**Supplementary information**

1. **Description of geomorphic features mapped in Figure 3 of this study.**

Expanded from O’Brien et al. (2009) and Post et al. (2014).

|  |  |
| --- | --- |
| **Geomorphic feature** | **Description** |
| Shelf bank | Banks on the shelf at depths <500 m and therefore subject to iceberg scouring. |
| Shelf deep | Areas on the shelf delineated by closed contours deeper than 500 m. |
| Cross shelf valley | Shelf depressions, commonly shallower than 500 m, that are connected to the shelf edge by valleys. |
| Coastal terrane | Inshore areas at depths delimited roughly by the 200 m contour, and therefore within the photic zone |
| Island coastal terrane | Mapped as for coastal terrain around large, rugged islands |
| Ice Shelf cavity | Areas beneath floating ice tongues. |
| Upper slope | Upper limit of the continental slope mapped as a position at which the rate of change in gradient is at a maximum, to a lower limit ~2500 m where the gradient reduces. |
| Lower slope | Mapped from ~2500 m, or where there is a reduction in slope gradient, to a lower limit at the point where canyons are no longer obvious (~3500 m). |
| Trough mouth fan | Broad aprons of sediment on the upper slope, extending from the shelf break to 2500–3000 m water depth. |
| Structural slope | Low relief topographic features formed from underlying structures, such as basement protrusions, that extend beyond the lower slope. |
| Margin ridges | Large protrusions extending hundreds of meters above the abyssal plain formed from igneous or basement intrusions. |
| Marginal plateau | Areas of relatively flat seafloor that extend from the continental margin, but are separated from the shelf by a saddle |
| Abyssal plain | Smooth, sediment covered area of seafloor |
| Contourite drift | Mounds of sediment that rise gently above the surrounding sea floor, constructed by strong bottom currents. |
| Rough seafloor | Rugged seafloor consists of a mixture of hard and soft substrates reflecting the protrusion of small basement hills and ridges beneath the sediment surface. |
| Seamount | Roughly circular areas which rise above the surrounding sea floor by at least 1000 m. |
| Seamount ridges | Elongate ridges which are hundreds to thousands of meters high relative to the surrounding seafloor. |
| Mid ocean ridge valley | Elongate troughs several hundreds of meters deeper than the rift shoulders, with a pronounced central rift valley. |
| Fracture zone | Steep cliffs developed on major crustal fracture zones, formed during rifting and seafloor spreading. |
| Trough | Closed elongate depressions more than 4500 m deep and hundreds of kilometres long. Mostly straight. |
| Trench | Arcuate areas of very deep ocean floor, more than 5000 m deep. Formed by subduction of oceanic crust at convergent plate margins. |
| Island arc | Arcuate ridges capped with volcanic islands formed adjacent to subduction zones. |
| Volcano | Active volcanoes that impinge directly on the marine environment. |
| Plateau | Relatively flat regions elevated by at least a few hundred meters above the surrounding seafloor. The edge is defined as the line of maximum change in slope above the region that slopes to the ocean floor. |
| Plateau slope | Broad sloping regions around the margins of larger plateaus. |
| Ridge | Elongate ridges that extend from large plateaus and other features |
| Wave affected bank | Areas of banks shallower than 200 m which are likely impacted by large, long period swells and storm waves. |
| No data | Features could not be mapped due to lack of data. Usually in areas of heavy sea ice accumulation. |

1. **Distribution of benthic records and mapping of Figure 4.**

**The MEASO Polygon was used to extract the data from GBIF and OBIS**

"POLYGON((180.0 -44.3,173.0 -44.3,173.0 -47.5,170.0 -47.5,157.0 -47.5,157.0 -45.9,150.0 -45.9,150.0 -47.5,143.0 -47.5,143.0 -45.8,140.0 -45.8,140.0 -44.5,137.0 -44.5,137 -43,135 -43,135.0 -41.7,131.0 -41.7,131.0 -40.1,115.0 -40.1,92.0 -40.1,92.0 -41.4,78.0 -41.4,78.0 -42.3,69.0 -42.3,69.0 -43.3,47.0 -43.3,47.0 -41.7,30.0 -41.7,12.0 -41.7,12.0 -40.3,10.0 -40.3,10.0 -38.3,-5.0 -38.3,-5.0 -38.9,-9.0 -38.9,-9.0 -40.2,-13.0 -40.2,-13.0 -41.4,-21.0 -41.4,-21.0 -42.5,-39.0 -42.5,-39.0 -40.7,-49.0 -40.7,-49.0 -48.6,-54.0 -48.6,-54.0 -55.7,-62.7972582608082 -55.7,-64.0 -55.7,-64.0 -57.8,-71.0 -57.8,-71.0 -57.8,-71.0 -58.9,-80.0 -58.9,-80 -40,-125 -40,-167 -40,-167.0 -42.6,-171.0 -42.6,-171.0 -44.3,-180.0 -44.3,-180.0 -85, 0 -85,180.0 -85,180.0 -44.3))”

