPA Planning e-group.

New Developments from July 2016 to April 2017

A. Sensitivity analyses and analyses by zone in order to interpret the conservation objects that have more influence in the identification of priority areas and MPA model (see Domain 1 MPA proposal – PART C, WG-EMM-17/25 Rev.1);

B. Inclusion of the border area between Domains 1 and 3 as validation of independent analysis;

C. Technical adjustments in the identification of critical habitats for mammals and birds, to better improve their spatial representation (See data form objective 5c);

D. Temporal-spatial analysis of Domain 1 krill fisheries, with the aim of identifying relevant areas, as well as the areas where krill dependant predators and preys overlap.

B) Overlap between DOMAIN 1 and 3

All relevant conservation objectives and spatial layers were extended to the 30 km buffer zone into Domain 3 and Marxan analyses were performed with this new data set. We found that priority areas for conservation are being selected around the north tip of the Antarctic Peninsula, including areas to the east into the buffer zone between domains, suggesting that both MPA processes (Domain 1 and Weddell Sea) independently identify those areas as important for conservation (See Annex 1).

D) Temporal-spatial analysis of Domain 1 krill fisheries (for further details see WG-EMM-17/22):

Several analyses were performed to understand the spatial and temporal variability of the krill fishery in the Domain 1. Krill fishery hotspots were identified and results proved that this fishery varies intra- and inter-annually. Moreover, krill catches also change across time and space. The analyses concluded that the development of a single krill fishing cost layer to be included in the Marxan analysis is not feasible, as it might not adequately represent current or future fishing patterns for Domain 1.

It is important to take into consideration the areas that might be more resilient to future condition in the Climate Change context. Domain 1 Marine Protected Area Preliminary Proposal: PART D (SC-CAMLR-XXXVI-XX) provides results on simulations estimating favourable nursery areas for Antarctic krill. Simulation assessed how the effect of projected environmental variation, including increased temperature and winds, enhanced transport of CDW, and projected sea ice, may alter circulation pathways and hence advection of krill larvae and the distribution of krill along the WAP shelf. Projected nursery areas by 2030 occupy the mid and inner-shelf, consistent with bathymetric depressions and biological hot spots (e.g. Crystal Sound and Palmer Deep). Projected circulation pathways may enhance advection of krill larvae from nursery areas into the inner shelf, to regions such as the Gerlache Strait and the area between Anvers and Renaud Island. Increased advection of CDW into the inner shelf may also support a successful descend-ascend cycle and enhance krill early development (see SC-CAMLR-XXXVI-XX).

IDENTIFICATION OF PRIORITY AREAS FOR CONSERVATION

TECHNICAL ANALYSIS

The Domain 1 MPA planning process used the Marxan software (WG-EMM-12/69), a widely used decision-support tool that is based on systematic conservation planning and assists in the process of protected area system design (Ball *et al.* 2009). Marxan efficiently identifies priority areas for conservation where spatial features are captured based on their established conservation targets.

Conservation objectives

Eight conservation objectives comprising 143 spatial layers were used in the analysis for the identification of Priority Areas for Conservation (Annex 2 in WG-EMM-17/24). Due to the intrinsic differences among spatial features based on the various objectives they seek to protect, variables defined to run Marxan differ. Most variables were directly related to the area that each spatial feature occupy in Domain 1 (conservation objectives 1, 2, 3, 4, 6, 7 and 8); meanwhile in some cases the variable was related to the intensity of use of a determined area (conservation objective 5). Conservation target for each spatial layer was defined and agreed by experts (WG-EMM-15/42, Annex 1).

The Southern Shelf South Orkney Islands MPA (SS SOI MPA), Vulnerable Marine Ecosystems (VME), and Antarctic Specially Protected Areas (ASPA) and Antarctic Specially Managed Areas (ASMA) with marine components (ASPAs 144, 145, 146, 149, 151, 152 and 153; ASMAs 1, 4 and 7), were all “locked-in” in Marxan analyses to allow for the protection already given by these areas.

