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# Copepod species abundance from the Southern Ocean and other regions (1980 - 2005) – a legacy

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**Abstract.** Copepods are often the predominant taxa in marine zooplankton and play an important role in the food web as intermediators between primary producers, the microbial loop and higher trophic levels. Due to their short life cycles and their rapid response to changing environments they are good indicators for ecosystem health and status. Investigating the effects of environmental change on planktonic copepods and thus the pelagic ecosystem requires data on species abundance and distribution. Here, we present 33 data sets with abundance and occurrence of planktonic copepods from 20 expeditions to the Southern Ocean (Weddell Sea, Scotia Sea, Amundsen Sea, Bellingshausen Sea, Antarctic Peninsula), one expedition to the Magellan region, one latitudinal transect in the Eastern Atlantic Ocean, one expedition to the Great Meteor Bank and one expedition to the northern Red Sea and Gulf of Aqaba. In this data compilation a total of 349 stations between 1985 and 2005 were archived. These data sets are now freely available at PANGAEA via the persistent identifier https://doi.org/10.1594/PANGAEA.884619. During most expeditions depth-stratified samples were taken with a Hydrobios multinet with 5 or 9 nets. On few occasions a Nansen or Bongo net was deployed. The deepest sample reached down to 2880 meter. As metadata sampling date and date/time, latitude, longitude, bottom depth, sampling depth interval, volume of filtered water and information of the net type and mesh size were recorded. Abundance and distribution data for 284 calanoid copepod species and 28 taxa of other copepod orders are provided. The taxonomic concept was consistent throughout the data sets. The density of calanoid copepod species was separately counted for females, males and copepodites. For selected species also the individual copepodite stages were counted.

## 1 Introduction

Copepoda (Crustacea) are probably the most successful metazoan group known, being more abundant than insects, although far less diverse (Humes, 1994; Schminke, 2007). They occur in all aquatic ecosystems, from freshwater to marine and hypersaline environments, and from polar waters to hot springs (Huys and Boxshall, 1991). Although copepods are evolutionary of benthic origin (Bradford-Grieve, 2002), they have also successfully colonised the pelagic marine environment where they can account for 80 – 90% of the total zooplankton abundance (Longhurst, 1985). In the Southern Ocean, copepods are next to Antarctic krill and salps the most important zooplankton organisms, both in abundance and biomass (e.g. Pakhomov et al., 2000; Shreeve et al., 2005; Smetacek and Nicol, 2005; Ward et al., 2014; Tarling et al., 2017). In the Southern Ocean, copepods are also the most diverse zooplankton taxon accounting for more than 300 species (Kouwenberg et al., 2015). However, only a few species dominate the Antarctic copepod community: the large calanoids *Calanoides acutus*, *Calanus propinquus*, *Metridia gerlachei*, *Paraeuchaeta antarctica*, the small calanoids *Microcalanus pygmaeus*, *Ctenocalanus citer* and the cyclopoids *Oithona* spp. and species of the family Oncaeidae (e.g. Hopkins et al., 1985; Atkinson, 1998; Schnack-Schiel, 2001; Tarling et al., 2017). Together these taxa can comprise up to 95% of the total abundance and up to 80% of the total biomass of copepods (Schnack-Schiel et al., 1998). However, the smaller calanoid species alone can account for up to 80% of the abundance of calanoid copepods (Schnack-Schiel, 2001).

Numerous studies on zooplankton have been conducted in the past in the Atlantic sector of the Southern Ocean (e.g. Boysen-Ennen and Piatkowski, 1988; Hopkins and Torres, 1988; Boysen-Ennen et al., 1991; Pakhomov et al., 2000; Dubischar et al., 2002; Ward et al., 2014; Tarling et al., 2017). A major zooplankton monitoring programme in the Southern Ocean is the Continuous Plankton Recorder survey (SO-CPR), providing a large-scale coverage of surface Antarctic zooplankton species distribution abundances over the last 25 years (Hosie et al., 2003; McLeod et al., 2010). The CPR is a plankton sampler that can be towed in approximately 10 m depth by ships of opportunity, thus allowing to rapidly sample vast regions of the oceans (Reid et al., 2003). In the device zooplankton organisms are retained by a mesh and preserved in formalin. A recent review summarises the present knowledge on abundance and distribution of Southern Ocean zooplankton (Atkinson et al., 2013). In the Weddell Sea however, occurrence data of copepods and other zooplankton species are scarce. We aim to fill this gap with the here presented data sets.

In recent years there is ample evidence that marine ecosystems are greatly affected by climate change and ocean acidification (e.g. Beaugrand et al., 2002; Edwards and Richardson, 2004; Rivero-Calle et al., 2015; Smith et al., 2016). In the Southern Ocean, the pelagic ecosystem is likely to be severely affected by increasing water temperatures and the resulting reduction of sea ice coverage in the Southern Ocean (Zwally, 1994; Smetacek and Nicol, 2005). It has already been observed over decades that the biomass of Antarctic krill decreases (Atkinson et al., 2004), but little is known about the environmental effects on copepods. Within the pelagic ecosystem zooplankton communities and thus copepods are good indicators for ecosystem health and status due to their short life cycles und their rapid response to changing environments (Reid and Edwards, 2001; Chust et al., 2017). Furthermore, they are generally not commercially exploited and thus are likely to reflect impacts of environmental changes more objectively. To better understand the effects of environmental change on planktonic copepods e.g. via biodiversity analyses and ecological niche modelling, data on species occurrence, abundance and distribution are essential. Often modelling studies however are limited by the scarcity of available plankton data (Chust et al., 2017). Thus, freely available data sets on abundance and presence/absence of copepod species are of great importance for future studies on environmental changes in the pelagic realm. The here presented data sets on copepod species and life stages (female, male, copepodites) occurrences and abundance from the Southern Ocean, the eastern Atlantic Ocean, the Magellan region and the Red Sea provide a unique resource for biodiversity and modelling studies.

## 2 Methods

### 2.1 Sampling locations

The presented data sets were collected during 24 research cruises with several research vessels from 1980 to 2005 (Table 1). Most of the data sets (28 datasets from 20 cruises) are based on samples from the Southern Ocean (Fig. 1), collected onboard R/V Polarstern (25 data sets from 16 cruises), R/V Meteor (1 data set), R/V John Biscoe (1 data set) and R/V Polarsirkel (1 data set). Southern Ocean sampling locations were restricted to the Weddell Sea, the Scotia Sea, the Antarctic Peninsula, the Bellingshausen Sea and the Amundsen Sea (Fig. 1).

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Additionally, four data sets were collected in other regions (Table 1). In 1994 net samples were collected onboard R/V Victor Hensen in the Magellan region. Two data sets are based on research cruises with R/V Meteor, to the Great Meteor Bank in the North Atlantic (1998) and to the northern Red Sea and the Gulf of Aqaba (1999). In 2002, plankton net samples were taken during a research cruise with R/V Polarstern along a transect in the eastern tropical Atlantic Ocean (Table 1).

Maximum sampling depth varied greatly among stations due to different bottom depths (Table 1). However, during eleven cruises to the Southern Ocean the maximum depth was restricted to 1000 m, even at locations with greater bottom depths. In the eastern Atlantic Ocean (PS63) sampling depth was restricted to the upper 300 m.

## 2.2 Sampling gear

Plankton nets are designed to capture zooplankton organisms. Three types of nets were deployed: Bongo nets, single opening-closing Nansen nets and multiple opening-closing nets.

### 2.2.1 Nansen net

During the expeditions PS04, DAE1979/80, and JB03 net sampling was carried out with a Nansen net (Table 1). The Nansen net is an opening-closing plankton net for vertical tows (Nansen, 1915; Currie and Foxton, 1956). Thus, it is possible to sample discrete depth intervals to study the vertical distribution of zooplankton. The Nansen net has an opening of 70 cm diameter and is usually 3 m long. Two different mesh sizes were used: 200 µm for the cruises PS04 and JB03, and 250 µm for DAE1979/80. To conduct discrete depth intervals the net is lowered to maximum depth and then hauled to a certain depth and closed via a drop weight. Then the net is hauled to the surface and the sample is removed. This process of sampling depth intervals can be repeated until the surface layer is reached. The volume of filtered water was calculated using the mouth area and depth interval due to the lack of a flowmeter.

### 2.2.2 Multinet systems

Most presented data sets are based on plankton samples taken with a multinet system (MN) from Hydrobios (Table 1) a revised version (Weikert and John, 1981) of the net described by Be et al. (1959). The multinet is equipped with five (midi) or nine (maxi) plankton nets, with a mouth area of 0.25 and 0.5 $m^2$, respectively. These nets can be opened and closed at depth on demand from the ship via a conductor cable. Thus, they allow sampling of discrete water layers. The net system was hauled with a general speed of 0.5 m/s. Mesh sizes varied between the data sets from 55 to 300 µm (Table 1). In the Southern Ocean the mesh sizes were consistent within regions: In the Weddell Sea 100 µm mesh size was used with a few exceptions during PS06. In the Scotia Sea and near the Antarctic Peninsula a mesh size of 200 µm was employed. In the Bellingshausen Sea and the Amundsen Sea multinet hauls with 55 µm mesh sizes were carried out. In other regions mesh sizes of 100 µm (PS63, M42/3), 150 µm (M44/2) and 300 µm (VH1094) were used. The MN maxi was only deployed during the research cruise M44/2 in the northern Red Sea.

