Baseline data layers used for spatial planning, monitoring and research in relation to the Ross Sea region Marine Protected Area

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Abstract

This paper provides data layers relevant to establishing the baseline for the Ross Sea region Marine Protected Area (MPA). We provide data used to investigate environmental and ecological spatial patterns as part of the design and evaluation process for the Ross Sea region MPA, including spatial maps and information on key Ross Sea ecosystem processes, and data layers used to determine the pelagic and benthic bioregionalisations. We also include data layers which we consider likely to be useful in contributing to defining the "baseline" state of the Ross Sea region.

1. Introduction

A proposal to establish a Ross Sea region Marine Protected Area (RSRMPA) was accepted by CCAMLR in 2016 and came into effect in December 2017 under Conservation Measure (CM) 91-05. This CM requires that research and monitoring be carried out associated with the Ross Sea region MPA consistent with SC-CAMLR-XXXVI/20 (Dunn et al., 2017). Paragraph 21 of SC-CAMLR-XXXVI/20 requests that each CCAMLR members make "baseline data" available to the Scientific Committee, as follows:

> *Baseline data*
>
> *21. Baseline data will be used to assess changes and whether the RSRMPA is achieving its specific objectives. A large amount of baseline data already exist. Some of these data were used to develop the RSRMPA and the distribution maps provided in Appendix 1. Additional, baseline data also exist and are reported in the literature. Several documents submitted to working groups and workshops of the Scientific Committee (e.g., WG-EMM-10/11, WG-EMM-10/30, and WS-RMP-17/03) contain bibliographies or citation lists that indicate where baseline data can be found. Members are encouraged to collate these data and make them available to the Scientific Committee in advance of the first review by Scientific Committee of Members activities related to the RSRMPA Research and Monitoring Plan in 2022 (CM 91-05 para. 15).*

2. Data layers

2.1 Types of baseline data provided

Since 2010 New Zealand and the United States have submitted several scientific documents to SC-CAMLR and its Working Groups to support the design, designation, and objectives of a Marine Protected Area (MPA) in the Ross Sea region (Delegations of New Zealand and the USA, 2014; Dunn et al., 2017). Associated with these documents and analyses are spatial data layers associated with the MPA specific objectives. The data provided here are:

- data layers used to define the key Ross Sea ecosystem processes used in the Ross Sea region design (vector shapefiles);
- data layers used to determine the pelagic and benthic bioregionalisations for the Ross Sea region (spatially-referenced raster);

- derived benthic and pelagic bioregions (vector shapefiles); and
- data layers which otherwise contribute to defining the "baseline" state of the Ross Sea region (spatially-referenced raster).

These data layers are given in more detail in Sections 2.2, 2.3, 2.4, and 2.5.

2.2 Key ecosystem processes in the Ross Sea region

The data layers defining key ecosystem processes in the Ross Sea region are provided as Arc-GIS vector shapefiles (Table 1). These layers are generally as described in WS-MPA-11/25 and SC-CAMLR-XXX/10, and more recently updated (Dunn et al., 2017). Fishing effort (C2) data used in the planning process is not provided. We note that data layers 1-30 have already been submitted to CCAMLR and are available here: https://www.ccamlr.org/en/document/data/planning-domain-8-ross-sea-region

Note that data associated with Dunn et al. (2017) fig 1 (SC-CAMLR-XXXIII/BG/23, fig 1) "Mammal & bird habitat" is the outcome of spatial habitat models described in Ballard et al. (2010) is not provided. This information was part of the US contribution to the MPA planning process.

2.3 Data layers used to derive bioregionalisations

The data layers defining key ecosystem processes in the Ross Sea region are provided as spatially-referenced raster files in netCDF format (Table 2), with additional information in Sharp et al. (2010).

2.4 Ross Sea region bioregionalisations

The Ross Sea region pelagic and benthic bioregionalisations are provided here as Arc-GIS vector shapefiles (Table 3). These bioregionalisations are those used to develop the plans for the Ross Sea region MPA (Sharp et al., 2010).