Cost layer

Although Marxan is able to incorporate human activities in the process of identifying priority areas for conservation, the changing spatial-temporal variability in krill fishing activities was deemed to be a constraint in the development of a single cost layer that adequately accounted for fishing dynamics (see WG-EMM-17/22). According to this, the Domain 1 MPA planning process has used a fixed-value cost layer that does not incorporate data on krill fishing. Nevertheless, krill fishing catch and effort information has been an integral part of the preliminary proposal and has been considered during the definition of the MPA model and its management zones.

Calibration

Marxan results highly depend on appropriate calibration of its parameters (Ardron *et al.* 2010; Ball *et al.* 2009). Extensive analyses were performed pursuing the most adequate values for BLM (Boundary Length Modifier) - that accounts for the compactness of the design reserve -, SPF (Species Penalty Factor) - that contemplates penalties for not meeting protection targets -, and NUMITNS/NUMREPS (Number of Iterations/Number of repeat runs) – where both ensure that enough optimal solutions are found; please refer to the above references for further details on these parameters. Domain 1 MPA planning process used the following values for final runs: BLM=0.03, SPF=11.68, and NUMITNS=1e7, NUMREPS=100, based on calibrations performed using ZONAE COGITO (Watts *et al.* 2011).

RESULTS

Final Marxan run identified Priority Areas for Conservation (PAC) in Domain 1 (Fig. 1). These PAC were identified based on the frequency selection of planning units, e.g. the number of times a planning unit was selected as part of a good solution from all repeat runs. Interestingly, PAC seem to be rather consistent among runs, likely associated with an adequate calibration (note the low dispersion in PU frequency selection in Fig. 1).

