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DE LA FAUNE ET LA FLORE MARINES
DE L'ANTARCTIQUE

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**Progress report on the scientific data compilation and analyses in support
of the development of a CCAMLR MPA in the Weddell Sea (Antarctica)**

Delegation of Germany

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Author(s) Delegation of Germany

Address(s)

Name and email address of person submitting paper: karl-hermann.kock@ti.bund.de

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Abstract

At the CCAMLR meeting in 2012, the Commission welcomed the offer of Germany to take the lead in developing a Weddell Sea MPA for consideration in 2014. Subsequently, the German Federal Ministry of Food, Agriculture and Consumer Protection tasked the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research to compile and analyse scientific data for identifying areas which require particular protection in the Weddell Sea. Work under this project started mid-April 2013. This progress report is based on WG-EMM-13/22 which was submitted to WG-EMM 2013 in Bremerhaven, Germany. Germany intends to update the Scientific Committee on the actual state of our project, particularly on the main proceeds of a national data workshop held in Bremerhaven early September 2013. The main objectives of this document are (i) to propose the planning area of our evaluation study, (ii) to provide an update on the data situation, (iii) to draw attention to the forthcoming (early April 2014) international expert workshop on the planning of a Weddell Sea MPA.

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Progress report on the scientific data compilation and analyses in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica)

This report has been compiled by the following persons:

K. Teschke¹, H. Bornemann¹, A. Bombosch¹, E. Burkhardt¹, P. Brtnik², B. Dorschel¹, H. Feindt-Herr³, D. Gerdes¹, J. Gutt¹, S. Hain¹, H. Herata⁴, K. Jerosch¹, R. Knust¹, K.-H. Kock⁵, H. Pehlke¹, M. Schlüter¹, W. Schwarzbach⁴, V. Siegel⁵, V. Strass¹, I. van Opzeeland¹, H. von Nordheim⁶ & T. Brey¹

¹ Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany

² Deutsches Meeresmuseum, Stralsund, Germany

³ Institute for Terrestrial and Aquatic Wildlife Research, University of Veterinary Medicine Hannover, Germany

⁴ Federal Environment Agency, Section I 3.5, Dessau-Roßlau, Germany

⁵ Johann Heinrich von Thünen Institute, Institute of Sea Fisheries, Hamburg, Germany

⁶ Federal Agency for Nature Conservation, Section II 5.2, Vilm, Germany

Background and need for action

In recent years, CCAMLR Member States have undertaken substantial efforts to designate marine protected areas (MPAs) in the Southern Ocean in order to provide better protection to Antarctic wildlife. Important milestones were:

- (i) the designation of the South Orkney Islands southern shelf area as a MPA by CCAMLR in 2009 (Conservation Measure 91-03),
- (ii) the adoption of a general framework for the establishment of CCAMLR MPAs in 2011 (Conservation Measure 91-04) and
- (iii) the identification of nine MPA planning domains in the CCAMLR area in the same year.

MPA planning for six domains is underway and proposals for MPAs in the Ross Sea and in East Antarctica are currently being discussed by CCAMLR. For three domains, particular CCAMLR Member States were asked to take the lead in MPA planning.

At the CCAMLR meeting in 2012, the Commission welcomed the offer of Germany to take the lead in developing a MPA proposal in Planning Domain 3 (Weddell Sea) for consideration in 2014. Subsequently, the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) tasked the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI) to compile and analyse data considered to be relevant for identifying potential conservation areas and measures in the Weddell Sea. This project started mid-April 2013 under the lead of Prof. Dr. Thomas Brey.

This progress report follows WG-EMM-13/22 which was submitted to WG-EMM 2013 in Bremerhaven. Germany intends to update the Scientific Committee on the actual state of our project, particularly on the proceeds of the national data workshop held in Bremerhaven from the 11th - 13th September 2013. The main objective of this national workshop was to bring together all relevant German experts and institutions involved in Antarctic research and corresponding nature conservation issues to establish the scientific background for a Weddell Sea MPA proposal.

The main objectives of this document are:

1. to present the proposal for the boundaries of the planning area, i.e. the area our scientific analysis is restricted to;
2. to provide an updated summary of the data identification and acquisition process;
3. to draw attention on the forthcoming (early April 2014) international expert workshop that shall provide the opportunity for scientists from all CCAMLR member states to discuss the actual state and further progress of the Weddell Sea MPA evaluation.

Planning area

The Weddell Sea with an area of approximately 2.8 million km² is the largest of the 14 marginal seas of the Southern Ocean. Water depths in the Weddell Sea range from about 100 m at the edge of the ice shelf and 5000 m in the Weddell Sea abyssal plain. Compared to the continental shelf of oceans north of the Southern Ocean, the Weddell Sea shelf is deep

with depths of 400–500 m (Laws 1985), and thus the shelf break is located approx. two to four times deeper than in other oceans which usually lies at 200 m (Knox 2007). Those depths arise from the extraordinary weight of Antarctic ice cap, which depresses the Antarctic continent by approx. 200 m (Smetacek & Nicol 2005). Prominent bathymetric features of the Weddell Sea are the relative narrow, complex structured shelf and steep slope in the eastern Weddell Sea, and the broad shelf in the southern Weddell Sea that extends up to several 100 km from the coast and is cut through by the deeper Filchner Trench (Schenke et al. 1998; see Fig. 2).

The Weddell Sea plays an important role for driving global thermohaline circulation ("global ocean conveyor belt") and ventilating the global abyssal ocean, as a considerable part of the Antarctic Bottom Water is generated in the Weddell Sea (Knox 2007, Fahrbach et al. 2009). The formation of those dense water masses in the Weddell Sea is facilitated by the large-scale cyclonic Weddell Gyre (see Fig. 1). Its global relevance has made the Weddell Gyre the subject of much scientific attention in the past, including studies of temporal variation in either the gyre itself or the surrounding ocean-ice-atmosphere system and the climate impact on it (Fahrbach et al. 2004, McKee et al. 2011).

Regarding the unique nature of Antarctic marine biota, the shelves and slopes of the eastern and south-eastern part of the Weddell Sea constitutes particular examples of diverse marine communities. Here, in some areas biodiversity is comparable to tropical regions (Brey et al. 1994), and there is a large number of endemic species (Arntz et al. 1994, Clarke & Johnston 2003, Mühlenhardt-Siegel 2011). For example, the Weddell Sea region with approx. 20 % endemism for molluscs has higher levels of endemism than the adjacent region of the Antarctic Peninsula (Linse et al. 2006). Moreover, unique biocoenoses occur in the eastern Weddell Sea, such as the structurally and ecologically complex sponge associations (Barthel & Gutt 1992). Considerable physical impact along the south-eastern Weddell Sea shelf, mainly caused by icebergs scouring, leads to diverse benthic communities with the coexistence of a succession of stages at regional scales (Gerdes et al. 2003, Gutt & Piepenburg 2003, Knust et al. 2003). Regarding Weddell Sea plankton communities, there is an open water oceanic, eastern shelf and south eastern/southern shelf community with quite some differences in the occurrence of Antarctic krill and ice krill (Siegel 1982, Boysen-Ennen & Piatkowski 1988).