2.5 Additional data layers potentially useful for defining the baseline

Additional data layers are provided that are deemed potentially useful for defining the baseline ecosystem state for the Ross Sea region (Table 4). These additional baseline data layers were made available to and were considered by the Ross Sea region bioregionalisation workshop (Pinkerton et al., 2007; Pinkerton et al., 2009; Sharp et al., 2010) but were not used formally in the bioregionalisations. Many of these data were derived from Earth-observation satellite remote sensing (e.g. chlorophyll-a concentrations from ocean colour satellites; sea-ice remote sensing; sea-surface temperature remote sensing), from climatological analyses (e.g. nutrient concentrations), from numerical model hindcast re-analyses (e.g. HIGEM[1] modelling) or from ongoing monitoring studies (e.g. Southern Ocean Continuous Plankton Recorder project). The data provided summarise data available at 2008. These layers can be updated as required to define and characterise the baseline state of the Ross Sea region in different years.

These data layers are provided as spatially-referenced raster files in netCDF format.

[1] High Resolution Global Environmental Monitoring, http://higem.nerc.ac.uk/

Table 1. Data layers used to define the key Ross Sea region ecosystem processes used in the Ross Sea region design, and identified in the Ross Sea region MPA research and monitoring plan (Dunn et al., 2017). These data layers are submitted as GIS shape files. * Area here is as given in Sharp & Watters (2011), WS-MPA-11/25.

Area*	Layer name	Description	Source
1	Shelf front	Ross Sea shelf front	WG-EMM-10/30, WG-EMM-10/11; Dunn et al., 2017 fig 3(a)
2	Polar front	Polar front in Ross Sea region	WG-EMM-10/30, WG-EMM-10/11; Dunn et al., 2017 fig 3(b)
3	Balleny Islands	Balleny Islands and proximity	WG-EMM-10/30, WG-EMM-10/11; Dunn et al., 2017 fig 3(c)
4	Polynya MIZ	Ross Sea polynya Marginal Ice Zone	WG-EMM-10/30, WG-EMM-10/11; Dunn et al., 2017 fig 3(d)
5	Eastern pack ice	Eastern Ross Sea persistent pack ice	WG-EMM-10/30, WG-EMM-10/11; Dunn et al., 2017 fig 3(e)
8	Antarctic krill	Core distribution of Antarctic krill	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 4(a)
9	Crystal krill	Core distribution of crystal krill	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 4(b)
10	Antarctic silverfish	Core distribution of Antarctic silverfish	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 4(c)
11	Adelie foraging	Core breeding (summer) foraging area for Adelie peguins in Ross Sea region	From WG-EMM-10/30; colonies and tracking data from WG-EMM-10/11; Dunn et al., 2017 fig 5(a)
12	Emperor foraging	Core breeding (summer) foraging area for Adelie peguins in Ross Sea region	From WG-EMM-10/30; colonies and tracking data from WG-EMM-10/11; Dunn et al., 2017 fig 5(b)
13	Weddell seal foraging	Core, summer foraging areas for Weddell seals	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 6(a)
14	Killer whale type-C	Core, summer foraging areas for type-C killer whales (orca)	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 6(b)
6	Ross Sea polynya	Southern Ross Sea shelf persistent winter polynya	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 7(a)
7	Coastal polynyas	Coastal polynyas	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 7(b)
16	Terra Nova Bay	Terra Nova Bay including the TNB polynya	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 7(c)
15	Victoria Land coast	Victoria Land Coast coastal buffer and platelet ice formation	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 7(d)
30	Pennell Bank polynya	Pennell Bank polynya	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 7(e)
18	Toothfish settlement	Settlement of subadult Antarctic toothfish on Ross Sea shelf	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Hanchet et al. (2008); Dunn et al., 2017 fig 8(a)
19	Toothfish dispersal	Antarctic toothfish dispersal to slope	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Hanchet et al. (2008); Dunn et al., 2017 fig 8(b)
20	Toothfish slope feeding	Adult antarctic toothfish feeding on Ross Sea slope	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Hanchet et al. (2008); Dunn et al., 2017 fig 8(c)
21+22	Toothfish spawning	Antarctic toothfish spawning areas	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Hanchet et al. (2008); Dunn et al., 2017 fig 8(*)
23	Balleny Is seamounts	Balleny Island area seamounts	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 9(a)
24	Admiralty seamount	Admiralty seamount	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 9(b)
25	Cape Adare slope	Cape Adare proximity continental slope	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 9(c)
26	SE continental slope	Southeastern continental slope	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 9(d)
27	McMurdo Sound	Southern McMurdo Sound	From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 9(e)
28 (new)	Scott seamount	Scott seamount	SC-CAMLR-XXXIII/BG/23 rev 1 fig 10; Dunn et al., 2017 fig 9(f)

Table 2: Data layers used to define the Ross Sea region pelagic and benthic bioregionalisations (Sharp et al., 2010). These layers are submitted as spatially-referenced netCDF raster files.