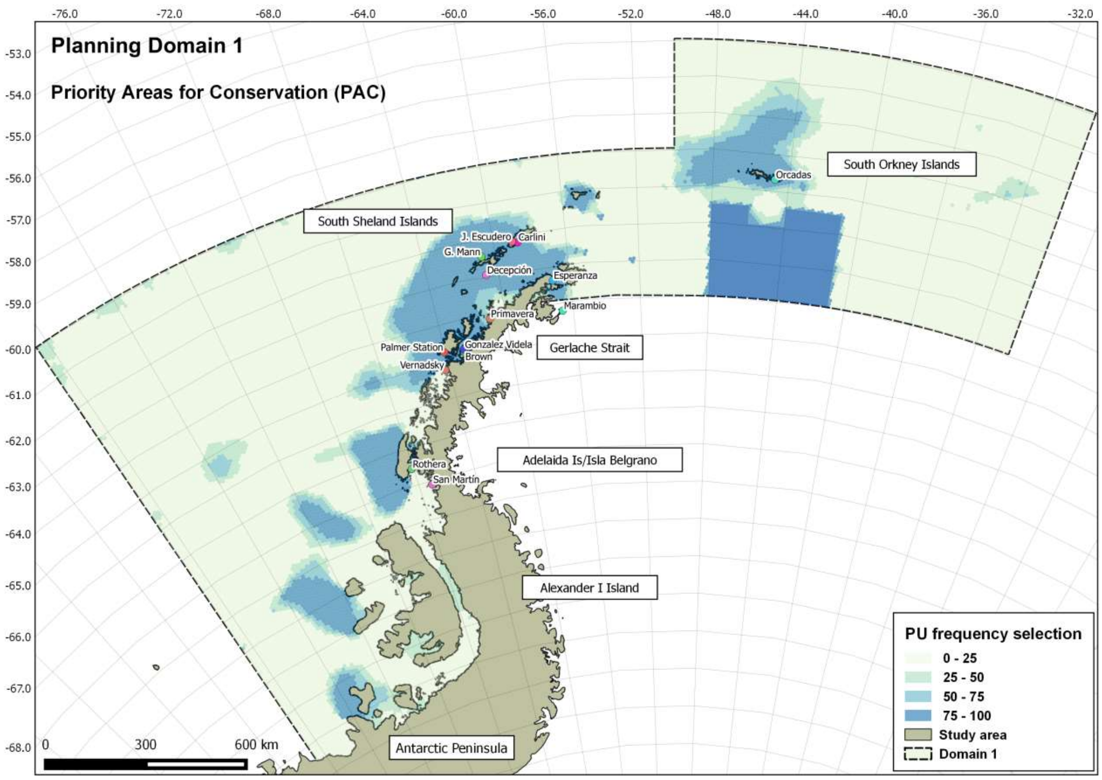

Figure 1: Location of Priority Areas for Conservation (PAC). Planning Unit (PU) selection frequency after performing 100 Marxan repeat runs. South Orkney Island Southern Shelf MPA was locked in into the analysis, so conservation objects already cover by the area were considered.

These PAC captured all conservation objects based on their established conservation targets providing spatial regions where complex, numerous and spatial-variable features overlap. This overlap is not evenly distributed across Domain 1 and PAC concentrate in specific regions around South Shetland Island, the Antarctic Peninsula and South Orkney Islands. To further assist in the consideration of the identified PAC, Domain 1 was thought in terms of ecoregions that differ not only in their morphology, geology and ecology, but also in their current management and resilience to climate change.

ECOREGIONS

Ecoregions are large geographical areas characterized by the uniqueness of their morphology, geology, climate, flora and fauna. This ecological division has also been used in discussions and has led to the partition of relevant data layers. So far, it has been distinguished the ecoregion of South Orkney Islands (48.2), the Northwestern Antarctic Peninsula and the Southwestern Antarctic Peninsula for objective 1 (benthic ecoregions), objective 2 (pelagic ecoregions), objective 5 (breeding colonies), objective 6 (fishes) and objective 8 (canyons) (WG-EMM-15/42). As to keep in line with previous agreements Domain 1 can be thought in terms of these ecoregions and further divided based on current fishery management and Climate Change.

The first specific division is between FAO statistical subareas 48.1 and 48.2, incorporating into the process an ecological and a management division, aimed to facilitate management strategies for both subareas.

The second specific division is between the north and the south of the west Antarctic Peninsula, and takes into consideration the effects of Climate Change. The limit of 65° between North WAP (NWAP) and South WAP (SWAP) was decided following Steinberg *et al.* (2015). The authors demonstrated the existence of a latitudinal gradient along the WAP wherein the south the climate is colder and drier (continental climate) while in the north, the climate is warmer, mostly maritime (Ducklow *et al.* 2013). In the WAP this gradient has been observed in Anvers Island with an ice free season while in the south of Marguerite Bay, the ice persists more than 7.5 months.

It is well known that the western Antarctic Peninsula is one of the areas that has experienced one of the most evident changes in air and water temperature since the second half of the 20th century (Convey *et al.* 2009; Turner *et al.* 2009, Meredith and King 2005). Since the 1950's, air temperature has warmed by 3^{o}C and surface seawater by 1^{o}C (Meredith and King 2005; Clarke *et al*. 2007). The Antarctic Peninsula is expected to continue to experience some of the most rapid climatic warming on the planet, with a further increase in seawater temperature of 2^{o}C predicted over the next 100 years (Vaughan *et al.* 2003; Meredith and King 2005, IPCC 2014). Marine communities in Antarctica are considered climate-sensitive due to their high regional heterogeneity and uniqueness (Grange and Smith 2013), and the current and projected changes in air and water temperature and ocean acidification (OA) on the Antarctic Peninsula constitute potentially major threats to these communities that may not only result in altered species distributions, community composition and food web structure, but also ecosystem functioning (Berg *et al.* 2010). In this regard several studies have identified threats at different levels (individual/species, community and ecosystem level).