Whereas the coasts along the Antarctic Peninsula are one of the world's fastest warming regions and winter sea ice duration in those regions is shortening (Parkinson 2002), climatic conditions remained relatively stable in the eastern and south-eastern Weddell Sea. Although, projections until the end of this century also show considerable warming along the eastern coast of the Weddell Sea (Hellmer et al. 2012), this geographic region is likely to play an important role in providing refugia for ice dependent key ecosystem components, such as penguins, in the near future. Accordingly, in response to a presentation by the United Kingdom regarding the likely impact of climate change upon emperor penguins (*Aptenodytes forsteri*), the recent 36th ATCM meeting in Brussels, Belgium (20-29 May 2013) endorsed the monitoring of emperor penguin colonies to identify potential climate change refugia (WP010 2013).

In summary, the Weddell Sea constitutes a unique region in the Southern Ocean in terms of ocean and ice dynamics as well as regarding marine biota, their adaptation to short-term environmental variation, and their response to long-term climate change.

Boundaries of the planning area

At the 2013 EMM meeting in Bremerhaven the area to be considered in the scientific data compilation and analyses to form the base line study for a potential Weddell Sea MPA (WS-MPA) was discussed (see report of EMM 2013, SC-CAMLR-XXXII/03, §§ 3.4-3.6).

The WS-MPA project group stressed the fact that the boundary between MPA Planning Domain 3 (Weddell Sea) and Planning Domain 4 (Bouvet-Maud) cut right through the middle of a biogeographically homogeneous region, particularly on the Antarctic shelf. Therefore, the WS-MPA project group proposed to extend the planning area into Planning Domain 4. The EMM recognized these difficulties, but asked for a meaningful and distinct definition of the extended planning area (see SC-CAMLR-XXXII/03, § 3.6).

Correspondingly, the WS-MPA project group proposes the planning area for the evaluation of a Weddell Sea MPA to consist of Planning Domain 3 (Weddell Sea) and that part of Priority Area 6 (one of 11 priority areas identified by WG-EMM / SC-CAMLR-XXVII, later substituted by the 9 MPA Planning Domains, SC-CAMLR-XXX) located in Planning Domain 4 (Fig. 3). **Please note** that these boundaries do **not** resemble the boundaries of any proposed Weddell Sea MPA.

- **Northern border**
 - 64°S from The Antarctic Peninsula to 20°W (= northern border of Planning Domain 3)
 - 64°S from 20°W to 20°E (covers Priority Area 6 in Planning Domain 4)
- **Eastern border**
 - 20°E (= eastern border of Priority Area 6 in Planning Domain 4)
- **Western border**
 - Antarctic Peninsula
- **Southern border**
 - Continental margin and shelf ice margin respectively

Germany considers this area biogeographically meaningful, as it covers a specific oceanographic and ecological entity, i.e. the Weddell Gyre system south of the Antarctic Circumpolar Current (Fig. 1), and includes the whole eastern Weddell Sea shelf as well.

Update on the data retrieval process

Table 1 and 2 provide a systematic overview of the current data situation. More than ten large environmental data sets are listed at the moment. These data sets mainly include satellite data, having a high temporal resolution and are freely available. For example, satellite observations

on daily sea ice concentration, derived from the Advanced Microwave Scanning Radiometer – Earth Observing System (AMSR-EOS) instrument on board the Aqua satellite, are available by several Internet web sites (see Tab. 1; Fig. 4 and 5). In addition, daily sea surface temperatures derived from the Advanced Very-High Resolution Radiometer instrument on board the three NOAA TIROS-N series of polar-orbiting satellites can be obtained from the Modular Ocean Data Assimilation System operated by the United States Naval Research Laboratory.

An environmental data set that is based on satellite data and *in situ* data (e.g. multi-beam data) is for example the first regional digital bathymetric model established by the International Bathymetric Chart of the Southern Ocean (IBCSO) programme (Arndt et al. 2013; see Fig. 2). This chart model covers circum-Antarctic waters and is based on data from hydrographic offices, scientific institutions and data centres.

Sediment data are one example for typical *in situ* data sets (Table 1). A substantial data set on Weddell Sea sediments can be extracted from the scientific data information system PANGAEA, an ICSU World Data Center, hosted by the AWI and the Centre for Marine Environmental Science (MARUM), University Bremen. Sediment samples were taken during several *Polarstern* cruises between 1983 and 1997 with large box corer, multicorer or minicorer (Diekmann & Kuhn 1999). This data set (based on point data) seems to be generally suitable for the bio-regionalisation analyses after the classification and spatial interpolation of the sediments by means of the intersection with diverse bathymetric derivatives (e.g. depth, rugosity).

Data on Weddell Sea oceanography were sampled since 1984 in different time intervals. Those data are available for the most part at PANGAEA (see Tab. 1) and are described in several publications (Fahrbach et al. 1995, 2004, 2007, 2011; Klatt et al. 2007, see Fig. 1). Alternatively, oceanographic parameters may be obtained for high-resolution oceanographic models run at AWI.

So far, 15 ecological data sets on zooplankton, zoobenthos, fish and mammals are listed. Data sets on zooplankton include mainly krill data. Next to some snapshot studies from research operations in the 1970s and 1980s, most historical krill data (until 2004) are available in the data base *krillbase* (<http://www.iced.ac.uk/science/krillbase.htm>). More recent data on zooplankton (2004 to 2008) are published in Siegel (2012) and Hunt et al. (2011). Haul-by-haul krill catch data from commercial operations are stored as a summary data base by CCAMLR.

Two substantial zoobenthic data sets are listed in Table 2. Gutt et al. (2013a) provide a comprehensive data set on the geographical distribution of Antarctic macrobenthic communities. This data set, consisting of approx. 90 individual data sets, has a temporal coverage from 1956 to 2010 and covers almost the entire Southern Ocean (Gutt et al. 2013b). Although the data show a considerable patchiness at regional scale, the south-eastern Weddell Sea is covered well, and thus the data set provides unique geo-referenced biological basic information for the planning of a Weddell Sea MPA. Furthermore, a large quantitative macrobenthos data set exists at the AWI. Macrobenthic samples were taken during 10 *Polarstern* cruises in the south-eastern and eastern Weddell Sea shelf area from 1987 to 2013 (e.g. Gerdes et al. 1992). In addition, there is a considerable number on specific higher taxonomic groups - particularly polychaetes (e.g. Montiel et al. 2005, Schüller & Hilbig 2007,

Stiller 1996), molluscs (e.g. Hain 1990), crustaceans (e.g. Brandt et al. 2007) and echinoderms (e.g. Piepenburg et al. 1997, Brey & Gutt 1991, Gutt 1991) - mainly sampled along the Weddell Sea shelf, but also in deeper waters. In total more than 20 smaller data sets on higher taxonomic groups of macrozoobenthos, partly stored in the ANTABIF data portal, and on macrofaunal communities (e.g. Galeron et al. 1992, Voß 1988) were sighted and discussed in our national workshop (not listed in Tab. 2).