Generally, the volume of filtered water was calculated from the surface area of the net opening (midi: 0.25 $m^2$, maxi: 0.5 $m^2$) and the sampling depth interval. For the data sets from PS63, PS65, PS67 and M44/2 a mechanical digital flowmeter was used to record the filtering efficiency and to calculate the abundances (see Skjoldal et al., 2013, p. 4). The flowmeter is situated in the mouth area of the net and measures the water flow, providing more accurate volume values of the filtering efficiency.

### 2.2.3 Bongo net

During one research cruise (PS06) 61 additional samples were taken with the Bongo net (McGowan and Brown, 1966) to study selected calanoid copepod species. The Bongo net contains two nets that are lowered simultaneously for vertical plankton tows. The opening diameter is 60 cm, and the length of the nets is 2.5 m with a mesh size of 300 µm. The volume of filtering water was recorded with a flowmeter and used for the calculation of abundance.

### 2.2.4 Effects of variable net types and mesh sizes

Quantitative sampling of copepods and zooplankton is challenging. Major sources of error are patchiness, avoidance of nets and escape through the mesh (Wiebe, 1971; Skjoldal et al., 2013). These errors are defined by mesh sizes and net types, in particular the mouth area. The effect of patchiness cannot be investigated here due to the lack of replicates.

To our knowledge the sampling efficiency of the Nansen net and the MN midi have not been compared directly (Wiebe and Benfield, 2003; Skjoldal et al., 2013). However, it has been stated that the catches with Nansen net are considerably lower than with the WP-2 net (Hernroth, 1987), although the WP-2 net is considered as a modified Nansen net with a cylindrical front section of 95 cm and a smaller mouth area (57 cm$^2$, Skjoldal et al., 2013). The WP-2 net with 200 µm mesh size however, is in its sampling efficiency, measured as total zooplankton biomass, comparable to the MN midi with 200 µm mesh size (Skjoldal et al., 2013). Thus, it has to be taken into account during future analysis that the abundance values from the Nansen net are not directly comparable to those from the MN midi.

The mesh size has a different effect on the zooplankton catch. It is well known that small sized copepod species (< 1 mm) and thus in particular non-calanoid species (e.g. Oithonidae, Oncaeidae) and juvenile stages also from calanoid copepods (e.g. *Microcalanus*, *Calocalanus*, *Disco*) pass through coarse mesh sizes (≥ 200 µm), while they are retained in finer mesh sizes (Hopcroft et al., 2001; Paffenhöfer and Mazzocchi, 2003). Thus, abundances of smaller specimens, and the species and life stage composition may vary considerably, when comparing samples from the Bellingshausen and Amundsen Seas (55 µm mesh size), around the Antarctic Peninsula (200 µm) and the Weddell Sea (100 µm).

## 2.3 Sample processing and analysis

All samples were preserved immediately after sampling in a 4% formaldehyde-seawater solution. Samples were stored at room temperature until they were sorted in the laboratory. The formaldehyde solution was removed, the samples were rinsed and copepods were identified and counted under a stereomicroscope from a fraction of the sample. Abundant species were sorted from one fourth or less of the sample while the entire sample was screened for rare species. Samples were divided with a Motoda plankton splitter (Motoda, 1959; Van Guelpen et al., 1982). Abundance was calculated using the surface area of the net opening and the sampling depth interval or the recordings of the flowmeter. Samples for re-analysis are only available for the cruises M42/3 and M44/2.

Except for five data sets (Cornils and Schnack-Schiel, 2017; Cornils, Metz and Schnack-Schiel, 2017a, b, c, d) all data sets were sorted and identified by Elke Mizdalski. Thus, the taxonomic concept has been used consistently throughout the data sets. A wide variety of identification keys and species descriptions have been used to identify the copepods, which cannot be all named here. References of first descriptions and drawings of all species can be found at Razouls et al. (2005 – 1018). Calanoid copepods were identified to the lowest taxa possible, in general

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genus or species. Furthermore, of each identified taxon females, males and copepodite (juvenile) stages were separated. Cyclopoid copepods were identified to species level in four data sets (Cornils et al., 2017a, b, c, d). Previously published data sets were revised to ensure consistency of species names throughout the data set collection (Michels et al., 2012; Schnack-Schiel et al., 2007; Schnack-Schiel, 2010; Schnack-Schiel et al., 2010). In the present compilation we have used the currently acknowledged copepod taxonomy as published in WoRMS (World register of Marine Species (WoRMS Editorial Board, 2018)) and at Razouls et al. (2005 – 2018). Species names have been linked to the WoRMS database, so future changes in taxonomy will be tracked. In the parameter comments the “old” names are archived that were used initially when the specimens were identified. All used species names can be found as “Copepod species list” under “Further details” at https://doi.org/10.1594/PANGAEA.884619 or at http://hdl.handle.net/10013/epic.65463ec2-e309-4d57-8fe3-0cebdd7dce70. We provided also the unique identifier (Aphia ID) from WoRMS and notes on the distribution of each species.

When specimens could not be identified due to the lack of identification material, uncertainties in the taxonomy or missing parts they were summarized under the genus name (e.g. *Disco* spp., *Diaixis* spp., *Paracalanus* spp., *Microcalanus* spp.) or family name (e.g. Aetideidae copepodites). In most data sets few individuals could not be assigned to any family or genus. These are summarized as Calanoida female, Calanoida male and Calanoida copepodites.

## 3 Data sets

### 3.1 Metadata

Each data set has its own persistent identifier. The metadata are consistent among all data sets, thus ensuring the comparability of the data sets and document their quality.

The following metadata can be found in each data set:

- “Related to:” includes the corresponding cruise report, related data sets and scientific articles that might have used part of the data previously.
- “Other version:” In a few cases we have revised a previously published version of the data to ensure consistent species names throughout all data sets (for more information see section 2.3).
- “Projects:” shows internal projects or those with external funding. In the present case all data sets are related to internal projects of the AWI (Alfred Wegener Institut Helmholtz Centre for Polar and Marine Research) research program.
- “Coverage:” gives the min/max values of the georeferences (latitude/longitude) of all stations
- “Event(s):” comprises a list of station labels, latitude/longitude of the position, date/time of start and end of station, elevation giving the bottom depth, campaign contains the cruise label (including optional labels), basis is the name of the research vessel. Device contains the net type, which was deployed and the comment may show further details of the station operation.
- “Parameter(s):” list of parameters used in the data set with columns containing the full and short name, the unit, the PI (which in this data compilation is always Sigrid Schnack-Schiel, except for one data set (https://doi.org/10.1594/PANGAEA.880239), and the method with a comment. The parameter “Date/Time of event” is not always identical with “Date/Time” given in the event. This is the case when

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the "Device" in the event is set to "Multiple Investigations" and thus the starting time of all investigations at this event is given. "Date/Time of event" however, is the time when the plankton net haul started.

"Elevation" provides information on the bottom depth of the plankton station, if available.

Three parameters describe the sampling depths interval. "Depth, water" is the mean depth of the sampled depth interval. "Depth top" and "Depth bot" describe the upper and lower limit of the sampling depth interval, respectively.

"Volume" is the amount of water that was filtered during each net tow, either calculated using the mouth area of the net and depth interval or with a flowmeter (section 2.2.2). "Comment" gives the detailed information on the net type, the net number and mesh size. In the following list of parameters are the copepod taxa for which abundance data were recorded. Calanoid taxa are separated in female, male and copepodites. Species names are consistent throughout all data sets, which ensures the comparability of the data sets (see section 2.3). The "short names" of each taxon consist of the first letter of the generic name and the name of the species. In nine cases this results in identical short names (*Pleuromamma antarctica*, *Paraeuchaeta antarctica* = *P. antarctica*; *Temoropia minor*, *Temorites minor* = *T. minor*; *Chiridius gracilis*, *Centropages gracilis* = *C. gracilis*; *Clausocalanus minor*, *Calanopia minor* = *C. minor*; *Heterostylites longicornis*, *Haloptilus longicornis* = *H. longicornis*; *Scolecithricella abyssalis*, *Spinocalanus abyssalis* = *S. abyssalis*; *Scaphocalanus magnus*, *Spinocalanus magnus* = *S. magnus*). Thus, we advise to use the full scientific names of these species in further analyses.

## 3.2 Temporal station distribution

While samples of the Magellan region (November 1994), the Gulf of Aqaba and the northern Red Sea (February/March 1999), Great Meteor Bank (September 1998) and Eastern Atlantic Ocean (November 2002) were restricted to one year and one season, the Southern Ocean was sampled multiple times (Table 1). Samples in the Southern Ocean were taken from 1980 to 2005 (Table 1, Fig. 2 a, b). The highest number of zooplankton samples was taken in the 1980s (Fig. 2 b). In the 1980s the sampling effort was concentrated to the Antarctic Peninsula, the Scotia Sea and the Weddell Sea (Fig. 2 a). Samples were taken in multiple years. In the 1990s until 2005 most samples were taken in the Bellingshausen and Amundsen Sea, with fewer samples in the western and eastern Weddell Sea. Two transects were sampled across the Weddell Sea in the 1990s in austral summer and autumn (Fig. 2 b). In general, most stations were sampled during summer (December to February), followed by autumn (March to May) and spring (September to November), while winter samples are only available from 1986 in the eastern Weddell Sea (Fig. 2 b, c). Summer and autumn samples are widely distributed from the Amundsen Sea to the eastern Weddell Sea (Fig. 2 b), while spring and autumn samples are mostly present from the Scotia Sea and Eastern Weddell Sea. Most samples were taken in January and February (Fig. 2 d). Samples are scattered throughout the entire day (Fig. 3.).

