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Title **Proposal for the establishment of a marine CCAMLR MPA in the Weddell Sea (Antarctica) – First conceptual outline**

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Abstract

In recent years, CCAMLR member states undertook substantial efforts to designate marine protected areas (MPAs) in the Southern Ocean. While MPA planning for six domains is underway, for three domains 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 Weddell Sea MPA for consideration in 2014. Subsequently, the German Federal Ministry of Food, Agriculture and Consumer Protection tasked the Alfred Wegener Institute (AWI) to compile and analyse scientific data for identifying potential conservation areas and measures in the Weddell Sea. The work under this project started mid-April 2013. Here, in our first conceptual outline, we *(i)* present the principal target area of our evaluation study aiming at a Weddell Sea MPA, *(ii)* give a systematic overview of our preliminary data retrieval accompanied by an invitation to all experts from within and outside CCAMLR to contribute relevant information and data sets and *(iii)* set out the project timeline in detail, i. a. to highlight an international expert workshop on the planning of a Weddell Sea MPA in 2014.

Proposal for the establishment of a marine CCAMLR MPA in the Weddell Sea (Antarctica)

- First conceptual outline –

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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. 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 in an advanced stage by CCAMLR. For three domains, 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 the scientific data background information and data for identifying potential conservation areas and measures in the Weddell Sea. The work under this project started mid-April 2013 and is being carried out by a project team (see list of authors) under the lead of Prof. Dr. Thomas Brey.

Here, in our first conceptual outline we would like to inform the Working Group on Ecosystem Monitoring and Management (WG-EMM) about the work carried out so far by the AWI on the national level in regard to planning for a Weddell Sea MPA. The objectives of this document are:

1. to present the principal target area of our evaluation study aiming at a Weddell Sea MPA;
2. to give a systematic overview of our preliminary data retrieval and to welcome any contributions which EMM experts can make to the ongoing work in form of expertise

and/or data from the Weddell Sea, especially with regard to parameters such as phyto- and zooplankton, penguins and *Dissostichus* spp. research longline fisheries;

3. to set out the timeline, milestones and deliverables from April 2013 to the submission of a German proposal for a Weddell Sea MPA for consideration by the CAMLR Commission in October 2014. Here, in particular we would like
    a. to highlight that an international expert workshop on the planning of a Weddell Sea MPA to be held in March/April 2014 in order to discuss and exchange views with colleagues from all CCAMLR member states.
    b. to invite EMM experts to comment on the proposed work plan, as appropriate.

Study 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. Its borders are defined by the ice-shelf edge and glaciated coasts of Coats Land in the east and of Graham Land in the west. The southern border is formed by the Ronne-Filchner shelf ice, while the northern border is the Atlantic-Indian Ridge (see Fig. 1). 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; Fig. 1).

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. 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).

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, pelagic key ecosystem components in the near future (e.g. Antarctic krill, ice krill, Antarctic silverfish, sea birds, marine mammals). 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 addition, suitable Antarctic minke whale (*Balaenoptera bonaerensis*) habitats seem to be associated with sea ice covered areas, such as southern to eastern realm of the Weddell Sea, at least during the Antarctic summer (Kasamatsu et al. 1998, Scheidat et al. 2011, Bombosch 2013). 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). Antarctic krill, one principal food source for sea birds and marine mammals, may prefer the climatic relatively stable eastern Weddell Sea region in the future.

In summary, the south-eastern part of 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 adaption to short-term environmental variation, and their response to long-term climate change. Therefore, the wider eastern and south-eastern Weddell Sea will become the principal target area for Germany's work regarding the planning of a Weddell Sea MPA.

Preliminary data retrieval

Since the foundation of the Alfred Wegener Institute in 1980, the establishment of the permanent German Antarctic research station (*Georg von*) *Neumayer* on the Ekström ice shelf (see Fig. 1) in the 1980/1981 season and the commissioning of the icebreaking research vessel *Polarstern* in 1982, one of the main focus areas of the German basic Antarctic research was the Weddell Sea. During the last 30 years, national and international research activities yielded a tremendous amount of environmental (e.g. geophysics, glaciology, geology, physical oceanography) and ecological (e.g. biogeography, biodiversity, productivity) data.