ID	Layer name	Description	Source
Tseabed	Seabed temperature	Water temperature at the seabed from HIGEM model (°C)	Sharp et al. (2010), fig 4(a)
bathy	Bathymetry	Water depth (m) from GEBCO (2003)	Sharp et al. (2010), fig 4(b), 6(c)
rugosity	Seabed rugosity	Seabed roughness based on GEBCO (2003) 1 min data	Sharp et al. (2010), fig 4(c)
speedSeabed	Bottom current speed	Mean annual current speed at the seabed from HIGEM model	Sharp et al. (2010), fig 4(d)
iceFreeDays	Ice free days	Mean number of ice-free (<15% ice cover) days per year, 1980-2007	Sharp et al. (2010), fig 4(e)
iceScour	Ice scour	Prevalence of seabed scouring by icebergs (Sharp et al., 2010, p 28)	Sharp et al. (2010), fig 4(f)
T200m	Temperature at 200 m	Water temperature (°C) at 200 m from HIGEM model	Sharp et al. (2010), fig 6(a)
S200m	Salinity at 200 m	Water salinity (PSU) at 200 m from HIGEM model	Sharp et al. (2010), fig 6(b)
iceNovDec	Sea-ice change November-December	Climatological change in sea-ice concentration (%) between November and December	Sharp et al. (2010), fig 6(d)
iceNov	November sea-ice	Climatological sea-ice concentration (%) in November	Sharp et al. (2010), fig 6(e)

Table 3: The Ross Sea region pelagic and benthic bioregionalisations (Sharp et al., 2010). These layers are submitted as Arc-GIS vector shapefiles.

ID	Layer name	Description	Source
BenthicBioR	Benthic bioregionalisation	Benthic bioregionalisation of the Ross Sea region	Sharp et al. (2010), fig 1
PelagicBioR	Pelagic bioregionalisation	Pelagic bioregionalisation of the Ross Sea region	Sharp et al. (2010), fig 2

Table 4: Additional data layers deemed potentially useful for defining the Ross Sea region environment and ecosystem baseline. These layers are submitted as spatially-referenced netCDF raster files.