It should be taken into account that several copepod species in regions with pronounced seasonality of primary production, e.g. in high latitudes or upwelling regions (Conover, 1988; Schnack-Schiel, 2001) undergo seasonal vertical migration (e.g. *Rhincalanus*, *Calanoides*). They reside in deep water layers during period of food scarcity and rise to the surface layers when the phytoplankton blooms start. Furthermore, other species undergo pronounced diel vertical migrations (e.g. *Pleuromamma*) from mesopelagic layers during daytime to avoid predators to epipelagic waters at night to feed (Longhurst and Harrison 1989). Thus, to avoid biases in the comparison of the

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vertical distribution of copepod species season and daytime should be considered during further analysis of the data sets.

## 3.3 Copepoda

In total, specimens from six copepod orders were recorded in the compiled data sets.
However, in 29 data sets only calanoid copepods were identified on species level. Specimens of other copepod orders were comprised in families or orders.

### 3.3.1 Calanoida

In total 284 calanoid species could be separated in 29 data sets (see "Copepod species list" at https://doi.pangaea.de/10.1594/PANGAEA.884619). These species are representatives of 28 families and 91 genera (Table 2). In the Southern Ocean abundance and distribution data for 96 calanoid species were archived. In the eastern Atlantic Ocean 125 and around the Great Meteor Bank 135 calanoid copepod species could be identified (Table 2). These numbers already indicate the well-known fact that species richness in the tropical and subtropical open oceans is much higher than in the polar Southern Ocean (e.g. Rutherford et al., 1999; Tittensor et al., 2010). Compared to these the number of calanoid species (60) in the subtropical northern Red Sea is low, which is expected due to the shallow sills at the entrance of the Red Sea and the high salinity (see Cornils et al. 2005). The lowest number of calanoid species (35) was found in the Magellan Region. Calanoid copepod families with the highest number of species were Aetideidae (33), Augaptilidae (27) and Scolecitrichidae (40; Table 2). All calanoid species were counted separately as females, males and copepodites. For selected species also the five copepodite stages were counted individually (Table 3). Also, *Rhincalanus gigas* nauplii were counted during four expeditions (PS09, PS21, PS23, PS29).
It is notable that none of the calanoid species were found in all five regions (see "Copepod species list" "Copepod species list" at https://doi.pangaea.de/10.1594/PANGAEA.884619). In contrast, many species were only recorded in one region: 60 species were found only in the Southern Ocean, while 43 and 38 were found only in the data sets from the Great Meteor Bank and the transect in the eastern Atlantic Ocean, respectively. 24 species were found only in the Red Sea and six were identified only from samples in the Magellan region. Of the calanoid families eleven were distributed at all five regions (Table 2).
As an example for the geographical and vertical distribution of the copepods three abundant genera were chosen (Fig. 4). While *Microcalanus* spp. (not separated in species due to uncertainties in the taxonomy) and *Spinocalanus* spp. (9 species; Table 2) are abundant down to 1000 m, the two species of *Ctenocalanus* (2 species, Fig. 4) and *Stephos* occur mainly in the epipelagic layer of the ocean. This is in accordance with their known vertical distribution (Schnack-Schiel and Mizdalski, 1994, Bode et al., 2018). Comparing the abundance of *Spinocalanus* and *Microcalanus* from all regions suggests that the abundance of these taxa is far greater in the Southern Ocean than in the warmer regions of the ocean. This picture however, has to be treated with caution, since the tropical Atlantic was only sampled in the upper 300 m of the water column and was thus too shallow for the meso- and bathypelagic genera (Bode et al., 2018).
In the case of *Ctenocalanus* and *Stephos* our data sets reveal that closely related species within a genus may have contrasting distribution patterns. *Stephos longipes* and *Ctenocalanus citer* are restricted to colder and polar waters of the southern hemisphere, while *Ctenocalanus vanus* occurs in both the Red Sea and the warm Atlantic Ocean. *Stephos maculosus* occurs only in the Red Sea (see arrow in Fig. 4). Furthermore, the distribution patterns reveal

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that of the four genera only *C. citer* has a higher abundance in the samples from the Bellingshausen and Amundsen Seas, and around the Antarctic Peninsula, while *S. longipes*, *Microcalanus* spp. and *Spinocalanus* spp. all have higher abundances in the Eastern Weddell Sea. This may be due to the lower water depth at the Peninsula since *Microcalanus* and *Spinocalanus* are considered as mesopelagic to bathypelagic. Thus, they are often not found at shallow stations (< 300 m depth). In case of the sea ice-associated *S. longipes*, low sea-ice conditions and offshore stations may have caused the restricted distribution. *S. longipes* occurred mainly in the upper water layers, but was also recorded with low abundances in deeper layers (Fig. 4). This pattern may be due to its life cycle, shifting seasonally from a sea-ice associated to a bentho-pelagic life cycle (Schnack-Schiel et al., 1995).

### 3.3.2 Other Copepoda

In total, 28 non-calanoid taxa were recorded. Four data sets provide only abundance and distribution data for non-calanoid copepod orders (PS06, PS10, PS29, PS35; Table 1), in particular on species of the order Cyclopoida from the families Oithonidae (2 species) and Oncaeidae (6 species; Table 2). They were separated in female, male, copepodite stages 1, 2, 3, 4, and 5. During VH1094 also *Oithona* species were identified (Table 2). In all other data sets species of these two families were not separated. In all regions representatives of the family Lubbockiidae were recorded. In the subtropical and tropical samples of PS63, M44/2 and M42/3 also abundances of species of the families Corycaeidae and Sapphirinidae, and of the genus *Pachos* were recorded. Except for PS65, species of the order Harpacticoida were not separated. In the latter five species were identified, mainly sea-ice associated harpacticoids (Table 2; Schnack-Schiel et al., 1998). Also, specimens of the orders Monstrilloida, Mormonillida and Siphonostomatoida were counted.

In most data sets, copepod nauplii are also recorded as one parameter. However, due to the small size of nauplii they were not sampled quantitatively and should be discarded in further analysis.

### 3.4 Further remarks on the usage of the data compilation

Generally, the cruise reports have been linked to each data set. The cruise reports provide valuable information on the itinerary, zooplankton sampling procedures and on other scientific activities on-board that could be useful for the data analysis (e.g. CTD data). We have also added scientific article that are related to individual data sets. Abundance data of selected species and data sets have been published previously in scientific articles. These articles are linked to the respective data sets (under “Related to”).

To use the data they can be downloaded individually as tab-delimited text files or altogether as a .zip file to allow an import to other software e.g. in R (R core team, 2018) or Ocean Data View (Schlitzer, 2015) for further analysis. Due to the consistent taxonomic nomenclature the individual files can be concatenated easily. It should be kept in mind however, that not all data sets are directly comparable due to difference in net type and mesh sizes (see section 2.2.4). In these cases we recommend to use only presences and absences of the species.

To evaluate the vertical and spatial distribution of marine plankton hydrographic information such as temperature and salinity profiles are essential. The relevant publications are available at https://doi.org/10.1594/PANGAEA.884619, see “Further details”. Recently, a summary of the physical oceanography of R/V Polarstern has been published (Driemel et al., 2017) with CTD data archived in PANGAEA as well (Rohardt et al., 2016), except for the cruises PS04 (ANT-II/2), PS14 (ANT-VII/2), PS21 (ANT-X/3), PS63 (ANT-XX/1) and PS65 (ANT-XXII/2) (see Table 1). For these five cruises information on temperature and salinity profiles exist only for PS63 (Schnack-Schiel et al., 2010) and for PS65 the CTD profiles can be downloaded (https://doi.org/10.1594/PANGAEA.742627; Absy et al., 2008). For M11/4 a CTD data set is also available (https://doi.org/10.1594/PANGAEA.742745; Stein, 2010). To connect the CTD data with the corresponding plankton net haul the metadata "Event" and "Date/time" can be used. Furthermore, cruise track and station information are available in the cruise reports as well as on the station tracks for each cruise (https://pangaea.de/expeditions/). For the other two R/V Meteor cruises hydrographic information is available in scientific articles (M42/3: Beckmann and Mohn, 2002; Mohn and Beckmann, 2002; M44/2: Cornils et al., 2005; Plähn et al., 2002). Metadata information of the cruise JB03 can be downloaded from: https://www.bodc.ac.uk/resources/inventories/cruise_inventory/report/5916/. To date, no hydrographic information is publicly available for the cruises DAE79/80 and VH1094.

Additionally, we have archived abundance of other zooplankton organisms from the cruises ANT-X/3, ANT-XVIII/5b, M42/3 and M44/2. These can be downloaded at https://doi.org/10.1594/PANGAEA.883833, https://doi.org/10.1594/PANGAEA.884581, https://doi.org/10.1594/PANGAEA.883771 and https://doi.org/10.1594/PANGAEA.883779.

## 4 Data availability

In total 33 data sets with 349 stations were archived in the PANGAEA® (Data Publisher for Earth & Environmental Science, www.pangaea.de) database. The persistent identifier https://doi.org/10.1594/PANGAEA.884619 links to the splash page of the data compilation. Metadata include DOI to cruise reports and related physical oceanography. Data are provided in consistent format as tab-delimited ASCII-files and are in Open Access under a CC-by license (Creative Commons Attribution 3.0 Unported).