Activities related to *Polarstern* cruises in the Weddell Sea from 1982 to 2012 concentrated in shelf areas of the southern and eastern Weddell Sea (Fig. 1; data retrieved from the scientific data information system PANGAEA, hosted by the AWI and the Centre for Marine Environmental Science (MARUM), University Bremen). Accordingly, ecological studies, such as demersal fish communities, tend to focus on these areas, too (Fig. 2).

Table 1 and 2 provide a systematic overview of our preliminary data retrieval. More than ten large environmental data sets are listed at the moment. These data sets mainly include satellite data. For example, daily sea ice concentration values derived from the Advanced Microwave Scanning Radiometer – Earth Observing System (AMSR-EOS) instrument on board the Aqua satellite. In addition, daily sea surface temperatures derived by the Advanced Very-High Resolution Radiometer instrument on board the three NOAA TIROS-N series of polar-orbiting satellites. Moreover, a first regional digital bathymetric model was the objective of the International Bathymetric Chart of the Southern Ocean (IBCSO) programme (Arndt et al. 2013; see Fig. 1-3 background layer). This model covers circum-Antarctic waters and is based on data from hydrographic offices, scientific institutions and data centres.

Next to the environmental data sets, eight ecological data sets are listed. For example, Gutt et al. (2013a) provide a comprehensive data set which gives an overview of the geographical distribution of Antarctic macrobenthic communities. The 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 has a high density of data, and thus the data set provides unique geo-referenced biological basic information for the planning of a Weddell Sea MPA. A further substantial data set is shown in Figure 2. More than 300 stations were sampled in 13 years between 1983 and 2011 during various *Polarstern* cruises regarding the benthos associated fish fauna (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). Moreover, considerable data on cetacean and pinniped sightings exist from the area. Since 2005, the AWI in cooperation with Reederei Laeisz, 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 surveyed in the Weddell Sea from 2005 to 2011 (Burkhardt 2009a-j, 2011, 2012; Fig. 3). 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).

However, at the moment, there is a particular lack of large ready-to-use phyto- and zooplankton data sets (except for krill); many small and scattered data sets exist at the AWI and other German research institutes, and their principal investigators are contacted in a timely manner. Moreover, according to our best knowledge, quantitative abundance data on whales, data on penguins and maybe other bird (e.g. petrels) colonies and their distribution pattern in the Weddell Sea are not available at the AWI. Additionally, we have no information so far regarding the *Dissostichus* spp. research longline fisheries carried out by Russia in CCAMLR subarea 48.5 and by Japan / South Africa in the southern part of CCAMLR subarea 48.6. As all those data would be very helpful and important for the further work, Germany would welcome and invites all experts from within and outside CCAMLR to contribute relevant information and datasets. Contact at the AWI for any such contributions is Dr. Katharina Teschke (Katharina.Teschke@awi.de).

In summary, all listed environmental and ecological data sets seem to be generally suitable for a baseline in order to establish a Weddell Sea MPA. However, the collation of additional data and the subsequent data preparation and analysis (i.e. merging of environmental and ecological data of different resolution in space and time) will show, if the data are actually appropriate in order to propose justified, appropriate and targeted conservation actions in the end.

Timeline - milestones and deliverables

To prepare a scientifically well-founded proposal for the establishment of a MPA in the Weddell Sea, the project is subdivided into three general clusters:

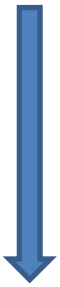
1) Inventory, reprocessing and analysis of existing data from the Weddell Sea to evaluate and identify key areas, which are in the need of protection.

2) Discussion, improvement and review of our scientific data and analytical approaches in a stepwise procedure together with experts (incl. EMM experts) at a national (11-13 Sept. 2013, Bremerhaven) and an international workshop (Mar. /Apr. 2014, Bremerhaven).

3) Transferring the results of the scientific analysis into a proposal for a CCAMLR MPA for the Weddell Sea, including a management plan and priorities for a corresponding research and monitoring plan.

Project activities will take into account the general framework for the establishment of CCAMLR MPAs (CM 91-04) and other relevant CCAMLR measures. The subsequent timing and completion of the project is primarily given by the relevant CCAMLR meetings which set the milestones and align with the evaluation of the deliverables.

