# 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: <u>https://www.ccamlr.org/en/document/data/planning-domain-8-ross-sea-region</u>

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 spatiallyreferenced 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<sup>1</sup> 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.

<sup>&</sup>lt;sup>1</sup> 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.

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         Ross Sea region         WG-EMM-10/30, WG-EMM-10/11; Dunn et al., 2017 fig 3(a)           3         Balleny Islands         Balleny Islands and proximity         WG-EMM-10/30, WG-EMM-10/11; Dunn et al., 2017 fig 3(a)           5         Eastern Ross Sea persistent pack ice         From WG-EMM-10/30, WG-EMM-10/11; Dunn et al., 2017 fig 3(a)           9         Crystal krill         Core distribution of rystal krill         From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 4(a)           10         Antarctic krill         Core distribution of rystal krill         From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 5(a)           11         Adelie foraging         Core distribution of Antarctic krill         From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 5(a)           12         Emperor foraging         Core distribution for spasse         From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 7(b)           13         Weddell seal         Core, summer foraging area for Adelie grassiont winter polynya         From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 7(b)           14         Killer whale type: Core, summer foraging area for Adelie saft         From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al.	Area*	Layer name	Description	Source
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23       Balleny Is       Balleny Island area       From WG-EMM-10/30, modified as described in WS-MPA-11/25;         24       Admiralty       Admiralty seamount       From WG-EMM-10/30, modified as described in WS-MPA-11/25;         24       Admiralty       Admiralty seamount       From WG-EMM-10/30, modified as described in WS-MPA-11/25;         25       Cape Adare slope       Cape Adare proximity continental slope       From WG-EMM-10/30, modified as described in WS-MPA-11/25;         26       SE continental slope       Southeastern continental slope       From WG-EMM-10/30, modified as described in WS-MPA-11/25;         27       McMurdo Sound       Southern McMurdo Sound       From WG-EMM-10/30, modified as described in WS-MPA-11/25;         28 (new)       Scott seamount       Scott seamount       Scott seamount		spawning	areas	Hanchet et al. (2008); Dunn et al., 2017 fig 8(*)
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24       Admiralty       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       Southeastern continental slope       From WG-EMM-10/30, modified as described in WS-MPA-11/25; Dunn et al., 2017 fig 9(c)         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(d)         28 (new)       Scott seamount       Scott seamount       Scott seamount		seamounts	seamounts	Dunn et al., 2017 fig 9(a)
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25       Cape Adare slope       Cape Adare proximity continental slope       From WG-EMM-10/30, modified as described in WS-MPA-11/25;         26       SE continental slope       Southeastern continental slope       Dunn et al., 2017 fig 9(c)         27       McMurdo Sound       Southern McMurdo Sound       From WG-EMM-10/30, modified as described in WS-MPA-11/25;         28 (new)       Scott seamount       Scott seamount       Scott seamount		seamount		Dunn et al., 2017 fig 9(b)
26       SE continental       Southeastern continental       Dunn et al., 2017 ftg 9(c)         26       SE continental       Southeastern continental       From WG-EMM-10/30, modified as described in WS-MPA-11/25;         27       McMurdo Sound       Southern McMurdo Sound       From WG-EMM-10/30, modified as described in WS-MPA-11/25;         28 (new)       Scott seamount       Scott seamount       Scott seamount	25	Cape Adare slope	Cape Adare proximity	From WG-EMM-10/30, modified as described in WS-MPA-11/25;
20     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(d)       28 (new)     Scott seamount     Scott seamount     Scott seamount	26	SE continent-1	continental slope	Dunn et al., 201 / fig 9(c) From WC FMM 10/20 modified dth-d-in WC MDA 11/25
Stope     Stope     Durin 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-C-AMLR-XXXIII/BG/23 rev 1 fig 10; Dunn et al., 2017 fig 9(f)	20	slope	southeastern continental	From wo-EWIWI-10/50, mounted as described in wo-WIPA-11/25; Dupp et al. 2017 fig 9(d)
27       Include Sound       Sound in Methando Sound       From WG-Law-10/50, modified as described in WS-MER-17/25,	27	McMurdo Sound	Southern McMurdo Sound	From WG_FMM_10/30 modified as described in WS_MPA_11/25.
28 (new) Scott seamount Scott seamount Scott seamount SC-CAMLR-XXXIII/BG/23 rev 1 fig 10: Dunn et al., 2017 fig 9(f)	21	Memuruo Soullu	Soutien Memurus Souliu	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)

ID	Layer name	Description	Source
Tseabed	Seabed	Water temperature at the seabed from	Sharp et al. (2010), fig 4(a)
	temperature	HIGEM model (°C)	
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-	Climatological change in sea-ice concentration (%) between November	Sharp et al. (2010), fig 6(d)
	December	and December	
iceNov	November sea-	Climatological sea-ice concentration	Sharp et al. (2010), fig 6(e)
	ice	(%) in November	

 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.