Query for robis

library(robis)

records <- robis::occurrence(geometry = "POLYGON((180.0 -44.3,173.0 -44.3,173.0 -47.5,170.0 -47.5,157.0 -47.5,157.0 -45.9,150.0 -45.9,150.0 -47.5,143.0 -47.5,143.0 -45.8,140.0 -45.8,140.0 -44.5,137.0 -44.5,137 -43,135 -43,135.0 -41.7,131.0 -41.7,131.0 -40.1,115.0 -40.1,92.0 -40.1,92.0 -41.4,78.0 -41.4,78.0 -42.3,69.0 -42.3,69.0 -43.3,47.0 -43.3,47.0 -41.7,30.0 -41.7,12.0 -41.7,12.0 -40.3,10.0 -40.3,10.0 -38.3,-5.0 -38.3,-5.0 -38.9,-9.0 -38.9,-9.0 -40.2,-13.0 -40.2,-13.0 -41.4,-21.0 -41.4,-21.0 -42.5,-39.0 -42.5,-39.0 -40.7,-49.0 -40.7,-49.0 -48.6,-54.0 -48.6,-54.0 -55.7,-62.7972582608082 -55.7,-64.0 -55.7,-64.0 -57.8,-71.0 -57.8,-71.0 -58.9,-80.0 -58.9,-80 -40,-125 -40,-167 -40,-167.0 -42.6,-171.0 -42.6,-171.0 -44.3,-180.0 -44.3,-180.0 -85,0 -85,180.0 -85,180.0 -44.3))", verbose = TRUE)

Query for rgbif

library(rgbif)

occ\_data(geometry='POLYGON((180.0 -44.3, 173.0 -44.3, 173.0 -47.5, 170.0 -47.5, 157.0 -47.5, 157.0 -45.9, 150.0 -45.9, 150.0 -47.5, 143.0 -47.5, 143.0 -45.8, 140.0 -45.8, 140.0 -44.5, 137.0 -44.5, 137 -43,135 -43, 135.0 -41.7, 131.0 -41.7, 131.0 -40.1, 115.0 -40.1, 92.0 -40.1, 92.0 -41.4, 78.0 -41.4, 78.0 -42.3, 69.0 -42.3, 69.0 -43.3, 47.0 -43.3, 47.0 -41.7, 30.0 -41.7, 12.0 -41.7, 12.0 -40.3, 10.0 -40.3,10.0 -38.3, -5.0 -38.3, -5.0 -38.9, -9.0 -38.9, -9.0 -40.2, -13.0 -40.2, -13.0 -41.4, -21.0 -41.4, -21.0 -42.5, -39.0 -42.5, -39.0 -40.7, -49.0 -40.7, -49.0 -48.6, -54.0 -48.6, -54.0 -55.7, -62.7972582608082 -55.7, -64.0 -55.7, -64.0 -57.8, -71.0 -57.8, -71.0 -58.9, -80.0 -58.9, -80 -40, -125 -40, -167 -40, -167.0 -42.6, -171.0 -42.6, -171.0 -44.3, -180.0 -44.3, -180.0 -85, 0 -85, 180 -85, 180.0 -44.3))', limit = 4000000)

However, it was not possible to get the data using this method as following the error below

Error in check\_limit(as.integer(limit)) :

Maximum request size is 1 million. As a solution, either use the GBIF web interface, or in R, split up your request in a way that makes sense for your use case. E.g., you could split up your request into geographic chunks, by country or by bounding box. Or you could split up your request taxonomically, e.g., if you want data for all species in a large family of birds, split up by some higher taxonomic level, like tribe or genus.