<u>Mid April to June 2013</u>



- 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

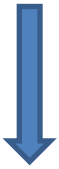
Milestone 1: Meeting of the CCAMLR Working Group on Ecosystem Monitoring and Management (WG-EMM, 1-10 July 2013, Bremerhaven)

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



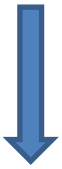
- Implementation of the results developed from the WG-EMM meeting
- Continuation of literature research and data inventory
- Organisation of a national workshop for the establishment of a marine CCAMLR-MPA in the Weddell Sea

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
- First data analyses
- Preparation of a preliminary report about the data compilation and analyses

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

Deliverable 6
Submission of a preliminary report on the data compilation and analyses to establish a Weddell Sea MPA and its presentation at the meeting of SC-CAMLR (incl. perspective of the work scheduled for 2014)

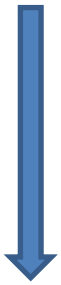
November to March/April 2014

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

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

Deliverable 7
Discussion of the work done by the AWI to establish a Weddell Sea MPA with experts of other CCAMLR member states

April to July 2014

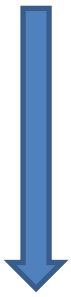


- Implementation of the results of the international workshop (incl. short report about the results of the workshop)
- Preparation of a report about preliminary results regarding the establishment of a Weddell Sea MPA
- Generation of first text modules regarding the conservation measures and the corresponding 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 statistical analyses and the compilation of the conservation measures for the Weddell Sea MPA

July to October 2014



- Implementation of the results of the WG-EMM meeting
- Preliminary proposal for marine spatial protection in the Weddell Sea for national consultation and coordination with responsible federal authorities (BfN, UBA)
- Revision and completion of the scientific work proposal
- Further development of text modules in respect of a conservation measure including a research and monitoring plan according to CCAMLR
- Establishment of 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 scientific work to account for a marine CCAMLR MPA in the Weddell Sea

Deliverable 10
Based on the working paper, presentation of a CCAMLR conservation measure 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

	Spatial and temporal resolution			
Parameter	**Spatial resolution**	**Period**	**Temporal resolution**	**Source**
Sea ice concentration (%)	6.25 km x 6.25 km	2002 - 2011	daily	Main publications: Kaleschke et al. (2001), Spreen et al. (2008) http://www.icdc.zmaw.de/seaiceconcentration_asi_amsre.html
Sea surface temperature (°C)	1/8° x 1/8°	1993 - 2013	daily	Barron & Kara (2006) http://www7320.nrlssc.navy.mil/modas/
Salinity (PSS)	1° x 1°		seasonal	http://www.nodc.noaa.gov/OC5/WOA05/pr_woa05.html
Dissolved oxygen (ml l^{-1}), inorganic nutrients (µM)	1° x 1°		seasonal	http://www.nodc.noaa.gov/OC5/WOA05/pr_woa05.html
Sea surface height (cm)	1/3° x 1/3°	1992 - 2011	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/
Bathymetry (m)	500 x 500 m	not applicable	not applicable	Arndt et al. (2013) www.ibcso.org
Clay mineral	approx. 90 samples	1984 - 1992	annual	Petschick et al. (1996) http://doi.pangaea.de/10.1594/PANGAEA.55955
Sea floor temperature (°C)	1° x 1°		seasonal	http://www.nodc.noaa.gov/OC5/WOA05/pr_woa05.html

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

	Spatial and temporal resolution			
Parameter	**Spatial resolution**	**Period**	**Temporal resolution**	**Source**
Krill abundance (mean no. krill/m²)	net hauls in northern and south-eastern Weddell Sea	1926 - 1939, 1976 - 2004	Snapshots in several years	Contact persons: Angus Atkinson, Evgeny Pakhomov, Volker Siegel http://www.iced.ac.uk/science/krillbase.htm
Macrobenthic communities (descriptive)	approx. 90 data sets	1956-2010	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
Macrobenthic communities (quantitative)	36 stations in total	1988 -1989	annual	Gerdes et al. (1992)
Polychaete abundance	4 to 13 stations/year	2000 - 2002	bi-annual	Hilbig (2004); Montiel et al. (2005)
Echinoderm abundance	34 Agassiz trawls	1983-1984	annual	Piepenburg et al. 1997
Demersal fish abundance and biomass	>300 hauls	1983-2011	time interval: 1-5 years	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
Cetacean sightings	10 *Polarstern* cruises	2005 - 2011	annual	Burkhardt (2009 a-j, 2011, 2012) http://www.pangaea.de/search?count=10&minlat=&minlon=&maxlat=&maxlon=&mindate=&maxdate=&env=All&q=elke+burkhardt+
Pinniped sightings	5 flight campaigns	1996-2001	annual	Ackley et al. (2006), Plötz et al. (2011 a-e) http://www.pangaea.de/search?count=10&minlat=&minlon=&maxlat=&maxlon=&mindate=&maxdate=&env=All&q=emage