## 5 Concluding remarks

Pelagic marine ecosystems like the Southern Ocean are threatened by increasing water temperatures and the reduction of sea-ice coverage due to climate change. These environmental changes are expected to cause also shifts in the community structure of pelagic organisms. Within the pelagic food web copepods have a central role as intermediator between the microbial loop and higher trophic level. Due to their short life cycles and their high diversity copepods offer a unique opportunity to study effects of environmental variables on numerous taxa with different life cycle strategies. It is also known that their species composition and abundance often reflect environmental changes such as temperature, seasonal variability or stratification (Beaugrand et al., 2002). To understand the complexity of ecological niches and ecosystem functioning, but also to investigate the effects of environmental changes a detailed knowledge of species diversity, distribution and abundance is essential. The present data compilation provides further information on spatial, vertical and temporal distribution of copepod species and may thus be used to obtain a better picture of species biogeographies. Many individual data sets can also be linked to corresponding CTD profiles (Table 1) and may thus be useful for modeling approaches such as species distribution or environmental niche modeling.

This data compilation represents the scientific legacy of Dr. Sigrid B. Schnack-Schiel (1946-2016), revealing her expertise and great interest in polar zooplankton ecology, but also exploring the zooplankton communities of tropical and subtropical regions.

**Competing interests**

The authors declare that they have no conflict of interest.

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**References**

Absy, J. M., Schröder, M., Muench, R. D. and Hellmer, H. H.: Physical oceanography from 120 CTD stations during POLARSTERN cruise ANT-XXII/2 (ISPOL), PANGAEA, doi:10.1594/PANGAEA.742627, 2008.

Atkinson, A.: Life cycle strategies of epipelagic copepods in the Southern Ocean, J. Mar. Syst., 15, 289–311, doi:10.1016/S0924-7963(97)00081-X, 1998.

Atkinson, A., Siegel, V., Pakhomov, E. and Rothery, P.: Long-term decline in krill stock and increase in salps within the Southern Ocean, Nature, 432, 100–103, doi:10.1038/nature02996, 2004.

Atkinson, A., Ward, P., Hunt, B., Pakhomov, E. A. and Hosie, G. W.: An overview of Southern Ocean zooplankton data: Abundance, biomass, feeding and functional relationships, CCAMLR Science, 19, 171–218, http://nora.nerc.ac.uk/id/eprint/502288, 2013.

Bé, A. W. B., Ewing, M. and Linton, L. W.: A quantitative multiple opening-and-closing plankton sampler for vertical towing, ICES J. Mar. Sci., 25(1), 36-46, doi:10.1093/icesjms/25.1.36, 1959.

Beaugrand, G., Reid, P. C., Ibanez, F. and Lindley, J. A.: Reorganization of North Atlantic marine copepod biodiversity and climate, Science, 296, 1692–1694, doi:10.1126/science.1071329, 2002.

Beckmann, A. and Mohn, C.: The upper ocean circulation at Great Meteor Seamount, Ocean Dyn., 52(4), 194–204, doi:10.1007/s10236-002-0018-3, 2002.

Bode, M., Hagen, W., Cornils, A., Kaiser, P. and Auel, H.: Copepod distribution and biodiversity patterns from the surface to the deep sea along a latitudinal transect in the eastern Atlantic Ocean (24N to 21S), Progr. Oceanogr., accepted, 2018

Boysen-Ennen, E. and Piatkowski, U.: Meso-and macrozooplankton communities in the Weddell Sea, Antarctica, Pol. Biol., 9(1), 17–35, doi:10.1007/BF00441761, 1988.

Boysen-Ennen, E., Hagen, W., Hubold, G. and Piatkowski, U.: Zooplankton biomass in the ice-covered Weddell Sea, Antarctica, Mar. Biol., 111, 227–235, doi:10.1007/BF01319704, 1991.

Bradford-Grieve, J. M.: Colonization of the pelagic realm by calanoid copepods. Hydrobiologia, 485(1-3), 223–244, doi:10.1023/A:1021373412738, 2002.

Chust, G., Vogt, M., Benedetti, F., Nakov, T., Villéger, S., Aubert, A., Vallina, S. M, Righetti, D., Not, F., Biard, T., Bittner, L., Benoiston, A.-S., Guidi, L., Villarino, E., Gaborit, C., Cornils, A., Buttay, L., Irisson, J.-O., Chiarelo, M., Vallim, A. L., Blanco-Bercial, L., Basconi, L. and Ayata, S.-D.: Mare Incognitum: A Glimpse into Future Plankton Diversity and Ecology Research, Front. Mar. Sci., 4, 68, doi:10.3389/fmars.2017.00068, 2017.

Conover, R. J.: Comparative life history in the genera *Calanus* and *Neocalanus* in high latitudes of the northern hemisphere, Hydrobiologia, 167(1), 127-142, doi:10.1007/BF00026299, 1988.

Cornils, A., Schnack-Schiel, S. B., Hagen, W., Dowidar, M., Stambler, N., Plähn, O. and Richter, C.: Spatial and temporal distribution of mesozooplankton in the Gulf of Aqaba and the northern Red Sea in February/March 1999, J. Plankton Res., 27(6), 505-518, doi:10.1093/plankt/fbi023, 2005.

Cornils, A., Metz, C. and Schnack-Schiel, S. B.: Abundance of planktonic Cyclopoida (Copepoda, Crustacea) during POLARSTERN cruise ANT-XI/3 (PS29), PANGAEA, doi:10.1594/PANGAEA.879718, 2017a.

Cornils, A., Metz, C. and Schnack-Schiel, S. B.: Abundance of selected planktonic Cyclopoida (Copepoda, Crustacea) during POLARSTERN cruise ANT-III/3 (PS06), PANGAEA, doi:10.1594/PANGAEA.879771, 2017b.

Cornils, A., Metz, C. and Schnack-Schiel, S. B.: Abundance of selected planktonic Cyclopoida (Copepoda, Crustacea) during POLARSTERN cruise ANT-V/3 (PS10), PANGAEA, doi:10.1594/PANGAEA.879772, 2017c.

Cornils, A., Metz, C. and Schnack-Schiel, S. B.: Abundance of selected planktonic Cyclopoida (Copepoda, Crustacea) during POLARSTERN cruise ANT-XII/4 (PS35), PANGAEA, doi:10.1594/PANGAEA.879773, 2017d.

Cornils, A. and Schnack-Schiel, S. B.: Abundance of planktonic Copepoda (Crustacea) during METEOR cruise M44/2 (Gulf of Aqaba, Red Sea) – additional stations, PANGAEA, doi:10.1594/PANGAEA.881901, 2017.

Cornils, A. and Schnack-Schiel, S. B.: Abundance and distribution of planktonic Copepoda in the Southern Ocean and other regions from 1980 to 2005, PANGAEA, doi:10.1594/PANGAEA.884619, 2018.

Currie, R. and Foxton, P.: The Nansen closing method with vertical plankton nets. J. Mar. Biol. Assoc. U. K., 35(3), 483-492, doi:10.1017/S002531540001033X, 1956.

Driemel, A., Fahrbach, E., Rohardt, G., Beszczynska-Möller, A., Boetius, A., Budéus, G., Cisewski, B., Engbrodt, R., Gauger, S., Geibert, W., Geprägs, P., Gerdes, D., Gersonde, R., Gordon, A. L., Grobe, H., Hellmer, H. H., Isla, E., Jacobs, S. S., Janout, M., Jokat, W., Klages, M., Kuhn, G., Meincke, J., Ober, S., Østerhus, S., Peterson, R. G., Rabe, B., Rudels, B., Schauer, U., Schumacher, S., Schröder, M., Sieger, R., Sildam, J., Soltwedel, T., Stangeew, E., Stein, M., Strass, V. H., Thiede, J., Tippenhauer, S., Veth, C., von Appen, W.-J., Weirig, M.-F., Wisotzki, A., Wolf-Gladrow, D. A. and Kanzow, T.: From pole to pole: 33 years of physical oceanography onboard R/V Polarstern, Earth Syst. Sci. Data, 9(1), 211-220, https://doi.org/10.5194/essd-9-211-2017, 2017.

Dubischar, C. D., Lopes, R. M. and Bathmann, U. V.: High summer abundances of small pelagic copepods at the Antarctic Polar Front—implications for ecosystem dynamics, Deep-Sea Res. II, 49(18), 3871–3887, doi:10.1016/S0967-0645(02)00115-7, 2002.

Edwards, M. and Richardson, A. J.: The impact of climate change on the phenology of the plankton community and trophic mismatch, Nature, 430: 881–884, doi:10.1038/nature02808, 2004.

Hernroth, L.: Sampling and filtration efficiency of two commonly used plankton nets. A comparative study of the Nansen net and the Unesco WP 2 net, J. Plankton Res., 9(4), 719–728, doi:10.1093/plankt/9.4.719, 1987.

Hopcroft, R. R., Roff, J. C. and Chavez, F. P.: Size paradigms in copepod communities: a re-examination, Hydrobiologia, 453(1), 133–141, doi:10.1023/A:101316791, 2001.

Hopkins, T. L.: The zooplankton community of Croker passage, Antarctic Peninsula, Pol. Biol., 4(3), 161–170, doi:10.1007/BF00263879, 1985.

Hopkins, T. L. and Torres, J. J.: The zooplankton community in the vicinity of the ice edge, western Weddell Sea, March 1986, Pol. Biol., 9, 79–87, doi:10.1007/BF00442033, 1988.

Hosie, G.W., Fukuchi, M. and Kawaguchi, S.: Development of the southern Ocean continuous plankton recorder survey, Prog. Oceanogr., 58, 263-284, doi:10.1016/j.pocean.2003.08.007, 2003.