Substantial research data cover the fish fauna of the Weddell Sea. During various *Polarstern* cruises between 1983 and 2011 the demersal fish fauna was sampled particularly along the Weddell Sea shelf, but also in the deeper waters (see Drescher et al. (2012), Ekau et al. (2012a, b), Hureau et al. (2012), Kock et al. (2012), Wöhrmann et al. (2012) and unpublished data hold by R. Knust, AWI; see Fig. 6). Furthermore, information is available on the distribution of oceanic pelagic fish (unpublished data hold by R. Knust, AWI). *Dissostichus* spp. catch data from fishery operations are stored as a summary data base by CCAMLR.

There is considerable information on cetacean and pinniped sightings in the Weddell Sea. A pinniped survey within the Antarctic Pack Ice Seals (APIS) programme, which was developed and executed by members of the Scientific Committee on Antarctic Research (SCAR) Group of Specialists on Seals and their national programmes, was carried out along the eastern coast of the Weddell Sea from 1996 to 2001. During five flight campaigns, which covered an area of more than 80,000 km of aerial transects, approx. 2,300 seals were counted in total (Ackley et al. 2006, Plötz et al. 2011a-e, Southwell et al. 2012). Moreover, the presence of pinnipeds and cetaceans is recorded year-round since 2005 by the coastal Perennial Acoustic Observatory in the Antarctic Ocean (PALAOA) near Neumayer Station, and additionally by several oceanographic moorings distributed along the Greenwich meridian and throughout the Weddell Sea (Van Opzeeland 2010). Regarding cetacean sightings, two data sets were discussed during the national workshop. Since 2005, the AWI systematically and continuously logs all sightings of cetaceans near RV *Polarstern* in the Southern Ocean (Marine Mammal Perimeter Surveillance, MAPS). By means of the MAPS project more than 1300 individuals from nine cetacean taxa were identified in the Weddell Sea from 2005 ongoing (Burkhardt 2009a-j, 2011, 2012). Those data were used to build a habitat suitability model of humpback and Antarctic minke whales in the Southern Ocean (see Bombosch 2013). Furthermore, quantitative cetacean sightings, surveyed during five *Polarstern* cruises from 2006 to 2013, serve as a basis for estimating local cetacean densities in the Weddell Sea (unpublished data hold by H. Feindt-Herr, Institute for Terrestrial and Aquatic Wildlife Research).

During the national workshop it became apparent that there are some data sets which are neither available at the AWI nor at the national institutes participated in the national workshop, but which seem to be relevant for the evaluation of a MPA in the Weddell Sea. At the moment, there is a particular lack of data on penguins and other bird (e.g. petrels), their colonies and their distribution patterns in the Weddell Sea. Moreover, additional information on the higher taxonomic resolution of sponges would be helpful for the characterisation of the zoobenthos communities in the Weddell Sea. Regarding those taxonomic groups, according to our best knowledge, a few data sets exist at German and international research institutes, and their principal investigators have already been, or will be, contacted in a timely manner. In terms of commercial and exploratory / research fishery operations for krill and *Dissostichus*

spp. (haul-by-haul CPUE data), historic data sets were recently requested from CCAMLR for CCAMLR subarea 48.5 and partly 48.6.

However, Germany has as yet no detailed information so far regarding the *Dissostichus* spp. research long-line fisheries carried out by Russia in CCAMLR subarea 48.5, other than that contained in papers presented by Russian colleagues at SAM 2013 and EMM 2013. As all those data would be very helpful and important for the further work, Germany would welcome and invites all experts from CCAMLR to contribute relevant information and data sets. Contact at the AWI for any such contributions is Dr. Katharina Teschke (Katharina.Teschke@awi.de). Please note, that a call for data will additionally be circulated via a CCAMLR Circular (SC CIRC) in the near future.

In summary, all listed data sets (Table 1 and 2) seem to be generally suitable to contribute to a geo-referenced integrated data base on Weddell Sea environment and ecology. However, the subsequent data preparation and analysis (i.e. merging of environmental and ecological data of different resolution in space and time) will show to which extent each data set is suitable indeed in terms of quality and coherence to contribute significantly to our task.

Timeline - milestones and deliverables

Under this heading, Germany would like to inform the Scientific Committee in particular that an international expert workshop concerning the scientific evaluation of the Weddell Sea is scheduled for early April 2014; the workshop will be organised and hosted by the Alfred Wegener Institute at Bremerhaven, Germany (contacts: Thomas.Brey@awi.de and Katharina.Teschke@awi.de). The major objective of the workshop will be to bring together scientists and experts from all CCAMLR Members to discuss the available data and any preliminary results derived from ongoing scientific studies and analyses to establish a robust scientific basis for further consideration of protective measures. Further information about the workshop will be circulated via an SC CIRC in the near future.

Germany would also like to update the Scientific Committee on the timeline, milestones and deliverables for the period April 2013 to October 2014 (CAMLR Commission meeting). This time schedule was already presented in our document WG-EMM-13/22 (WG-EMM 2013, Bremerhaven, Germany). Please note that the grey-coloured paragraphs indicate those tasks completed already.

Mid April to June 2013



- Research of relevant MPA literature (incl. CCAMLR documents)
- Inventory of existing geo-referenced data
- Rough localisation of the Weddell Sea region on that we will focus within the project
- Submission of a document to CCAMLR focussing on the scheduled work regarding the establishment of a Weddell Sea MPA and giving an overview of the existing geo-referenced data

Milestone 1: Meeting of the CCAMLR Working Group on Ecosystem Monitoring and Management (WG-EMM, 1-10 July 2013, Bremerhaven)

Deliverable 1

Presentation at WG-EMM about the scheduled work regarding the establishment of a Weddell Sea MPA, including an overview of the existing geo-referenced data supported by examples of GIS maps

Deliverable 2

AWI colloquium during the WG-EMM (4 July 2013) i. a. to discuss the work schedule of the Weddell Sea MPA project with members of the WG-EMM

July to September 2013



- Implementation of the results developed from the WG-EMM meeting
- Continuation of literature research and data inventory
- Organisation of a national workshop for the establishment of a marine CCAMLR-MPA in the Weddell Sea

Milestone 2: Realisation of a national workshop (11-13 September 2013, Bremerhaven)

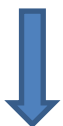
Deliverable 4

Briefing and integration of all relevant German experts, focused on Antarctic research and nature conservation, in the working approach of the AWI to establish a Weddell Sea MPA

Deliverable 5

Check-up of and potential addition to the data inventory

September to October 2013



- Implementation of the results developed from the national workshop
- Continuation of literature research and data inventory
- Preparation of a preliminary report about the data compilation

Milestone 3: Meeting of the CCAMLR Scientific Committee (SC, 21-25 October 2013, Hobart, Tasmania)

Deliverable 6

Submission of a preliminary report on the scientific data compilation and analyses in support of the development of a CCAMLR MPA in the Weddell Sea and its presentation as a German paper at the meeting of SC-CAMLR (incl. perspective of the work scheduled for 2014)

November to April 2014



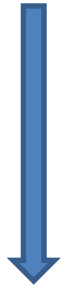
- Implementation of the results of SC-CAMLR meeting
- Organisation of an international workshop