ID	Layer name	Description
chla_summer	Summer chl-a	Summer chl-a concentration (mg/m3) from SeaWiFS and MODIS-Aqua (1997-2008)
chlamax	Max chl-a	Average of annual maximum monthly chl-a concentration (mg/m^3) from SeaWiFS and MODIS-Aqua (1997-2008)
chlamaxsd	Variability max chl-a	Interannual variability (standard deviation) of maximum monthly chl-a concentration from SeaWiFS and MODIS-Aqua (1997-2008)
chlamean	Annual mean chl-a	Long-term mean chl-a concentration (mg/m^3) from SeaWiFS and MODIS-Aqua (1997-2008)
CPR_copepods	Copepod abundance	Copepod abundance (relative units) from Southern Ocean CPR survey (Hosie et al., 2003; Pinkerton et al. 2008)
CPR_diversity	Zooplankton diversity	Zooplankton community diversity (relative units) from Southern Ocean CPR survey (Hosie et al., 2003; Pinkerton et al. 2008)
CPR_pteropod	Pteropod abundance	Pteropod abundance (relative units) from Southern Ocean CPR survey (Hosie et al., 2003; Pinkerton et al. 2008)
CPR_total_ab	Total zooplankton abundance	Total zooplankton abundance (relative units) from Southern Ocean CPR survey (Hosie et al., 2003; Pinkerton et al. 2008)
ice_apr	April sea-ice	Mean ice conc. (%) in April from SMMR-SSM/I-NASA (1979/80 to 2006/7), Cavalieri et al. (1990)
ice_aug	August sea-ice	Mean ice conc. (%) in August from SMMR-SSM/I-NASA (1979/80 to 2006/7)
ice_dec	December sea-ice	Mean ice conc. (%) in December from SMMR-SSM/I-NASA (1979/80 to 2006/7)
ice_dec_jan	Sea-ice change December-January	Change in ice concentration (%) between Dec and Jan from SMMR-SSM/I-NASA (1979/80 to 2006/7)
ice_feb	February sea-ice	Mean ice concentration (%) in February SMMR-SSM/I-NASA (1979/80 to 2006/7)
ice_jan	January sea-ice	Mean ice concentration (%) in January SMMR-SSM/I-NASA (1979/80 to 2006/7)
ice_jul	July sea-ice	Mean ice concentration (%) in July SMMR-SSM/I-NASA (1979/80 to 2006/7)
ice_jun	June sea-ice	Mean ice concentration (%) in June SMMR-SSM/I-NASA (1979/80 to 2006/7)
ice_mar	March sea-ice	Mean ice concentration (%) in March SMMR-SSM/I-NASA (1979/80 to 2006/7)
ice_marginal_dec	Marginal ice in December	Proportion of time with marginal ice (ice concentration 15-40%) in December SMMR-SSM/I-NASA (1979/80 to 2006/7)
ice_marginal_jan	Marginal ice in January	Proportion of time with marginal ice (ice concentration 15-40%) in January SMMR-SSM/I-NASA (1979/80 to 2006/7)
ice_may	May sea-ice	Mean ice concentration (%) in May from SMMR-SSM/I-NASA (1979/80 to 2006/7)
ice_pack_jan	Pack ice in January	Proportion of time with unconsolidated pack ice (ice concentration 40-70%) in January from SMMR-SSM/I (1979/80 to 2006/07) NASA algorithm
ice_sep	September sea-ice	Mean ice concentration (%) in September SMMR-SSM/I-NASA (1979/80 to 2006/7)
ice15sd	Variability in time ice-free	Interannual variability in proportion of year ice free (<15% ice concentration) SMMR-SSM/I-NASA (1979/80 to 2006/7)
N200	Nitrate concentration	Nitrate concentration at 200 m depth from WOCE global hydrographic data (Gouretski & Koltermann, 2004)
Ph200	Phosphate concentration	Phosphate concentration at 200 m depth from WOCE global hydrographic data (Gouretski & Koltermann, 2004)
Si200	Silicate concentration	Silicate concentration at 200 m depth from WOCE global hydrographic data (Gouretski & Koltermann, 2004)
S_HIGEM_bottom	Seabed salinity	Near seabed salinity from HiGEM 1.1 (Schaffrey et al. 2009)
S_HIGEM_surface	Surface salinity	Surface salinity from HiGEM 1.1 (Schaffrey et al. 2009)
speed_bottom	Seabed current speed	Near seabed current speed from HiGEM 1.1 (Schaffrey et al. 2009)
speed_surface	Surface current speed	Surface current speed from HiGEM 1.1 (Schaffrey et al. 2009)
sst	Sea-surface temperature	Sea-surface temperature from OIV2 data 1991–2006 (Reynolds & Smith, 1994)
sstgrad	Spatial gradient in sea-surface temperature	Spatial gradient in sea-surface temperature from OIV2 data 1991–2006 (Reynolds & Smith, 1994)
sstsum	Summer sea-surface temperature	Summer (Dec-Feb) sea-surface temperature from OIV2 data 1991–2006 (Reynolds & Smith, 1994)
PALK_all	Potential alkalinity water column	Potential alkalinity for whole water column from GLODAP project (Key et al. 2004; Sabine et al. 2005)
PALK_bottom	Potential alkalinity seabed	Potential alkalinity near seabed from GLODAP project (Key et al. 2004; Sabine et al. 2005)
PALK_surface	Potential alkalinity surface	Potential alkalinity for near surface from GLODAP project (Key et al. 2004; Sabine et al. 2005)
Alk_all	Alkalinity water column	Total alkalinity for whole water column from GLODAP project (Key et al. 2004; Sabine et al. 2005)
Alk_bottom	Alkalinity seabed	Total alkalinity near seabed from GLODAP project (Key et al. 2004; Sabine et al. 2005)
Alk_surface	Alkalinity surface	Total alkalinity for near surface from GLODAP project (Key et al. 2004; Sabine et al. 2005)
TCO2_all	Total CO_2 water column	Total CO_2 for whole water column from GLODAP project (Key et al. 2004; Sabine et al. 2005)
TCO2_bottom	Total CO_2 seabed	Total CO_2 near seabed from GLODAP project (Key et al. 2004; Sabine et al. 2005)
TCO2_surface	Total CO_2 surface	Total CO_2 for near surface from GLODAP project (Key et al. 2004; Sabine et al. 2005)

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