Humes, A. G.: How many copepods? Hydrobiologia, 292(1), 1–7, doi:10.1007/BF00229916, 1994.

Huys, R. and Boxshall, G. A.: Copepod evolution, The Ray Society, London, England, 468 pp., 1991

Kouwenberg, J. H. M., Razouls, C. and Desreumaux, N.: 6.6. Southern Ocean Pelagic Copepods, In: C. De Broyer, C., Koubbi, P., Griffith H. J., Raymond, B., d'Udekem d'Acoz, C., Van de Putte A. D., Danis, B., David, B., Grant, S., Gutt, J., Held, C., Hosie, G., Huettmann, F. and Post, A. (Eds.), The Biogeographic Atlas of the Southern Ocean, The Scientific Committee on Antarctic Research, Cambridge, 209 – 296, 2014.

Longhurst, A. R.: Relationships between diversity and the vertical structure of the upper ocean. Deep-Sea Res. 32: 1535 – 1570, doi:10.1016/0079-6611(85)90036-9, 1985.

Longhurst, A. R. and Harrison, W. G.: The biological pump: profiles of plankton production and consumption in the upper ocean, Progr. Oceanogr., 22, 47–123, doi:10.1016/0079-6611(89)90010-4, 1989.

McGowan, J. A. and Brown, D. M.: A new opening-closing paired zooplankton net, Scripps Inst. Ocean., Ref. 66-23, pp. 54, 1966.

McLeod, D. J., Hosie, G. W., Kitchener, J. A., Takahashi, K. T. and Hunt, B. P. V.: Zooplankton Atlas of the Southern Ocean: The SCAR SO-CPR Survey (1991 - 2008), Pol. Sci., 4(2), 353–385, doi:10.1016/j.polar.2010.03.004, 2010.

Michels, J., Schnack-Schiel, S. B., Pasternak, A. F., Mizdalski, E., Isla, E. and Gerdes, D.: Abundance of copepods during POLARSTERN cruise ANT-XXI/2 (BENDIX), PANGAEA, doi:10.1594/PANGAEA.754015, 2012.

Mohn, C. and Beckmann, A.: The upper ocean circulation at Great Meteor Seamount, Ocean Dyn., 52(4), 179–193, doi:10.1007/s10236-002-0017-4, 2002

Motoda, S.: Devices of simple plankton apparatus, Mem. Fac. Fish., Hokkaido Univ., 7, 73-94, http://hdl.handle.net/2115/21829, 1959.

Nansen, F.: Closing-nets for vertical hauls and for horizontal towing, ICES J Mar. Sci., s1(67), 3-8, doi:10.1093/icesjms/s1.67.3, 1915.

Paffenhöfer, G. A. and Mazzocchi, M. G.: Vertical distribution of subtropical epiplanktonic copepods, J. Plankton Res., 25(9), 1139–1156, doi:10.1093/plankt/25.9.1139, 2003.

Pakhomov, E. A., Perissinotto, R. and McQuaid, C. D.: Zooplankton structure and grazing in the Atlantic sector of the Southern Ocean in late austral summer 1993: Part 1. Ecological zonation, Deep-Sea Res. I, 47, 1663–1686, doi:10.1016/S0967-0637(99)00122-3, 2000.

Plähn, O., Baschek, B., Badewien, T. H., Walter, M. and Rhein, M.: Importance of the Gulf of Aqaba for the formation of bottom water in the Red Sea, J. Geophys. Res., 107(C8), 3108, doi:10.1029/2000JC000342, 2002.

R Core Team: R: A Language and Environment for Statistical Computing, Foundation for Statistical Computing, Vienna, Austria, https://www.R-project.org, 2018.

Razouls, C., de Bovee, F., Kouwenberg, J. and Desreumaux, N.: Diversity and geographic distribution of marine planktonic copepods. Sorbonne Universite, CNRS, available at http://copepodes.obs-banyuls.fr/, [Accessed February 10, 2018], 2005-2018.

Reid, P. C. and Edwards, M.: Long-term changes in the pelagos, benthos and fisheries of the North Sea, Senck. marit., 31(2), 107-115, doi:10.1007/BF03043021, 2001.

Reid, P. C., Colebrook, J. M., Matthews, J. B. L. and Aiken, J.: The Continuous Plankton Recorder: concepts and history, from Plankton Indicator to undulating recorders, Progr. Oceanogr., 58(2-4), 117–173, doi:10.1016/j.pocean.2003.08.002, 2003.

Rivero-Calle, S., Gnanadesikan, A., Del Castillo, C. E., Balch, W. M. and Guikema, S. D.: Multidecadal increase in North Atlantic coccolithophores and the potential role of rising CO2, Science, 350, 6267, 1533-1537, doi:10.1126/science.aaa9942, 2015.

Rohardt, G., Fahrbach, E., Beszczynska-Möller, A., Boetius, A., Brunßen, J., Budéus, G., Cisewski, B., Engbrodt R., Gauger, S., Geibert, W., Geprägs, P., Gerdes, D., Gersonde, R., Gor- don, A. L., Hellmer, H. H., Isla, E., Jacobs, S. S., Janout, M., Jokat, W., Klages, M., Kuhn, G., Meincke, J., Ober, S., Østerhus, S., Peterson, R. G., Rabe, B., Rudels, B., Schauer, U., Schröder, M., Sildam, J., Soltwedel, T., Stangeew, E., Stein, M., Strass, V. H., Thiede, J., Tippenhauer, S., Veth, C., von Appen, W.-J., Weirig, M.-F., Wisotzki, A., Wolf-Gladrow, D. A., and Kanzow, T.: Physical oceanography on board of POLARSTERN (1983-11-22 to 2016-02-14), PANGAEA, doi:10.1594/PANGAEA.860066, 2016.

Rutherford, S., D'Hondt, S. and Prell, W.: Environmental controls on the geographic distribution of zooplankton diversity, Nature, 400, 749–753, doi:10.1038/23449, 1999

Schlitzer, R.: Ocean Data View, http://odv.awi.de, last access: 02 January 2018, 2015.

Schminke, H. K.: Entomology for the copepodologist, J. Plankton Res., 29(Suppl. 1), i149–i162, doi:10.1093/plankt/fbl073, 2006.

Schnack-Schiel, S. B.: Aspects of the study of the life cycles of Antarctic copepods, Hydrobiologia, 453/454, 9–24, doi:10.1023/A:101319532, 2001.

Schnack-Schiel, S. B.: Abundance of copepods during POLARSTERN cruise ANT-VII/2 (EPOS I), PANGAEA, doi:10.1594/PANGAEA.754736, 2010.

Schnack-Schiel, S. B. and Mizdalski, E.: Seasonal variations in distribution and population structure of *Microcalanus pygmaeus* and *Ctenocalanus citer* (Copepoda: Calanoida) in the eastern Weddell Sea, Antarctica, Mar. Biol., 119(3), 357–366, doi:10.1007/BF00347532, 1994.

Schnack-Schiel, S. B., Thomas, D., Dieckmann, G. S., Eicken, H., Gradinger, R., Spindler, M., Weissenberger, J., Mizdalski, E. and Beyer, K.: Life cycle strategy of the Antarctic calanoid copepod *Stephos longipes*, Progr. Oceanogr., 36(1), 45–75, doi:10.1016/0079-6611(95)00014-3, 1995.

Schnack-Schiel, S. B., Hagen, W. and Mizdalski, E.: Seasonal carbon distribution of copepods in the eastern Weddell Sea, Antarctica, J. Mar. Syst., 17(1), 305–311, doi:10.1016/S0924-7963(98)00045-1, 1998.

Schnack-Schiel, S. B., Michels, J., Mizdalski, E., Schodlok, M. P. and Schröder, M.: Abundance of copepods from multinet samples during POLARSTERN cruise ANT-XXII/2 (ISPOL), PANGAEA, doi:10.1594/PANGAEA.646297, 2007.

Schnack-Schiel, S. B., Mizdalski, E. and Cornils, A.: Abundance of copepods from multinet samples during POLARSTERN cruise ANT-XX/1, version 1, PANGAEA, doi:10.1594/PANGAEA.753644, 2010.

Schnack-Schiel, S. B., Mizdalski, E. and Cornils, A.: Copepod abundance and species composition in the Eastern subtropical/tropical Atlantic, Deep-Sea Res. II, 57, 2064–2075, doi:10.1016/j.dsr2.2010.09.010, 2010.

Shreeve, R. S., Tarling, G. A., Atkinson, A., Ward, P., Goss, C. and Watkins, J.: Relative production of *Calanoides acutus* (Copepoda: Calanoida) and *Euphausia superba* (Antarctic krill) at South Georgia, and its implications at wider scales, Mar. Ecol. Prog. Ser., 298, 229–239, doi:10.3354/meps298229, 2005.

Skjoldal, H. R., Wiebe, P. H., Postel, L., Knutsen, T., Kaartvedt, S. and Sameoto, D. D.: Intercomparison of zooplankton (net sampling systems: Results from the ICES/GLOBEC sea-going workshop, Progr. Oceanogr., 108(C), 1–42. doi:10.1016/j.pocean.2012.10.006, 2013.

Smetacek, V. and Nicol, S.: Polar ocean ecosystems in a changing world, Nature, 437(7057), 362–368, doi:10.1038/nature04161, 2005.