Considering the importance of Antarctic krill as key species in the Antarctic marine food web, the effect of Climate Change can have important implications. In this regard, several studies have assessed the effects of factors such as OA and increased temperature on reproduction and physiology of Antarctic krill (Kawaguchi *et al.* 2013, Cascella *et al.* 2015). In addition, Cook *et al.* (2016) recently demonstrated the importance of mid-ocean temperature influencing glacier in the WAP, which can have important implications as glacial melting, and consequent increased occurrence of suspended particles in the water column can be detrimental for krill (Fuentes *et al.* 2016), hence cascading to the entire food web. A recent study addressed the negative consequences of the combined effects of different stressors such as increased water temperature, changes in timing and covers of sea ice, and reduced chlorophyll availability in krill habitats (Piñones and Fedorov 2016). This type of approach highlights the importance of improving our knowledge about climate change and its effects not only on Antarctic species, but also on processes and ecosystems.

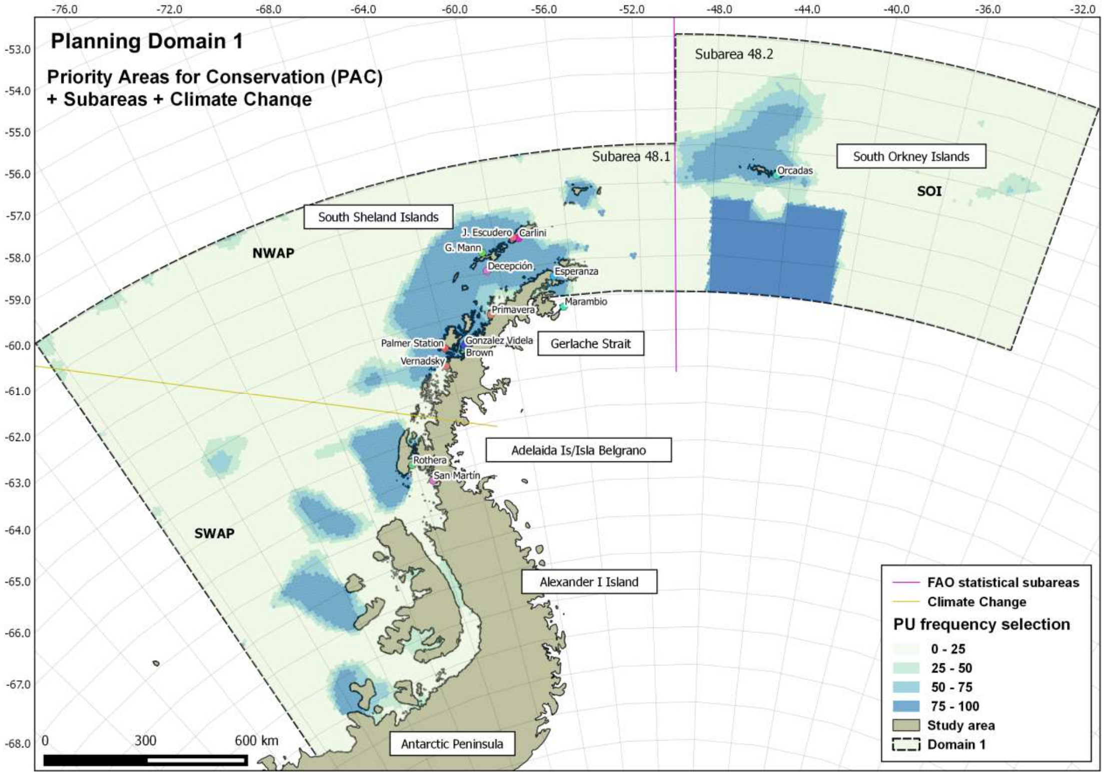

Figure 2: Priority areas for conservation considering the three ecoregions: South Orkney Islands (SOI), northwestern Antarctic Peninsula (NWAP) and southwestern Antarctic Peninsula (SWAP). Specific divisions are: 1) between Subareas 48.1 and 48, and 2) at approx. 66ºS, to divide between North and South of the Antarctic Peninsula.