Milestone 4: Organisation of an international workshop (early Apr. 2014, Bremerhaven)

Deliverable 7

Discussion with experts of other CCAMLR Member States of the scientific data compilation and analyses carried by the AWI in support of the development of a CCAMLR MPA in the Weddell Sea

April to July 2014



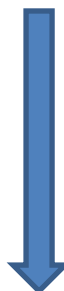
- Implementation of the results of the international workshop (incl. short report about the results of the workshop)
- Preparation of a report about preliminary scientific results regarding the establishment of a Weddell Sea MPA
- Generation of preliminary draft text modules for a proposal regarding the Weddell Sea MPA conservation measures and the corresponding research and monitoring plan according to CCAMLR (Conservation Measure 91-04)

Milestone 5: Meeting of the CCAMLR WG-EMM (early July 2014)

Deliverable 8

Submission of the project report and presentation of preliminary results regarding the scientific analyses in support of the development of CCAMLR MPA conservation measures in the Weddell Sea

July to October 2014



- Implementation of the results of the WG-EMM meeting
- Revision and completion of the scientific work
- Further development of text modules for a proposal in respect of the Weddell Sea MPA conservation measures including a research and monitoring plan according to CCAMLR
- Development of a proposal regarding priority elements for a research and monitoring plan

Milestone 6: Meeting of SC-CCAMLR and the CCAMLR Commission (end of October/early November 2014, Hobart, Tasmania)

Deliverable 9

Submission of a working paper and presentation of the results of the scientific work carried out in support of the development of CCAMLR MPA in the Weddell Sea

Deliverable 10

Based on the working paper, presentation of a proposal for CCAMLR MPA in the Weddell Sea including a management plan and priorities for a research and monitoring plan

Table 1: List of environmental data sets suitable for marine protected area evaluation in the Weddell Sea

Parameter	Spatial and temporal resolution			Source (contact person, publication, web site)
	Spatial resolution	Period	Temporal resolution	
Satellite data				
Sea ice concentration (%)	6.25 km x 6.25 km	2002 - Oct 4, 2011; Aug 2012 - ongoing	daily	Kaleschke et al. (2001), Spreen et al. (2008) http://www.icdc.zmaw.de/seaiceconcentration_asi_amsre.html http://www.iup.uni-bremen.de/seaice/amsr/
Sea surface temperature (°C)	1/8° x 1/8° (MODAS) 1/12° x 1/12° (HYCOM)	1993 - ongoing	daily	Barron & Kara (2006) MODAS: http://www7320.nrlssc.navy.mil/modas/ HYCOM: http://www7320.nrlssc.navy.mil/GLBhycom1-12/skill.html
Sea surface height (cm)	1/3° x 1/3°	1992 - ongoing	daily	Archiving, Validation & Interpretation of Satellite Oceanographic data (Aviso) http://www.aviso.oceanobs.com/en/
Chlorophyll-a concentration (mg/m ³)	0.83 km x 0.83 km	1997 - 2010	daily	National Aeronautics and Space Administration (NASA) Goddard Space Flight Center's Ocean Data Processing System (ODPS) http://oceandata.sci.gsfc.nasa.gov/SeaWiFS/L3SMI/
Satellite data combined with <i>in situ</i> data				
Bathymetry (m)	500 x 500 m	not applicable	not applicable	Arndt et al. (2013) www.ibcso.org
<i>In situ</i> data				
Sea temperature (°C), Salinity (PSS), Dissolved oxygen (ml l ⁻¹), inorganic nutrients (µM)	1° x 1°	1955-2006	Monthly, seasonal, annual	Locarnini et al. (2010), Antonov et al. (2010), Garcia et al. (2010a,b), http://www.nodc.noaa.gov/OC5/WOA09/pr_woa09.html
Clay mineral	approx. 90 samples	1984 - 1992	annual	Petschick et al. (1996) http://doi.pangaea.de/10.1594/PANGAEA.55955

Table 1 (contd.)

Parameter	Spatial and temporal resolution			Source (contact person, publication, web site)
	Spatial resolution	Period	Temporal resolution	
<i>In situ data</i>				
Sediment	In total approx. 300 surface sediment samples, Weddell Sea (incl. Lazarev Sea and Riiser-Larsen Sea)	1983-1997	time interval: 1-3 years	Diekmann & Kuhn (1999) http://doi.pangaea.de/10.1594/PANGAEA.730459
Weddell system	8 repeat hydrographic sections, moored instruments and profiling floats in the Weddell Gyre on the Greenwich meridian, Weddell Sea	1984-2008	Different time intervals	Fahrbach et al. (1995, 2004, 2007, 2011) Data are available at e.g. http://www.pangaea.de/
Weddell Gyre	206 ice-compatible vertically profiling floats, Weddell Sea	1999-2010	Snapshot in time	Klatt et al. (2007)

Table 2: List of ecological data sets for marine protected area evaluation in the Weddell Sea

Parameter	Sampling design and temporal resolution			Source (contact person, publication, web site)
	Sampling design	Period	Temporal resolution	
Zooplankton				
Krill and salp data (N/1000 m ³)	Net hauls, northern and south-eastern Weddell Sea	1923 - 1935, 1978 - 2004	Summary data base of most krill data available	Angus Atkinson, Evgeny Pakhomov, Volker Siegel Atkinson et al. (2004, 2008 and 2010) http://www.iced.ac.uk/science/krillbase.htm
Krill, krill larvae and zooplankton data (N/1000 m ³)	RMT nets along 3-4 transects, spacing 20-30 nautical miles, Lazarev Sea (approx. 50-80 stations per expedition)	2004 - 2008	One expedition per year	Volker Siegel (krill), Evgeny Pakhomov (zooplankton) Siegel (2012); Hunt et al. (2011)
Krill data from commercial operations (catch in tons)	Commercial trawls, random, Weddell Sea	1978 - 1990	Summary data base	David Ramm, CCAMLR data manager www.ccamlr.org
Zooplankton data incl. krill (N/1000 m ³)	RMT8 net, 30 stations randomly distributed, Weddell Sea eastern shelf	1982	Snapshot in time	Volker Siegel Boysen-Ennen & Piatkowski (1988)
Krill data (N/1000 m ³)	IKMT net, random sampling, Lazarev Sea	1977, 1982	Snapshot in time	Volker Siegel Makarov & Sysoeva (1985); Menshenina (1992); Siegel (2012)
Krill data (N/1000 m ³)	IKMT/Juday nets, random sampling, Weddell Sea eastern shelf	1977	Snapshot in time	Volker Siegel Fevolden (1979)
Zoobenthos				
Macrobenthic communities (descriptive)	approx. 90 data sets, Weddell Sea shelf	1956 - 2010	Summary data set, Snapshots in time	Gutt et al. (2013a, b) and references therein in regards to results and data http://ipt.biodiversity.aq/resource.do?r=macrobenthos

Table 2 (contd.)