Smith, J. N., De'ath, G., Richter, C., Cornils, A., Hall-Spencer, J. M. and Fabricius, K. E.: Ocean acidification reduces demersal zooplankton that reside in tropical coral reefs, Nat. Clim. Change, 6(12), 1124-1129, doi:10.1038/nclimate3122, 2016.

Stein, Manfred (2010): Physical oceanography during METEOR cruise M11/4. Bundesforschungsanstalt für Fischerei, Hamburg, PANGAEA, doi:10.1594/PANGAEA.742745, 2010.

Tarling, G. A., Ward, P. and Thorpe, S. E.: Spatial distributions of Southern Ocean mesozooplankton communities have been resilient to long-term surface warming, Glob. Change Biol., 24(1), 132–142, doi:10.1111/gcb.13834, 2017.

Tittensor, D. P., Mora, C., Jetz, W., Lotze, H. K., Ricard, D., Berghe, E.V. and Worm, B.: Global patterns and predictors of marine biodiversity across taxa, Nature, 466, 1098–1101, doi:10.1038/nature09329, 2010.

Van Guelpen, L., Markle D. F. and Duggan, D. J.: An evaluation of accuracy, precision, and speed of several zooplankton sub-sampling techniques, J. Cons. Int. Explor. Mer., 40, 226-236, doi:10.1093/icesjms/40.3.226, 1982.

Ward, P., Tarling, G. A. and Thorpe, S. E.: Mesozooplankton in the Southern Ocean: Spatial and temporal patterns from Discovery Investigations, Progr. Oceanogr., 120(C), 305–319, doi:10.1016/j.pocean.2013.10.011, 2014.

Weikert, H. and John, H.-C.: Experiences with a modified Bé multiple opening-closing plankton net, J. Plankton Res., 3(2), 167–176, doi:10.1093/plankt/3.2.167, 1981.

Wiebe, P. H.: A computer model study of zooplankton patchiness and ist effects on sampling error, Limnol. Oceanogr., 16, 29-38, doi:10.4319/lo.1971.16.1.0029, 1971.

Wiebe, P. H. and Benfield, M. C.: From the Hensen net toward four-dimensional biological oceanography, Progr. Oceanogr., 56(1), 7–136, doi:10.1016/S0079-6611(02)00140-4, 2003.

WoRMS Editorial Board: World Register of Marine Species. Available from http://www.marinespecies.org at VLIZ, (Accessed 2018-01-25), doi:10.14284/170, 2018.

Zwally H.J.: Detection of Change in Antarctica, In: Hempel G. (ed) Antarctic Science, Springer, Berlin, Heidelberg, pp. 126-143, doi:10.1007/978-3-642-78711-9_10, 1994.

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**Table 1**: Overview of the sampling periods and research cruises. Abbreviations of regions: Antarctic Peninsula (AP), Weddell Sea (WS), eastern Weddell Sea (EWS), Scotia Sea (SCO), Bellingshausen Sea (BS), Amundsen Sea (AS), western Weddell Sea (WWS), Eastern Atlantic Ocean (EAO), Magellan region (MR), Great Meteor Bank (GMB), Red Sea (RS); MN: Multinet. * Data sets with abundance only for non-calanoid copepod species.

| Cruise No. | Sampling period | Region | No. Stations | Net type | Max. sampling depth (m) | Mesh size (µm) | DOI of datasets | No. taxa | Available CTD profiles/ Information on hydrography |
|---|---|---|---|---|---|---|---|---|---|
| PS04<br>ANT-II/2 | 1983-10-24 –<br>1983-11-10 | AP | 14 | MN midi/<br>Nansen net | 1900 | 200 | doi:10.1594/PANGAEA.876508 | 110 | |
| PS06<br>ANT-III/3 | 1985-01-07 –<br>1985-02-24 | AP, EWS<br>WS<br>AP<br>EWS | 30<br>61<br>6<br>4 | MN midi<br>Bongo<br>MN midi<br>MN midi | 2880<br>245<br>400<br>2500 | 100/200<br>300<br>200<br>100 | doi:10.1594/PANGAEA.876726<br>doi:10.1594/PANGAEA.878275<br>doi:10.1594/PANGAEA.878276<br>doi:10.1594/PANGAEA.879771 | 258<br>28<br>21<br>14* | doi:10.1594/PANGAEA.860066 |
| PS09<br>ANT-V/1 | 1986-05-21 –<br>1986-05-31 | AP | 8 | MN midi | 1850 | 200 | doi:10.1594/PANGAEA.876734 | 162 | doi:10.1594/PANGAEA.860066 |
| PS10<br>ANT-V/2 | 1986-07-18 –<br>1986-09-05 | EWS | 18<br>3 | MN midi | 600 | 100 | doi:10.1594/PANGAEA.878277<br>doi:10.1594/PANGAEA.878278 | 22<br>169 | doi:10.1594/PANGAEA.860066 |
| PS10<br>ANT-V/3 | 1986-10-05 –<br>1986-11-24 | EWS | 7<br>24 | MN midi | 1000 | 100 | doi:10.1594/PANGAEA.879772<br>doi:10.1594/PANGAEA.878874 | 10*<br>211 | doi:10.1594/PANGAEA.860066 |
| PS14<br>ANT-VII/2 | 1988-11-09 –<br>1988-11-13 | SCO | 6 | MN midi | 1000 | 200 | doi:10.1594/PANGAEA.879290 | 172 | |
| PS14<br>ANT-VII/3 | 1988-11-26 –<br>1989-01-04 | SCO | 11<br>12 | MN midi | 1000 | 200 | doi:10.1594/PANGAEA.879231<br>doi:10.1594/PANGAEA.879232 | 192<br>52 | doi:10.1594/PANGAEA.860066 |
| PS14<br>ANT-VII/4 | 1989-01-17 –<br>1989-01-19 | SCO | 5 | MN midi | 1000 | 200 | doi:10.1594/PANGAEA.879230 | 166 | doi:10.1594/PANGAEA.860066 |
| PS16<br>ANT-VIII/2 | 1989-09-14 –<br>1989-10-06 | WS | 12 | MN midi | 1000 | 100 | doi:10.1594/PANGAEA.879308 | 186 | doi:10.1594/PANGAEA.860066 |
| PS18<br>ANT-IX/2 | 1990-11-22 –<br>1990-12-15 | WS | 9 | MN midi | 1000 | 100 | doi:10.1594/PANGAEA.879508 | 226 | doi:10.1594/PANGAEA.860066 |
| PS21<br>ANT-X/3 | 1992-04-11 –<br>1992-05-02 | EWS | 12 | MN midi | 1000 | 100 | doi:10.1594/PANGAEA.879536 | 227 | |
| PS23<br>ANT-X/7 | 1992-12-18 –<br>1993-01-16 | WS | 16 | MN midi | 1000 | 100 | doi:10.1594/PANGAEA.879562 | 240 | doi:10.1594/PANGAEA.860066 |
| PS29<br>ANT-XI/3 | 1994-01-28 –<br>1994-03-03 | BS, AS | 20<br>6 | MN midi | 1000 | 55 | doi:10.1594/PANGAEA.879712<br>doi:10.1594/PANGAEA.879718 | 220<br>42* | doi:10.1594/PANGAEA.860066 |
| PS35<br>ANT-XII/4 | 1995-04-12 –<br>1995-04-17 | AS | 6<br>5 | MN midi | 1000 | 55 | doi:10.1594/PANGAEA.879774<br>doi:10.1594/PANGAEA.879773 | 204<br>35* | doi:10.1594/PANGAEA.860066 |
| PS58 | 2001-04-18 – | BS | 9 | MN midi | 650 | 55 | doi:10.1594/PANGAEA.880375 | 143 | doi:10.1594/PANGAEA.860066 |

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|---|---|---|---|---|---|---|---|---|---|
| ANT-XVIII/5b | 2001-04-30 | | | | | | | | |
| PS63 ANT-XX/1 | 2002-11-02 – 2002-11-20 | EAO | 19 | MN midi | 300 | 100 | doi:10.1594/PANGAEA.880927 | 353 | Schnack-Schiel et al. (2010) |
| PS65 ANT-XXI/2 | 2003-12-09 – 2004-01-01 | EWS | 10 | MN midi | 900 | 100 | doi:10.1594/PANGAEA.880331 | 128 | doi:10.1594/PANGAEA.860066 |
| PS67 ANT-XXII/2 | 2004-12-01 – 2005-01-02 | WWS | 9 | MN midi | 1000 | 100 | doi:10.1594/PANGAEA.880983 | 172 | doi:10.1594/PANGAEA.742627 |
| DAE1979/80 | 1980-01-01 – 1980-02-08 | WS | 50 | Nansen net | 700 | 250 | doi:10.1594/PANGAEA.880239 | 61 | |
| JB03 | 1982-02-02 – 1982-03-02 | BS, AP, SCO | 45 | Nansen net | 2850 | 200 | doi:10.1594/PANGAEA.880568 | 182 | https://www.bodc.ac.uk/resources/inventories/cruise_inventory/report/5916/ |
| VH1094 | 1994-11-12 – 1994-11-24 | MR | 17 | MN midi | 400 | 300 | doi:10.1594/PANGAEA.880202 | 105 | |
| M11/4 | 1989-12-27 – 1990-01-08 | BS, AP | 22 | MN midi | 2500 | 200 | doi:10.1594/PANGAEA.880173 | 193 | doi:10.1594/PANGAEA.742745 |
| M42/3 | 1998-09-01 – 1998-09-16 | GMB | 17 | MN midi | 2500 | 100 | doi:10.1594/PANGAEA.882283 | 349 | Beckmann and Mohn (2002), Mohn and Beckmann (2002) |
| M44/2 | 1999-02-22 – 1999-03-07 | RS | 15<br>5 | MN maxi | 1300<br>500 | 150 | doi:10.1594/PANGAEA.881899<br>doi:10.1594/PANGAEA.880901 | 186<br>52 | Cornils et al. (2005),<br>Plähn et al. (2002) |