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Figures

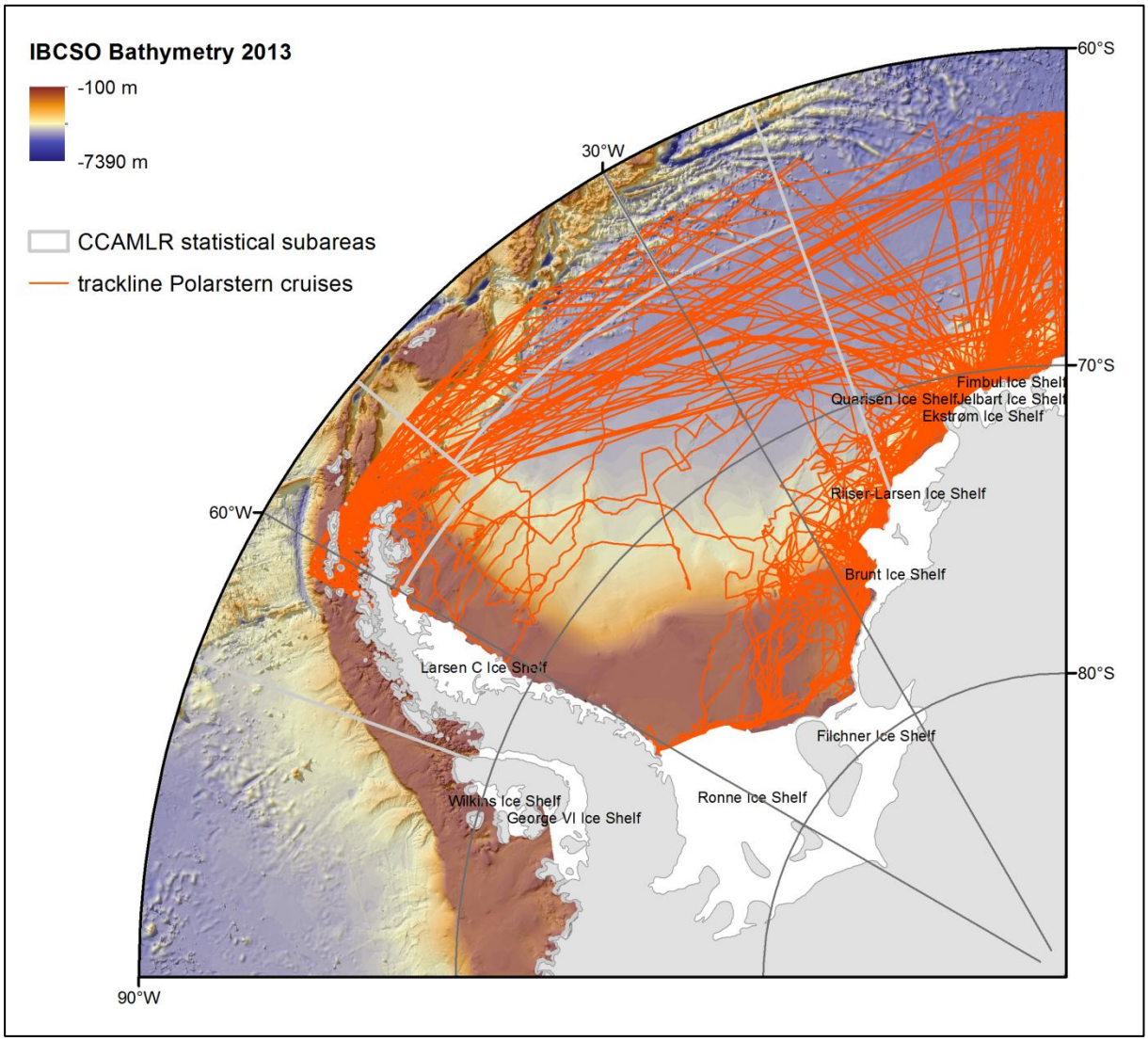

Figure 1: Tracklines of *Polarstern* cruises from 1982 to 2012. The GIS shape files of the CCAMLR statistical subareas are available at the homepage of CCAMLR (http://www.ccamlr.org/en/data/gis-shape-files-and-data-layers). The bathymetric chart of the Southern Ocean (IBCSO) is published by Arndt et al. (2013). The ice shelves are labelled and shown in white.