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	Benthic bioregionalisation of the Ross Sea	Sharp et al. (2010), fig 1
PelagicBioR	bioregionalisation Pelagic bioregionalisation	region Pelagic bioregionalisation of the Ross Sea region	Sharp et al. (2010), fig 2
Telagicblok	bioregionalisation	region	Sharp et al. (2010), fig 2

ID	Layer name	Description
chla_summer	Summer chl-a	Summer chl-a concentration (mg/m3) from SeaWiFS and MODIS-Aqua (1997-2008)
		Average of annual maximum monthly chl-a concentration (mg/m3) from SeaWiFS
chlamax	Max chl-a	and MODIS-Aqua (1997-2008)
		Interannual variability (standard deviation) of maximum monthly chl-a concentration
chlamaxsd	Variability max chl-a	from SeaWiFS and MODIS-Aqua (1997-2008)
11		Long-term mean chl-a concentration (mg/m <sup>3</sup> ) from SeaW1FS and MODIS-Aqua
chiamean	Annual mean chi-a	(1997-2008) Concerned abundance (relative units) from Southern Ocean CDP survey (Hosic et al
CDD commode	Copored abundance	2002: Binkorton et al. 2008)
CI K_copepous	copepou abundance	Zoonlankton community diversity (relative units) from Southern Ocean CPR survey
CPR diversity	Zooplankton diversity	(Hosie et al. 2003: Pinkerton et al. 2008)
er it_uiversity	200phankton arversity	Pteropod abundance (relative units) from Southern Ocean CPR survey (Hosie et al.,
CPR pteropod	Pteropod abundance	2003; Pinkerton et al. 2008)
- <b>i</b> I	Total zooplankton	Total zooplankton abundance (relative units) from Southern Ocean CPR survey
CPR_total_ab	abundance	(Hosie et al., 2003; Pinkerton et al. 2008)
		Mean ice conc. (%) in April from SMMR-SSM/I-NASA (1979/80 to 2006/7),
ice_apr	April sea-ice	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)
	Sea-ice change	Change in ice concentration (%) between Dec and Jan from SMMR-SSM/I-NASA
ice_dec_jan	December-January	(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 (19/9/80 to 2006/7)
ice_jun	June sea-ice	Mean ice concentration (%) in June SMMR-SSM/I-NASA (19/9/80 to 2006/7)
ice_mar	March sea-ice	Mean ice concentration (%) in March SMMR-SSM/I-NASA (19/9/80 to 2006/7)
ion marginal day	Marginal ice in	Proportion of time with marginal ice (ice concentration $15-40\%$ ) in December SMMB, SSM/LNASA (1070/20 to 2006/7)
ice_inarginar_dec	December	Department of time with marginal ice (ice concentration 15 40%) in January SMMP
ice marginal ian	Marginal ice in January	SSM/LNASA (1979/80 to 2006/7)
ice may	May sea-ice	Mean ice concentration (%) in May from SMMR_SSM/L-NASA (1979/80 to 2006/7)
ice_indy	Whay sea ree	Proportion of time with unconsolidated pack ice (ice concentration 40-70%) in
ice pack ian	Pack ice in January	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)
	Variability in time ice-	Interannual variability in proportion of year ice free (<15% ice concentration)
ice15sd	free	SMMR-SSM/I-NASA (1979/80 to 2006/7)
		Nitrate concentration at 200 m depth from WOCE global hydrographic data
N200	Nitrate concentration	(Gouretski & Koltermann, 2004)
		Phosphate concentration at 200 m depth from WOCE global hydrographic data
Ph200	Phosphate concentration	(Gouretski & Koltermann, 2004)
		Silicate concentration at 200 m depth from WOCE global hydrographic data
Si200	Silicate concentration	(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)
551	Spatial gradient in sea	Spatial gradient in sea-surface temperature from OIV2 data 1001_2006 (Develde &
sstorad	surface temperature	Smith 1994)
3515100	Summer sea-surface	Summer (Dec-Feb) sea-surface temperature from OIV2 data 1991–2006 (Revnolds &
sstsum	temperature	Smith. 1994)
	Potential alkalinity water	Potential alkalinity for whole water column from GLODAP project (Key et al. 2004;
PALK_all	column	Sabine et al. 2005)
	Potential alkalinity	Potential alkalinity near seabed from GLODAP project (Key et al. 2004; Sabine et al.
PALK_bottom	seabed	2005)
	Potential alkalinity	Potential alkalinity for near surface from GLODAP project (Key et al. 2004; Sabine
PALK_surface	surface	et al. 2005)
		Total alkalinity for whole water column from GLODAP project (Key et al. 2004;
Alk_all	Alkalinity water column	Sabine et al. 2005)
		Total alkalinity near seabed from GLODAP project (Key et al. 2004; Sabine et al.
Alk_bottom	Alkalinity seabed	
A 11	A 11 11 14 C	Total alkalinity for near surface from GLODAP project (Key et al. 2004; Sabine et al.
AIK_SUITACE	Alkalinity surface	2003) Total CO, for whole water column from CLODAD are is at (Key et al. 2004, 0.1)
TCO2 all	Total CO. mater ashires	1 July 2005)
TCO2_all TCO2_bottom	Total $CO_2$ water column Total $CO_2$ seabed	al. 2003) Total CO, near sealed from GLODAP project (Key et al. 2004; Sabine et al. 2005)
TCO2_surface	Total CO <sub>2</sub> surface	Total $CO_2$ for near surface from GLODAP project (Key et al. 2004; Sabine et al. 2005)

# 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.

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