Parameter	Sampling design and temporal resolution			Source (contact person, publication, web site)
	Sampling design	Period	Temporal resolution	
Macrobenthos (Ind. m ⁻² , wet weight m ⁻² , g C m ⁻² , g C m ⁻² y ⁻¹)	10 <i>Polarstern</i> cruises, Weddell Sea (south-) eastern shelf	1987 - 2013	Different time intervals	Dieter Gerdes, AWI; Gerdes et al. (1992)
Fish				
Mostly demersal fish data, but also pelagic fish data (abundance, biomass)	> 10 <i>Polarstern</i> cruises, mostly Weddell Sea shelf, but also deeper waters, > 300 hauls	1983 - 2011	Different time intervals	Julian Gutt, Rainer Knust, Karl-Hermann Kock Drescher et al. (2012), Ekau et al. (2012 a, b), Hureau et al. (2012), Kock et al. (2012), Wöhrmann et al. (2012) and unpublished data hold by R. Knust, AWI doi:10.1594/PANGAEA.786877, doi:10.1594/PANGAEA.786883, doi:10.1594/PANGAEA.786884, doi:10.1594/PANGAEA.786886, doi:10.1594/PANGAEA.786888, doi:10.1594/PANGAEA.786887
<i>Dissostichus</i> spp. fishery operations (catch in tons)	random, Weddell Sea		Summary data base	David Ramm, CCAMLR data manager www.ccamlr.org
Mammals				
Pinniped sightings	5 flight campaigns	1996 - 2001	annual	Ackley et al. (2006), Southwell et al. (2012) Plötz et al. (2011 a-e): http://www.pangaea.de/search?count=10&minlat=&minlon=&maxlat=&maxlon=&mindate=&maxdate=&env=All&q=emage doi: 10.1594/PANGAEA.760099, doi: 10.1594/PANGAEA.760098, doi: 10.1594/PANGAEA.760097, doi: 10.1594/PANGAEA.760101, doi: 10.1594/PANGAEA.760100
Pinniped and cetacean presence (acoustic data)	oceanographic moorings, Weddell Sea	2005 - ongoing	Daily, different starting times for single recorders	Kindermann (2013), http://doi.pangaea.de/10.1594/PANGAEA.773610 Van Opzeeland (2010)

Table 2 (contd.)

Parameter	Sampling design and temporal resolution			Source (contact person, publication, web site)
	Sampling design	Period	Temporal resolution	
Opportunistic cetacean sightings	15 <i>Polarstern</i> cruises	2005 - ongoing	Snapshot in time	Burkhardt (2009 a-i, 2011, 2012 and unpublished data) http://www.pangaea.de/search?count=10&minlat=&minlon=&maxlat=&maxlon=&mindate=&maxdate=&env=All&q=elke+burkhardt+ Bombosch (2013)
Quantitative cetacean sightings (N/km ²)	5 <i>Polarstern</i> cruises	2006 - 2013	time interval: 1-2 years	Helena Feindt-Herr, Institute for Terrestrial and Aquatic Wildlife Research, University of Veterinary Medicine Hannover

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Figures

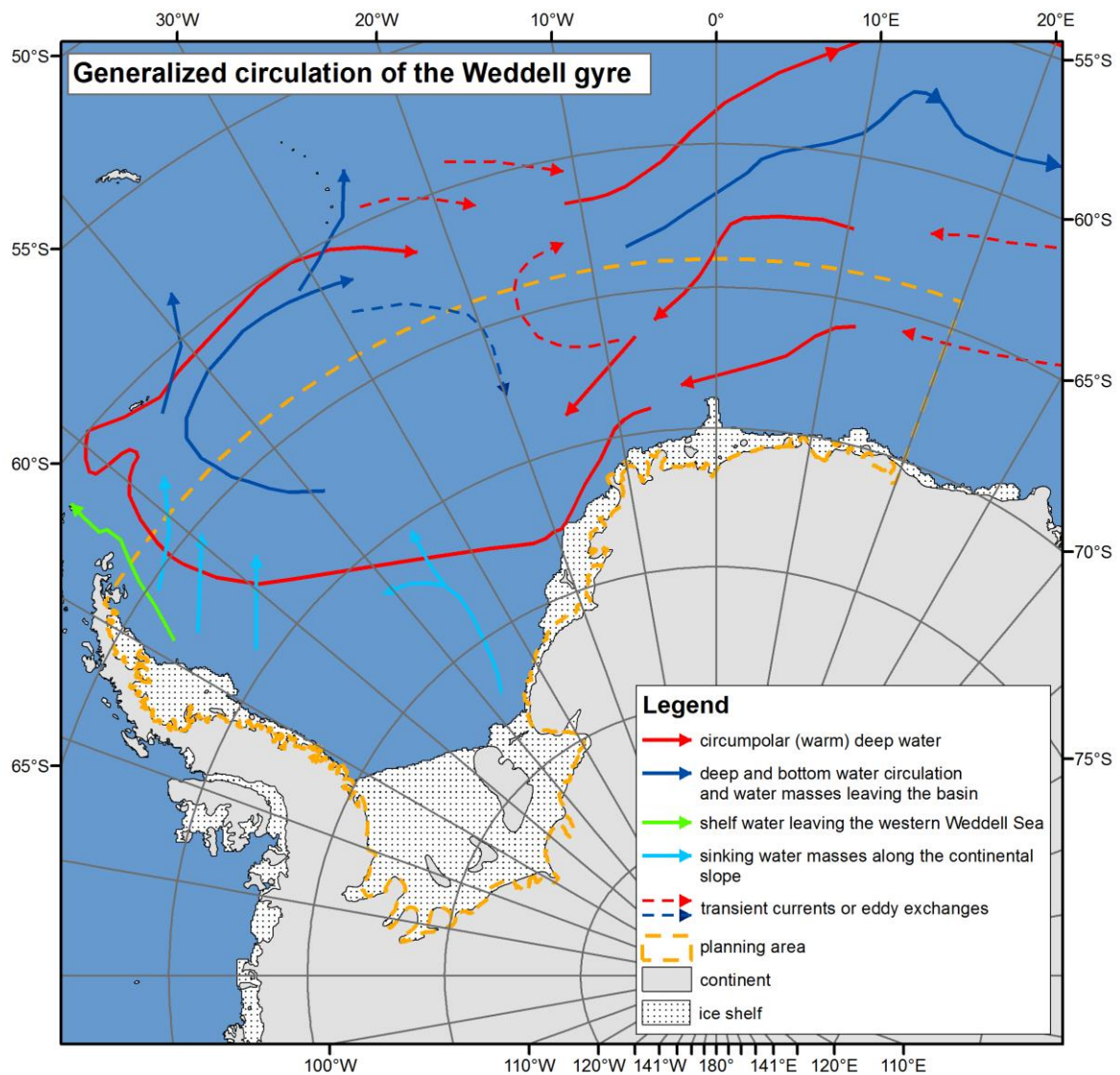


Figure 1: Generalized circulation of the Weddell gyre published by Fahrbach et al. (2011). The yellow dashed box shows the proposed planning area for the evaluation of a Weddell Sea MPA. Please note that the boundaries of the proposed planning area do not resemble the boundaries of any proposed Weddell Sea MPA.