CONCLUDING REMARKS

The Domain 1 MPA preliminary proposal includes – as the initial step – the identification of PAC in the Western Antarctic Peninsula - South Scotia Arc. The PAC here presented achieve the protection of representative examples of benthic and pelagic habitats, important ecosystem processes and important areas for life cycles of key species, and rare or unique habitats.

Identified PAC include regions that differ in the ecology, current management of fisheries and also in how they are exposed to environmental variation produced by climate change, hence the identification of these areas may provide relevant information in order to assess the interactions of anthropogenic activities and environmental factors when designating an MPA (WG-EMM-17, para. 4.15).

PAC can also serve other research and management strategies by providing areas where important benthic and pelagic habitats, processes and species spatially coincide, further improving the decision making process.

In this regard, Argentina and Chile propose the Scientific Committee considers the PAC identified in Domain 1 and their relevance to the MPA planning process, and other research and management strategies.

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REFERENCES

Ardron JA, Possingham HP and Klein CJ (eds). (2010). Marxan Good PracticesHandbook, Version 2.Pacific Marine Analysis and Research Association, Victoria, BC, Canada.165pp. www.pacmara.org

Atkinson A, Hill SL, Pakhomov E, Siegel V, Anadon R, Chiba S, Daly KL, Downie R, Fielding S, Fretwell P, Gerrish L, Hosie GW, Jessopp MJ, Kawaguchi S, Krafft BA, Loeb V, Nishikawa J, Peat HJ, Reiss CS, Ross RM, Quetin LB, Schmidt K, Steinberg DK, Subramaniam RC, Tarling GA, Ward P. (2017). KRILLBASE: a circumpolar database of Antarctic krill and salp numerical densities, 1926–2016. Earth Syst. Sci. Data, 9: 193-2107.

Atkinson A, Siegel V, Pakhomov E, Rothery P (2004)**.** Long-term decline in krill stock and increase in salps within the Southern Ocean. *Nature* 432: 100-103

Ball IR, Possingham HP and Watts M. (2009). Marxan and relatives: Software for spatial conservation prioritisation. Chapter 14: Pages 185-195 in Spatial conservation prioritisation: Quantitative methods and computational tools. Eds Moilanen A, KA Wilson and HP Possingham. Oxford University Press, Oxford, UK.

Berg MP, Kiers ET, Driessen G, van der Heijden M, Kooi BW, Kuenen F, Liefting M, Verhoef HA, and Ellers J. (2010). Adapt or disperse: understanding species persistence in a changing world. *Global Change Biology* 16:587-598.

Cascella K, Jollivet D, Papot C, Léger N, Corre E, Ravaux J, et al. (2015) Diversification, Evolution and Sub-Functionalization of 70kDa Heat-Shock Proteins in Two Sister Species of Antarctic Krill: Differences in Thermal Habitats, Responses and Implications under Climate Change. PLoS ONE 10(4): e0121642.

CCAMLR, 2015. Krill fishery report. Comm. Conserv. Antarct. Mar. Living Resour. 1–35.

CCAMLR-XXXIV/30. Revisions to the draft East Antarctic Representative System of Marine Protected Areas (EARSMPA) Conservation Measure. Delegation of the European Union and its Member States

CCAMLR-XXXIV/BG/37. Reflection Paper on a Proposal for a CCAMLR Weddell Sea Marine Protected Area (WSMPA). Delegation of the European Union and its Members Sates.

Clarke A, Murphy EJ, Meredith MP, King JC, Peck LS, Barnes DKA, Smith RC (2007) Climate change and the marine ecosystem of the western Antarctic Peninsula. Philos. Trans. R. Soc. Lond. B Biol. Sci. 362:149-166

Cook AJ, Fox AJ, Vaughan DG, Ferragno JG (2005).Retreating glacier fronts on the Antarctic Peninsula over the past half-century. *Science* 308: 540-544.