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**Table 2**: List of calanoid copepod genera, cyclopoid families and other orders compiled in this data collection, with notes on their distribution. The number of species for each genus is written in parentheses.

| Order | Family | Genus | Distribution | | | | |
|---|---|---|---|---|---|---|---|
| | | | Southern Ocean | Magellan region | Great Meteor Bank | Northern Red Sea | Eastern Atlantic Ocean |
| Calanoida | Acartiidae | *Acartia (3)* | | X | X | X | X |
| | Aetideidae | *Aetideopsis (3), Aetideus (5), Chiridiella (1), Chiridius (3), Chirundina (1), Euchirella (7), Gaetanus (8), Pseudeuchaeta (1), Pseudochirella (2), Undeuchaeta (2)* | X | X | X | | X |
| | Arctokonstantinidae | *Foxtonia (1)* | X | | X | | |
| | Arietellidae | *Arietellus (3), Paraugaptilus (1)* | | | | | X |
| | Augaptilidae | *Augaptilus (4), Euaugaptilus (7), Haloptilus (10), Pseudaugaptilus (1), Pseudhaloptilus (1)* | X | X | X | X | X |
| | Bathypontiidae | *Temorites (2)* | X | | X | | |
| | Calanidae | *Calanoides (3), Calanus (4), Mesocalanus (1), Nannocalanus (1), Neocalanus (3), Undinula (1)* | X | X | X | X | X |
| | Candaciidae | *Candacia (13)* | X | X | X | X | X |
| | Centropagidae | *Centropages (5)* | | X | X | X | X |
| | Clausocalanidae | *Clausocalanus (12), Ctenocalanus (2), Drepanopus (1), Farrania (1), Microcalanus (1)* | X | X | X | X | X |
| | Diaixidae | *Diaixis (1)* | | | | X | |
| | Discoidae | *Disco (1)* | X | | X | X | X |
| | Eucalanidae | *Eucalanus (2), Pareucalanus (2), Subeucalanus (5)* | X | X | X | X | X |
| | Euchaetidae | *Euchaeta (7), Paraeuchaeta (6)* | X | X | X | X | X |
| | Fosshageniidae | *Temoropia (3)* | X | | X | X | X |
| | Heterorhabdidae | *Disseta (1), Heterorhabdus (7), Heterostylites (2), Mesorhabdus (1), Microdisseta (1), Paraheterorhabdus (3)* | X | X | X | | X |
| | Lucicutiidae | *Lucicutia (13)* | X | X | X | X | X |
| | Metridinidae | *Metridia (8), Pleuromamma (8)* | X | X | X | X | X |
| | Nullosetigeridae | *Nullosetigera (3)* | | | X | | |
| | Paracalanidae | *Acrocalanus (5), Calocalanus (3), Delibus (1), Mecynocera (1), Paracalanus (4), Parvocalanus (1)* | | X | X | X | X |
| | Phaennidae | *Cephalophanes (2), Cornucalanus (1), Onchocalanus (4), Phaenna (1), Xanthocalanus (2)* | X | | X | X | X |
| | Pontellidae | *Calanopia (2), Labidocera (1), Pontellina (2), Pontellopsis (3)* | | | X | X | X |
| | Rhincalanidae | *Rhincalanus (4)* | X | X | X | X | X |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Scolecitrichidae | *Amallothrix (3), Archescolecithrix (1), Bradfordiella (1), Bradyidius (1), Cenognatha (1), Landrumius (1), Lophothrix (2), Macandrewella (1), Mixtocalanus (1), Pseudoamallothrix (5), Racovitzanus (2), Scaphocalanus (10), Scolecithricella (5), Scolecithrix (2), Scolecitrichopsis (1), Scottocalanus (1)* | X | X | X | X | X |
| | Spinocalanidae | *Mimocalanus (2), Mospicalanus (1), Spinocalanus (9), Teneriforma (2)* | X | X | X | | X |
| | Stephidae | *Stephos (2)* | X | | | X | |
| | Temoridae | *Temora (1)* | | | | | X |
| | Tharybidae | *Tharybis (2), Undinella (1)* | X | X | X | X | X |
| | | | | | | | |
| Cyclopoida | Corycaeidae | | | | X | X | X |
| | Hemicyclopinidae | | X | | | | |
| | Lubbockiidae | | X | | X | X | X |
| | Oithonidae | | X | X | X | X | X |
| | Oncaeidae | | X | X | X | X | X |
| | Sapphirinidae | | | | X | X | X |
| | Incertae sedis | | | | X | X | X |
| Harpacticoida | | | X | X | X | X | X |
| Monstrilloida | | | X | | X | | X |
| Mormonilloida | | | X | | X | | X |
| Siphonostomatoida | | | X | | | | |

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**Table 3**: Number of data sets that show species of which the copepodite stages 1 - 5 were separated and counted. Species with asterisks are from the northern Red Sea and the Gulf of Aqaba (M44/2).

| Species | No. data sets |
|---|---|
| *Amallothrix dentipes* | 5 |
| *Calanoides acutus* | 17 |
| *Calanus propinquus* | 16 |
| *Calanus simillimus* | 4 |
| *Ctenocalanus citer* | 12 |
| *Heterorhabdus austrinus* | 15 |
| *Mesocalanus tenuicornis** | 1 |
| *Metridia curticauda* | 14 |
| *Metridia* spp. *(M. gerlachei, M. lucens)* | 18 |
| *Microcalanus* spp. | 12 |
| *Nannocalanus minor** | 1 |
| *Paraheterorhabdus farrani* | 15 |
| *Pleuromamma antarctica* | 3 |
| *Pleuromamma indica** | 2 |
| *Pseudoamallothrix cenotelis* | 6 |
| *Rhincalanus gigas* | 17 |
| *Rhincalanus nasutus** | 1 |
| *Scolecithricella minor* | 6 |
| *Spinocalanus antarcticus* | 5 |
| *Spinocalanus longicornis* | 7 |
| *Spinocalanus terranovae* | 7 |
| *Stephos longipes* | 11 |
| *Undinula vulgaris** | 1 |

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**Figure legends**

Figure 1: Overview of all stations and sampling regions including the maximum sampling depths (colour scale bar) of the data set.

Figure 2: Sampling effort in the Southern Ocean; A: station distribution in years, B: station distribution in the annual cycle, C: Number of stations per year and season, D: Number of stations per month and year.

Figure 3: Sampling effort per daytime in the Southern Ocean. Daytime is important to understand the behaviour of diel vertical migrators. The number of stations is summarized for every hour of the day, e.g. the bar at 00:00 contains all stations taken between 00:00 and 00:59.

Figure 4: Distribution and abundance of selected genera (*Microcalanus*, *Spinocalanus*, *Ctenocalanus*, *Stephos*). Depth (m) is the mean depth of each sampling depth interval ("Depth water").