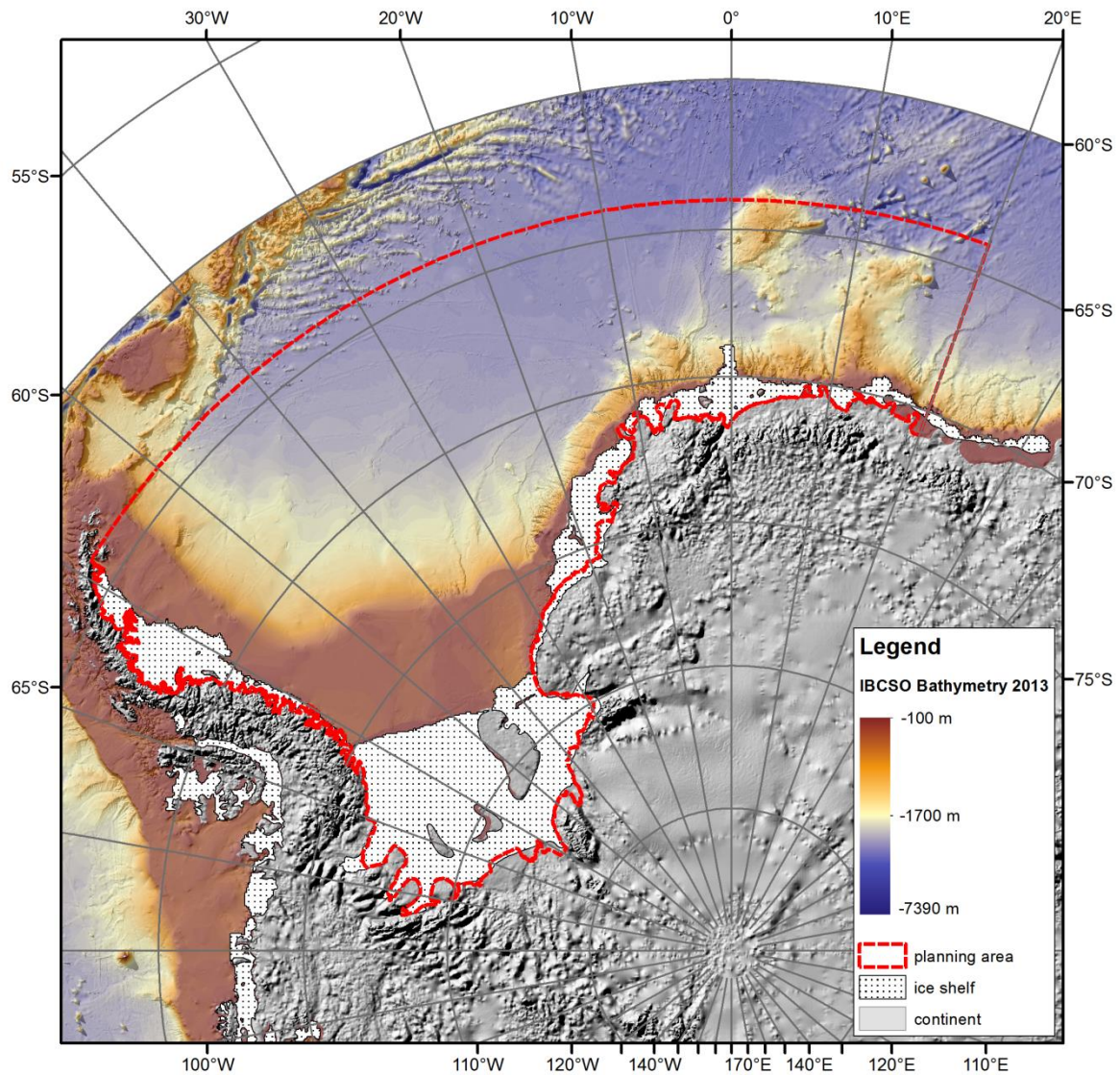


Figure 2: Bathymetry (in m) in the proposed planning area for the evaluation of a Weddell Sea MPA (red dashed box). Please note that the boundaries of the proposed planning area do not resemble the boundaries of any proposed Weddell Sea MPA. The bathymetric chart of the Southern Ocean (IBCSO) is published by Arndt et al. (2013).