Cook AJ, Holland PR, Meredith MP, Murray T, Luckman A, Vaughan DG (2016) Ocean forcing of glacier retreat in the western Antarctic Peninsula. Science 353: 283-286.

Convey P, Bindschadler R, di Prisco G, Fahrbach E, Gutt J, Hodgson D, Mayewski P, Summerhayes C, Turner J (2009) Antarctic climate change and the environment. Ant. Sci. 21: 541-563

Ducklow H.W., Fraser W.R., Meredith M.P., Stammerjohn S.E., Doney S.C., Martinson D.G., Sailley S.F., Schofield O.M., Steinberg D.K., Venables H.J., Amsler C.D. 2013. West Antarctic Peninsula: An ice-dependent coastal marine ecosystemin transition. Oceanography 26(3): 190–203.

Flores H, Atkinson A, Kawaguchi S, Krafft BA, Milinevsky G, Nicol S, Reiss C, et al. (2012). Impact of climate change on Antarctic krill. Marine Ecology Progress Series, 458: 1–19.

Forcada J (2007). The impact of climate change on Antarctic megafauna. *En: Impacts of global warming on polar ecosystems.* Duarte CM (ed.): Fundación BBVA. Madrid. pp. 85-110.

Fraser W and Hofmann E (2003). A predator's perspective on causal links between climate change, physical forcing and ecosystem response. *Mar EcolProgSer* 265: 1-15.

Fuentes V, Alurralde G, Meyer B, Aguirre GE, Canepa A,Wölfl A, Hass HC, Williams GN,

Grange LJ, Smith CR (2013) Megafaunal communities in rapidly warming fjords along the West Antarctic Peninsula: hotspots of abundance and beta diversity. PloS One 8: e77917

IPCC (2014) Summary for Policymakers. In: Edenhofer O, R., Pichs-Madruga, Sokona Y, Farahani E, Kadner S, Seyboth K, Adler A, Baum I, Brunner S, Eickemeier P, B.Kriemann, Savolainen J, Schlomer S, von Stechow C, Zwickel T, Minx JC (eds) Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom

Kawaguchi S, Ishida A, King R, Raymond B, Waller N, Constable A, Nicol S, Wakita M, Ishimatsu A. (2013). Risk maps for Antarctic krill under projected Southern Ocean acidification. Nat. Clim. Change, 3, 843–847.

Kawaguchi S, Kurihara H, King R, Hale L, Berli T, Robinson JP, Ishida A, Wakita M, Virtue P, Nicol S, Ishimatsu A. (2011). Will krill fare well under Southern Ocean acidification?Biol. Lett. 7, 288-291

McClintock J, Ducklow HW, Fraser W. (2008). Ecological responses to climate change on the Antarctic Peninsula. *Am Sci*96: 302-310.

Meredith MP, King JC. (2005). Rapid climate change in the ocean west of the Antarctic Peninsula during the second half of the 20th century. Geophys. Res. Lett. 32: L19604–L19609.

Meredith M, Stefels J, M. van Leeuwe. (2017). Marine studies at the western Antarctic Peninsula: Priorities, progress and prognosis. Deep/Sea Research II

Moline MA, Karnovsky NJ, Brown Z, Divoky GJ, Frazer TK, Jacoby CA, Torres JJ, Fraser WR (2008). High latitude changes in ice dynamics and their impact on polar marine ecosystems. The Year in Ecology and Conservation Biology 2008 1134: 267-319

Murphy EJ, Hofmann EE, Watkins JL, Johnston NM, PiñonesA, BalleriniT, Hill SL,TrathanPN,TarlingGA, Cavanagh RA, Young EF, Thorpe SE, Fretwell P (2013). Comparison of the structure and function of Southern Ocean regional ecosystems:The Antarctic Peninsulaand South Georgia. Journal of Marine Systems 109-110: 22-42.