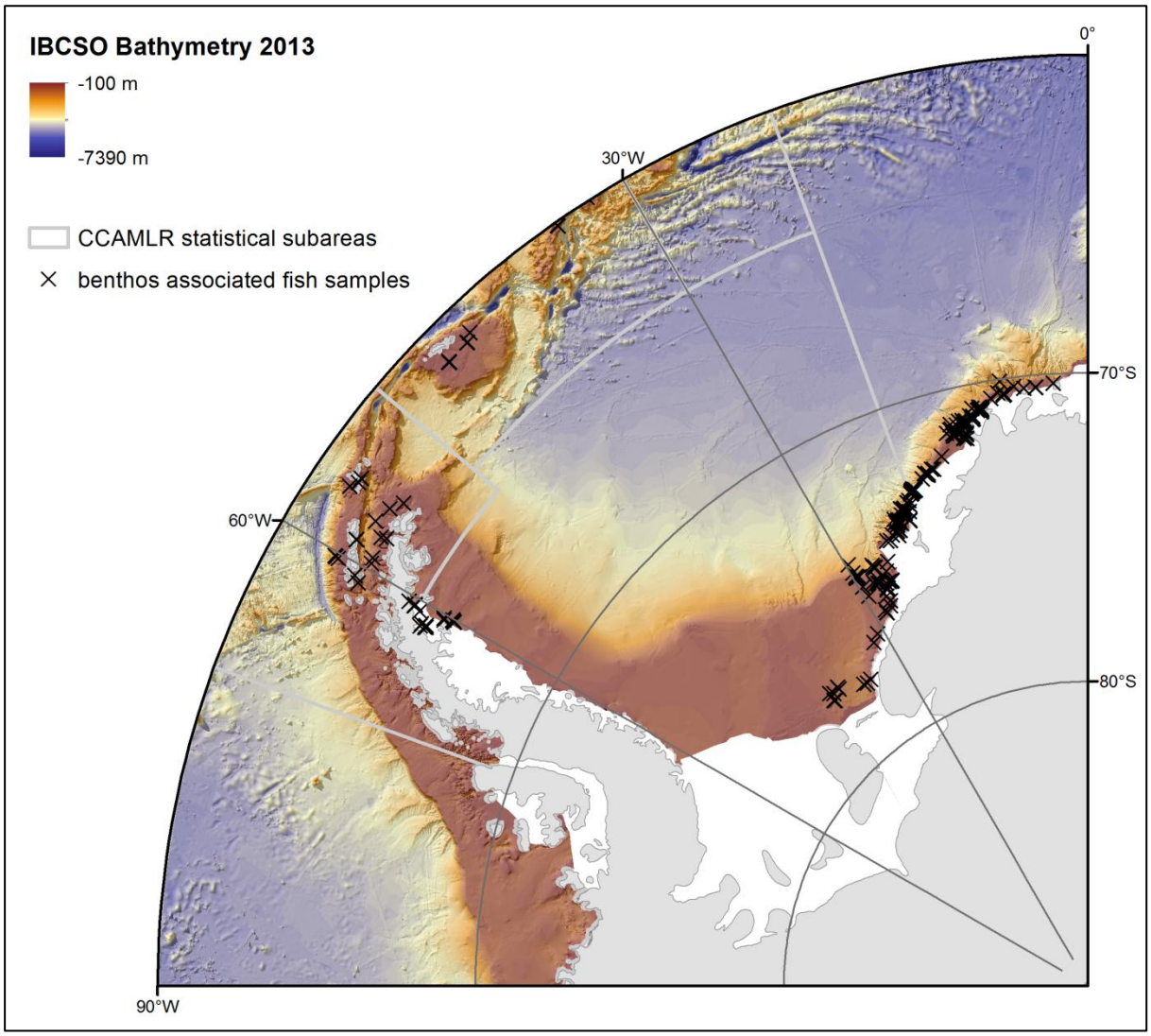

Figure 2: Benthos associated fish fauna sampled between 1983 and 2011 during various *Polarstern* cruises (see Drescher et al. (2012), Ekau et al. (2012 a, b), Hureau et al. (2012), Kock et al. (2012), Wöhrmann et al. (2012) and unpublished data hold by R. Knust, AWI). Further legend as in Fig. 1.