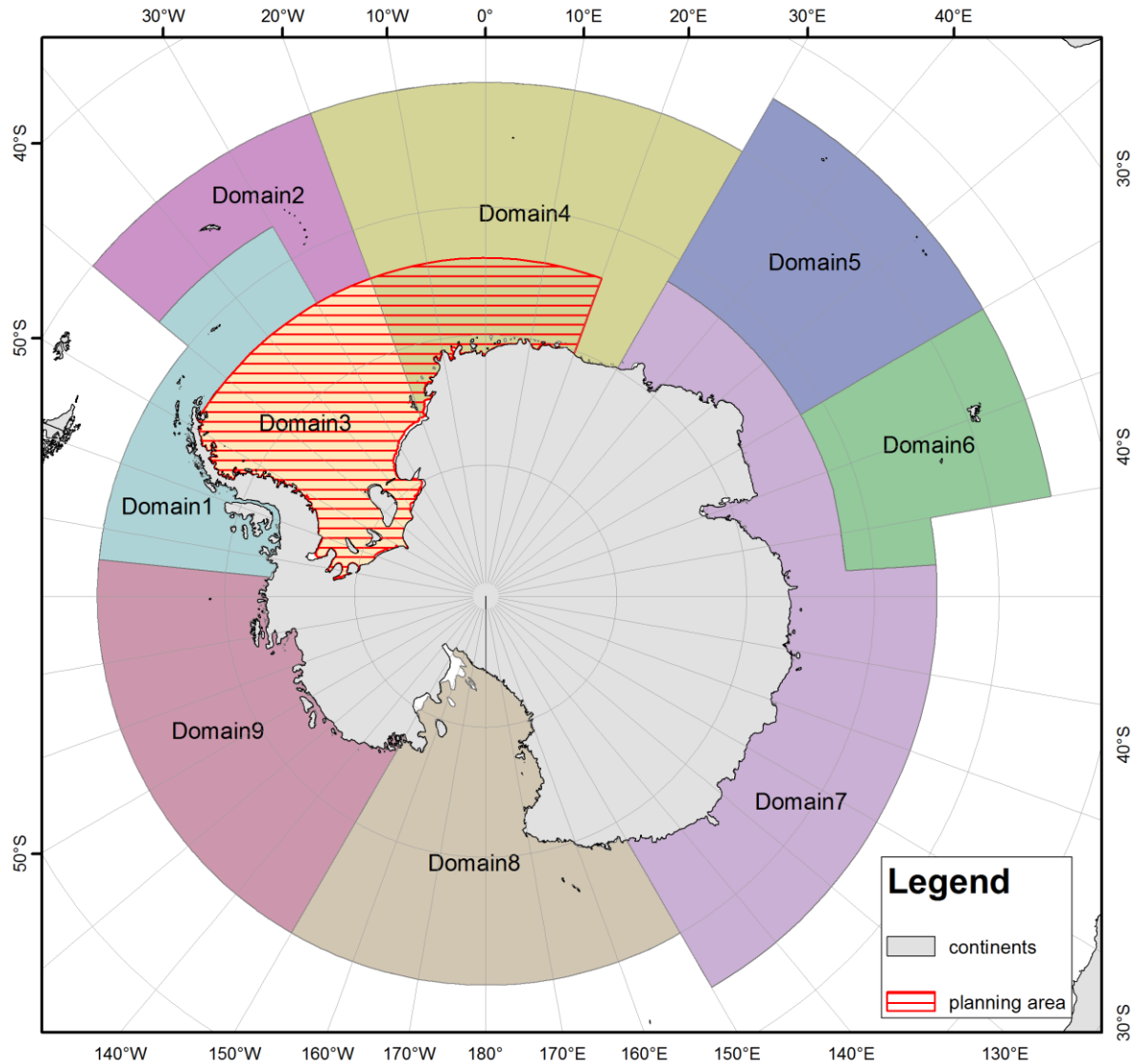


Figure 3: CCAMLR MPA Planning Domains and the proposed planning area for the evaluation of a Weddell Sea MPA (red shaded area). Please note that the boundaries of the proposed planning area do not resemble the boundaries of any proposed Weddell Sea MPA. Domain 1: Western Peninsula - South Scotia Arc, Domain 2: North Scotia Arc, Domain 3: Weddell Sea, Domain 4: Bouvet Maud, Domain 5: Crozet - del Cano, Domain 6: Kerguelen Plateau, Domain 7: Eastern Antarctica, Domain 8: Ross Sea, Domain 9: Amundsen - Bellingshausen.

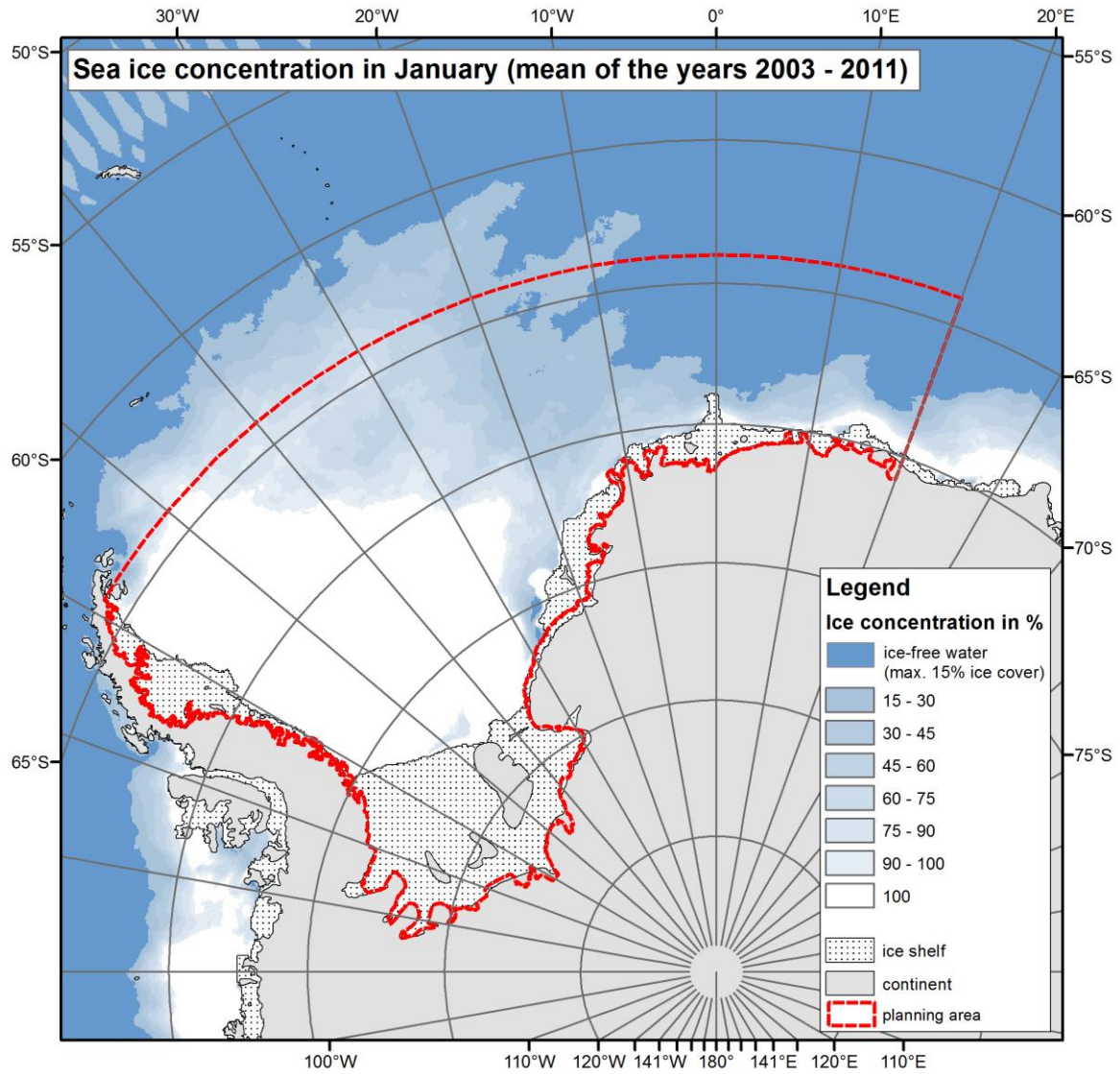


Figure 4: Sea ice concentration (in %) in the proposed planning area for the evaluation of a Weddell Sea MPA (red dashed box) for the month of January (mean of the years 2003-2011). Please note that the boundaries of the proposed planning area do not resemble the boundaries of any proposed Weddell Sea MPA.