Piñones A and Fedorov AV (2016). Projected changes of Antarctic krill habitat by the end of the 21st century, Geophys. Res. Lett., 43, 8580–8589

Stammerjohn SE, Drinkwater MR, Smith RC, Liu X (2003). Ice-atmosphere interactions during sea-ice advance and retreat in the western Antarctic Peninsula region. *J Geophys Res: Oceans* 108 (C10).

Stammerjohn SE, Martinson DG, Smith RC, Ianuzzi RA (2008a). Sea ice in the western Antarctic Peninsula region: Spatio-temporal variability from ecological and climate change perspectives. *Deep-Sea Res PT II* 55(18-19): 2041-2058.

Stammerjohn SE, Martinson DG, Smith RC, Yuan X, Rind D (2008b). Trends in antarctic annual sea ice retreat and advance and their relation to El Niño-southern oscillation and southern annular mode variability. *J Geophys Res: Oceans* 113(C3).

Stammerjohn SE, Massom R, Rind D, Martinson DG (2012). Regions of rapid sea ice change: an inter-hemispheric seasonal comparison. Geophys. Res. Lett. L06501 (39), 6.

Skvarca P, Rack W, Rott H, Ibarzabal Donangelo T (1999). Climatic trend and the retreat and disintegration of ice shelves on the Antarctic Peninsula: an overview. *Polar Res* 18 (2): 151-157.

Thomas ER, Marshall GJ, McConnell JR. (2008). A doubling in snow accumulation in the Western Antarctic Peninsula. Geophys. Res. Lett. L01706 (35), 1.

Turner J, Comiso JC, Marshall GJ, Lachlan-Cope TA, Bracegirdle T, Maksym T, Meredith MP, Wang Z, Orr A (2009). Non-annular atmospheric circulation change induced by stratospheric ozone depletion and its role in the recent increase of Antarctic sea ice extent. Geophys. Res. Lett. 36

Vaughan DG, Marshall GJ, Connolley WM, Parkinson CL, Mulvaney R, Hodgson DA, King JC, Pudsey CJ, Turner J (2003). Recent rapid regional climate warming on the Antarctic Peninsula. Clim. Change 60:243–274.

Watts ME, Stewart RR, Segan D, Kircher L, Possingham HP. 2011. Using the Zonae Cogito Decision Support System, a Manual. University of Queensland, Brisbane, Australia

WG-EMM-12/69. Report of the First Workshop on the Identification of Priority Areas for MPA Designation within Domain No. 1 (CCAMLR). Valparaiso 2012.

WG-EMM-14/40. Progress report on the development of MPAs in Domain 1. Arata J, Gaymer C, Squeo F, Marschoff E, Barrera-Oro E y Santos MM(INACH-IAA). Punta Arenas, Chile 7-18 de Julio de 2014.

WG-EMM-15/42. Report of the Second International Workshop for identifying Marine Protected Areas (MPAs) in Domain 1 of CCAMLR. Buenos Aires, Argentina.

WG-EMM-17/22 (A. Capurro, M. Santos and S. Grant). Incorporating information on the distribution of the krill fishery into Domain 1 MPA planning – report of the CCAMLR scholarship recipient.

WG-EMM-17/23 (Delegations of Argentina and Chile). Domain 1 Marine Protected Area Preliminary Proposal – PART A: MPA Model

WG-EMM-17/24 (Delegations of Argentina and Chile). Domain 1 Marine Protected Area Preliminary Proposal – PART B: Conservation objectives.

WG-EMM-17/25 Rev. 1 (Delegations of Argentina and Chile). Domain 1 Marine Protected Area Preliminary Proposal – PART C: Biodiversity Analysis by MPA zones

Annex 1: Overlap between Domain 1 and 3 Planning Domains