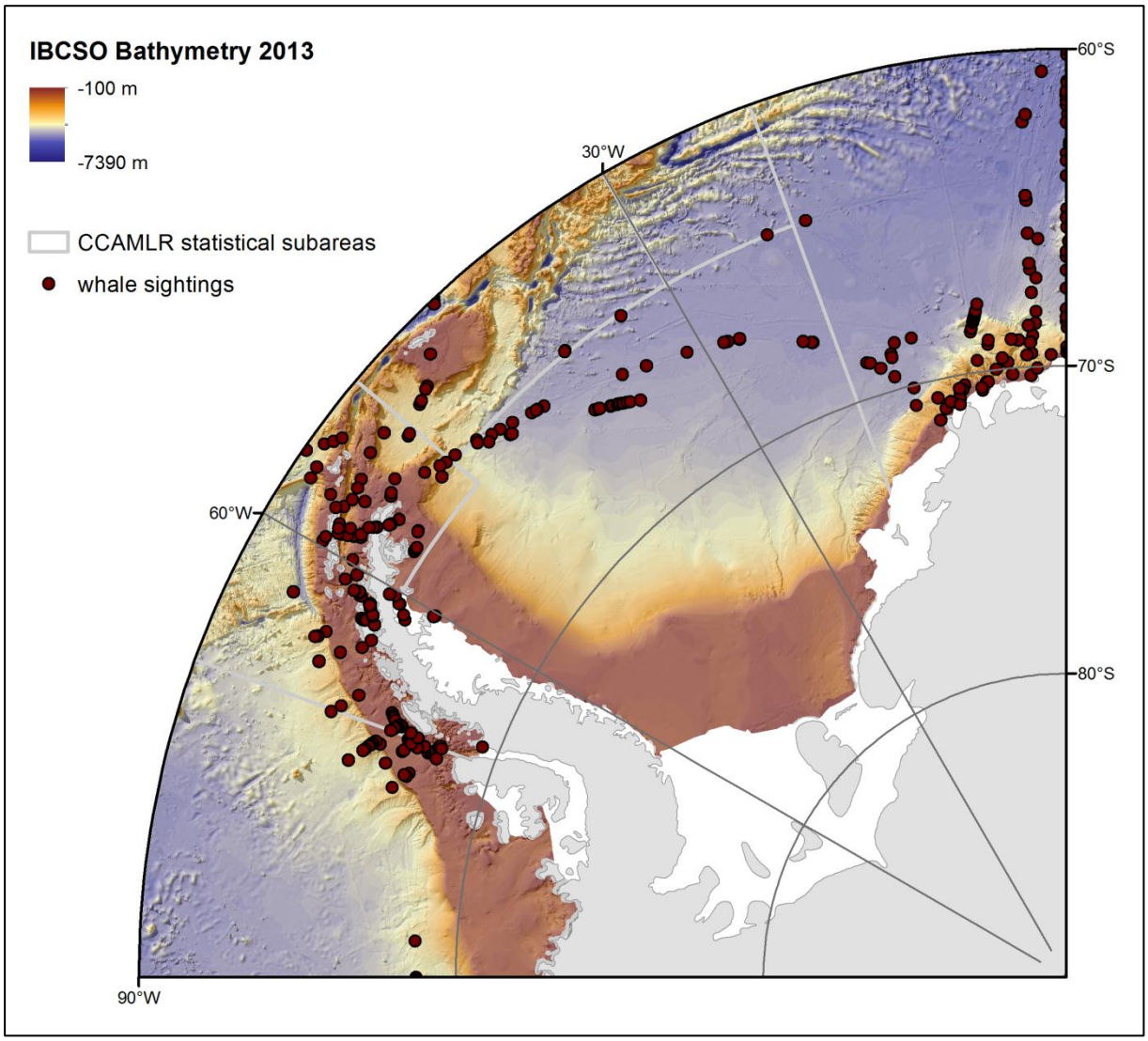

Figure 3: Whale sightings at annual *Polarstern* cruises from 2005 to 2011 (see Burkhardt 2009 a-j, 2011, 2012). Further legend as in Fig. 1.