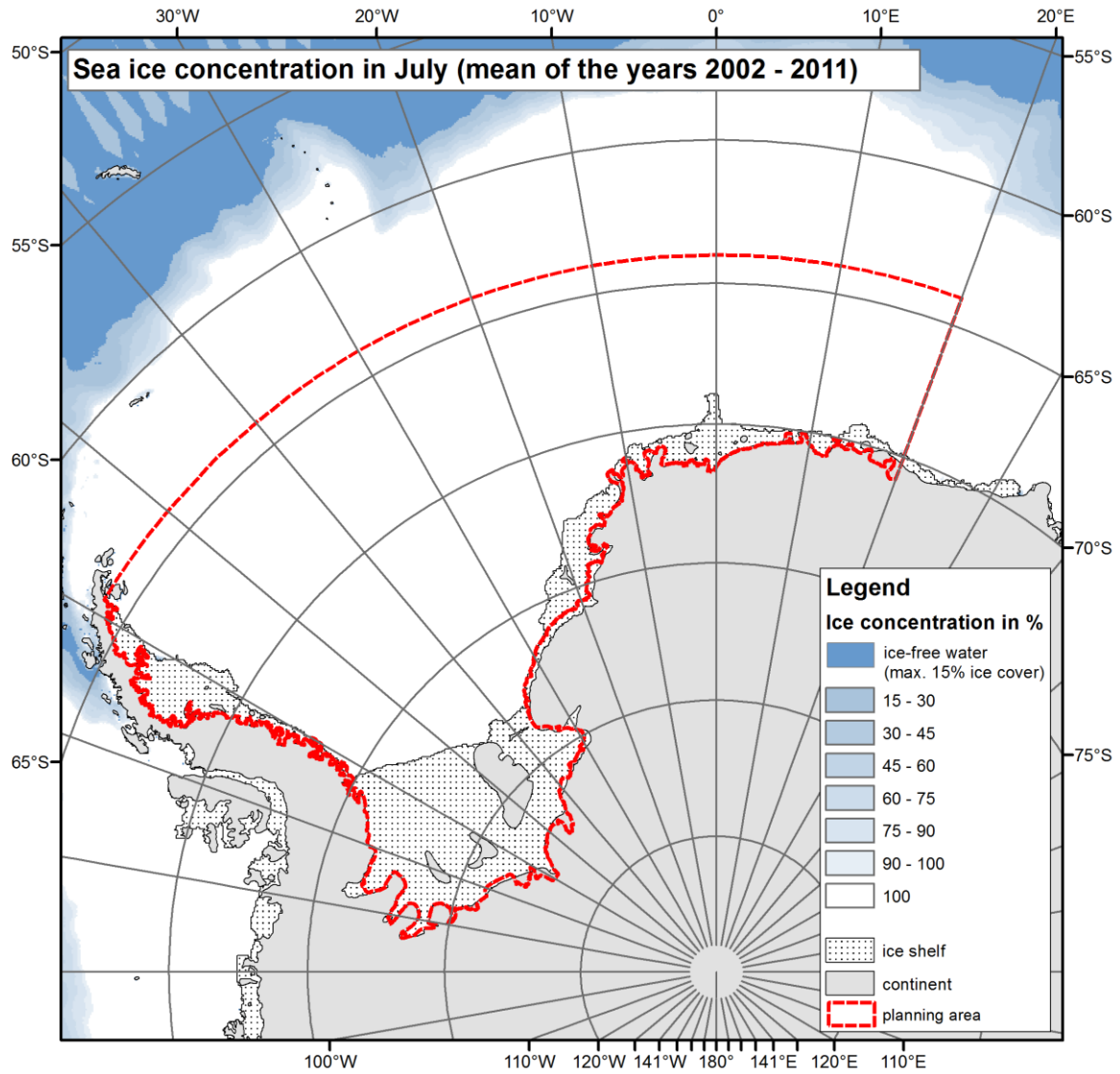


Figure 5: Sea ice concentration (in %) in the proposed planning area for the evaluation of a Weddell Sea MPA (red dashed box) for the month of July (mean of the years 2002-2011). Please note that the boundaries of the proposed planning area do not resemble the boundaries of any proposed Weddell Sea MPA.

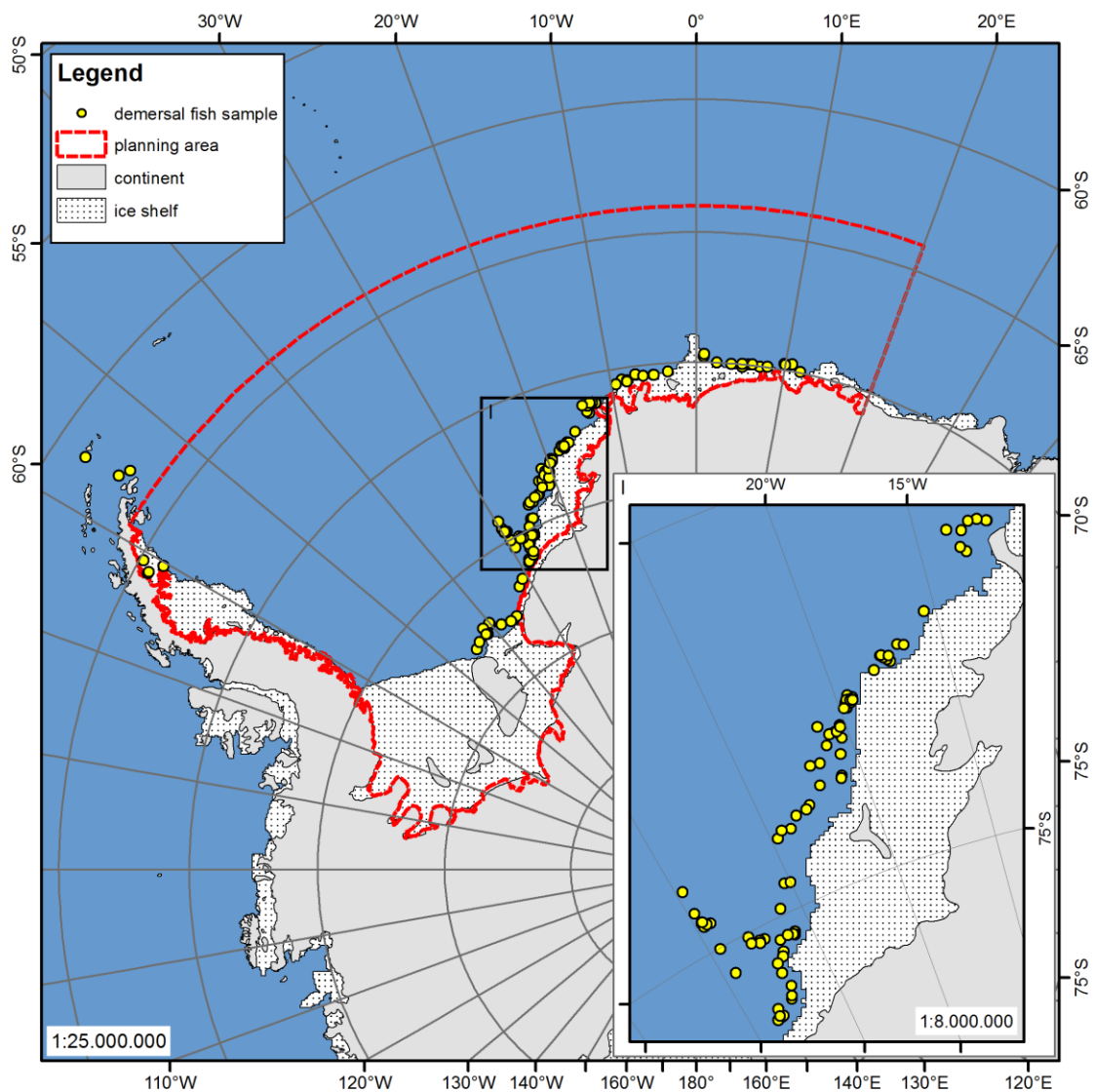


Figure 6: Demersal fish fauna sampled between 1983 and 2011 during various *Polarstern* cruises in the proposed planning area for the evaluation of a Weddell Sea MPA (red dashed box). Please note that the boundaries of the proposed planning area do not resemble the boundaries of any proposed Weddell Sea MPA. The data on demersal fish is published by Drescher et al. (2012), Ekau et al. (2012 a,b), Hureau et al. (2012), Kock et al. (2012), Wöhrmann et al. (2012) and unpublished data hold by R. Knust, AWI).