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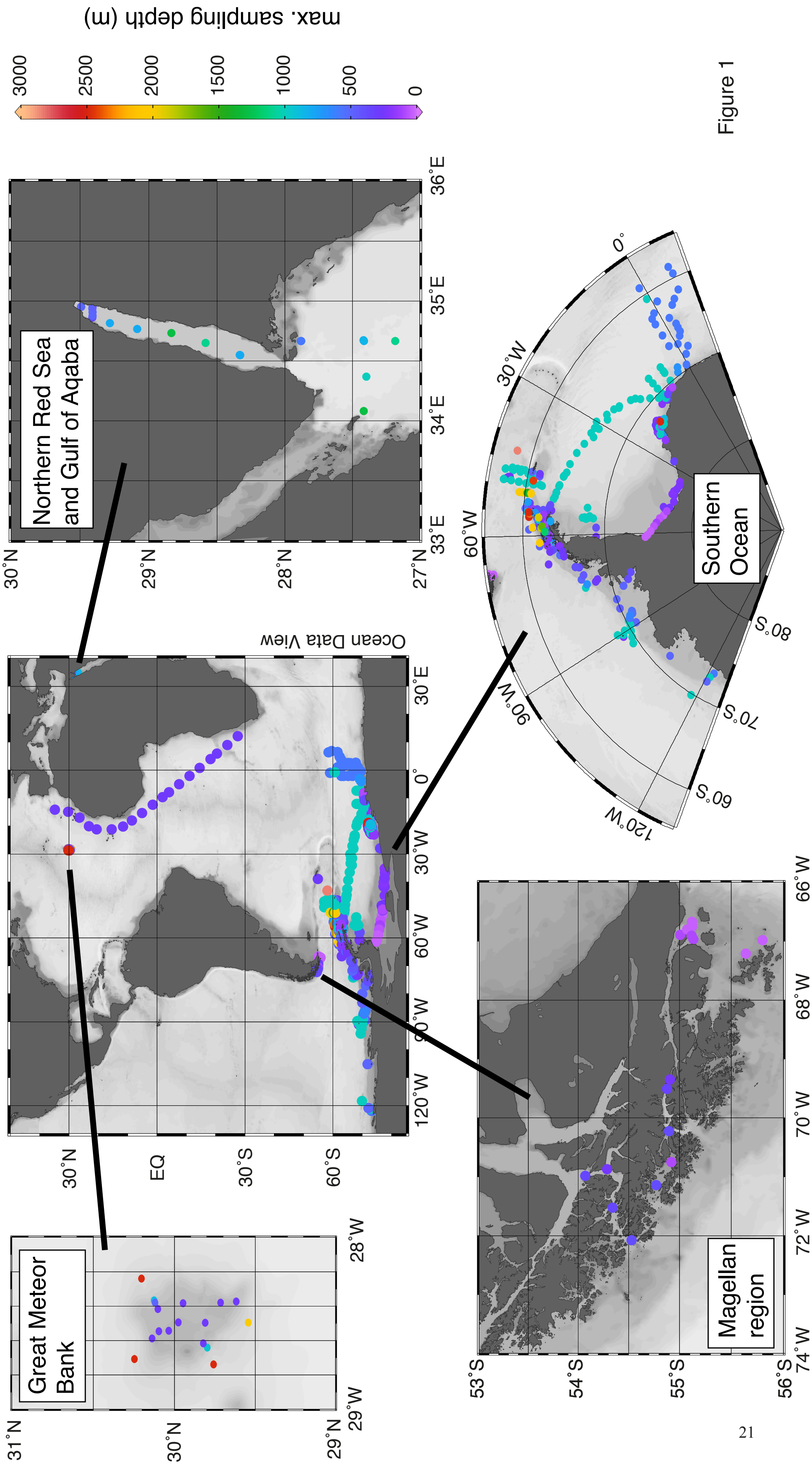
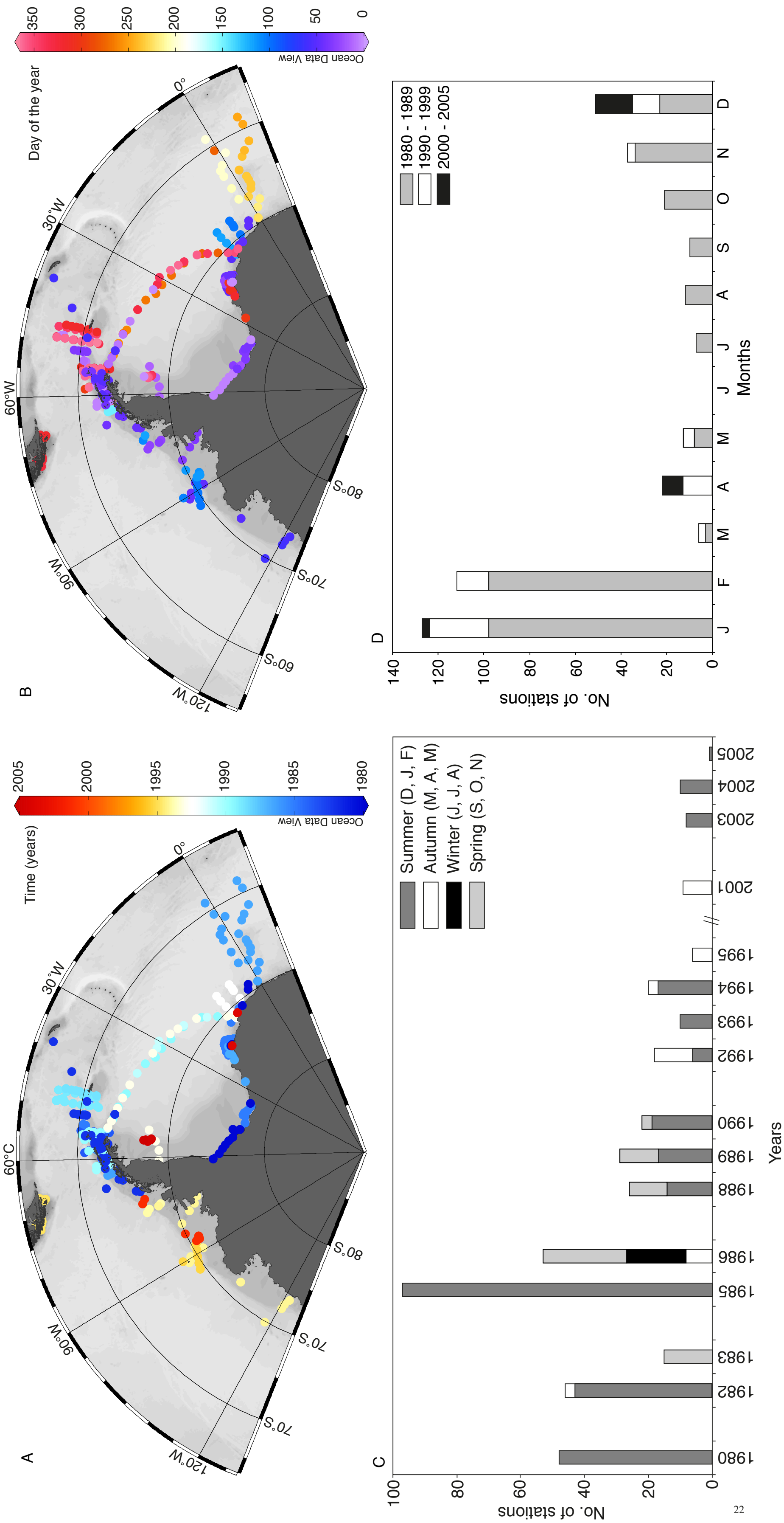



Figure 1

Figure 2


A
B
C
D
Time (years)
Day of the year
Ocean Data View
Summer (D, J, F)
Autumn (M, A, M)
Winter (J, J, A)
Spring (S, O, N)
1980 - 1989
1990 - 1999
2000 - 2005
No. of stations
Years
Months

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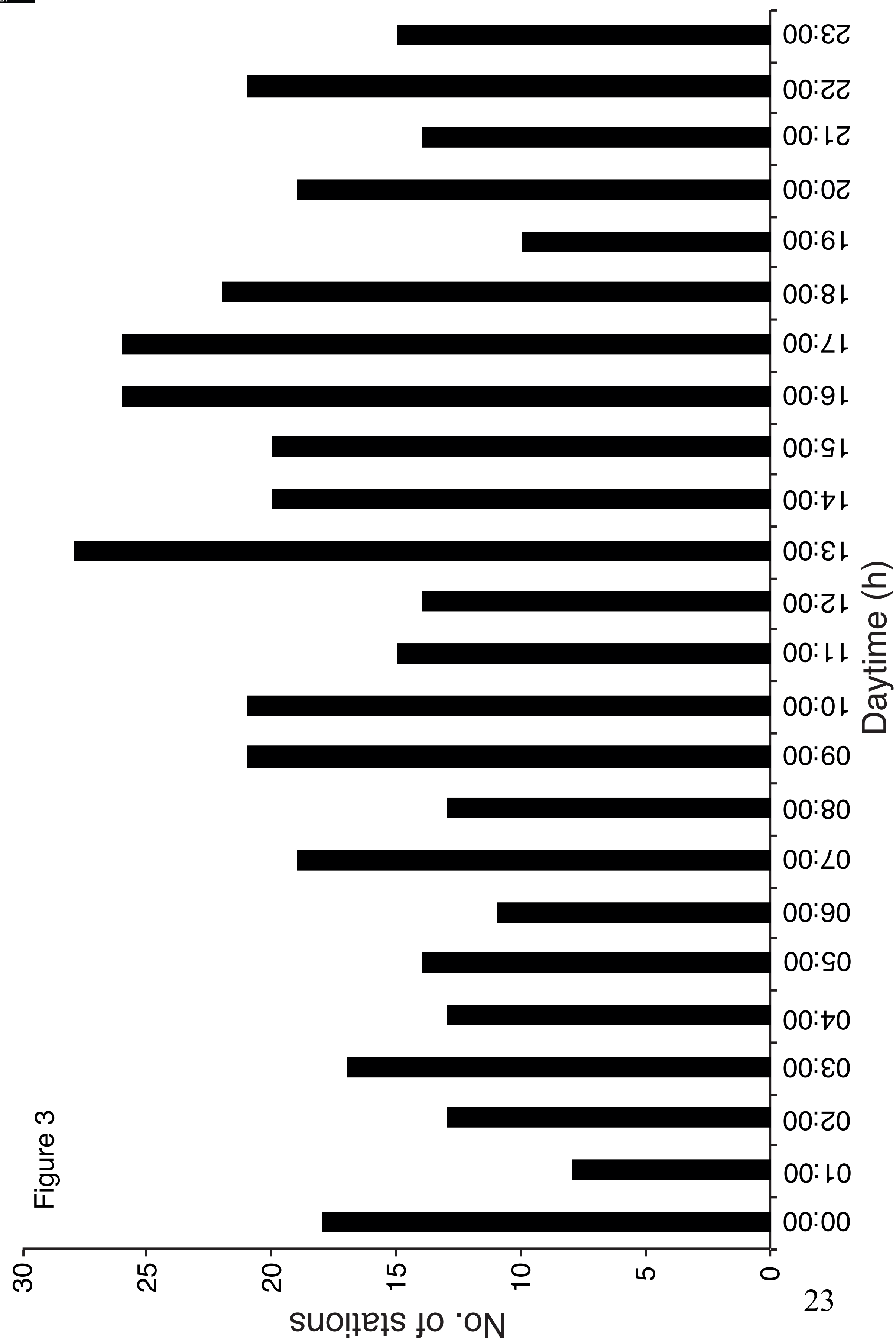


Figure 3

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Figure 4