Then we extracted the data from GBIF API and the download address is http://api.gbif.org/v1/occurrence/download/request/0034899-191105090559680.zip

When using this dataset please use the following citation:

GBIF.org (8 January 2020) GBIF Occurrence Download https://doi.org/10.15468/dl.zbsn7s

Download Information:

DOI: https://doi.org/10.15468/dl.zbsn7s (may take some hours before being active)

Creation Date: 13:37:00 8 January 2020

Records included: 3191133 records from 1486 published datasets

Compressed data size: 539.0 MB

Download format: DWCA

Filter used:

Geometry: POLYGON((180 -44.3,173 -44.3,173 -47.5,170 -47.5,157 -47.5,157 -45.9,150 -45.9,150 -47.5,143 -47.5,143 -45.8,140 -45.8,140 -44.5,137 -44.5,137 -43,135 -43,135 -41.7,131 -41.7,131 -40.1,115 -40.1,92 -40.1,92 -41.4,78 -41.4,78 -42.3,69 -42.3,69 -43.3,47 -43.3,47 -41.7,30 -41.7,12 -41.7,12 -40.3,10 -40.3,10 -38.3,-5 -38.3,-5 -38.9,-9 -38.9,-9 -40.2,-13 -40.2,-13 -41.4,-21 -41.4,-21 -42.5,-39 -42.5,-39 -40.7,-49 -40.7,-49 -48.6,-54 -48.6,-54 -55.7,-62.79 -55.7,-64 -55.7,-64 -57.8,-71 -57.8,-71 -58.9,-80 -58.9,-80 -40,-125 -40,-167 -40,-167 -42.6,-171 -42.6,-171 -44.3,-180 -44.3,-180 -85,0 -85,180 -85,180 -44.3))

HasCoordinate: true

HasGeospatialIssue: false

Data merging

In total we had 1,959,201 data records from OBIS and 3,183,981 data records from GBIF. All the data from OBIS and GBIF were merged to a single dataset.

1,959,201 OBIS records have been aggregated to 929,015 records

3,183,981 GBIF records have been aggregated to 1,268,330 records

The merged dataset contains 1,622,865 aggregated records

**Data cleaning**

All the data were cross taxon matched with WoRMS, duplicates removed, only data with geographic coordinates were selected, the fossil records were dropped, and records on land were removed.

**Mapping the distribution of benthic species**

Using a list of verified benthic species names from the data compiled for the SCAR Biogeographic Atlas the distribution data belonging to all ‘Benthic’ species were extracted. In total 161,711 distribution records (OBIS+GBIF, merged and cleaned) belonging to 7,945 benthic species on this list.

**Aggregating Data for Mapping the Species Distribution**

library(dplyr)

library(glue)

library(xlsx)

library(ggplot2)

library(rnaturalearth)

library(rnaturalearthdata)

library(sf)

# load and aggregate OBIS data

# aggregation is one on coordinates rounded to three decimals, species name, and year

load("data.Rda")

data\_obis <- records %>%

select(scientificName, originalScientificName, species, speciesid, aphiaID, decimalLatitude, decimalLongitude, eventDate, basisOfRecord, maximumDepthInMeters, minimumDepthInMeters, year = date\_year) %>%

mutate(

decimalLongitude = round(decimalLongitude, 3),

decimalLatitude = round(decimalLatitude, 3)

)

data\_obis\_agg <- data\_obis %>%

filter(!is.na(species) & species != "") %>%

group\_by(species, decimalLongitude, decimalLatitude, year) %>%

summarize()

remove("records")

# load and aggregate GBIF data

# aggregation is one on coordinates rounded to three decimals, species name, and year

data\_gbif\_full <- read.csv("./SO\_GBIF/occurrence.txt", sep = "\t", header = TRUE, quote = "", stringsAsFactors = FALSE)

data\_gbif <- data\_gbif\_full %>%

select(scientificName, species, decimalLongitude, decimalLatitude, eventDate, basisOfRecord, maximumDepthInMeters, minimumDepthInMeters, year) %>%

mutate(

decimalLongitude = round(decimalLongitude, 3),

decimalLatitude = round(decimalLatitude, 3)

)

data\_gbif\_agg <- data\_gbif %>%

filter(!is.na(species) & species != "") %>%

group\_by(species, decimalLongitude, decimalLatitude, year) %>%

summarize()

remove("data\_gbif\_full")

# merge datasets

data\_merged <- bind\_rows(data\_gbif\_agg, data\_obis\_agg) %>%

distinct()

# read taxon list

# for simplicity I'm only using ScientificName\_accepted column here where Species is not empty

# taxon\_list\_original <- read.xlsx("Pelagic\_Benthic\_atlas\_Species\_For\_Maddie.xlsx", sheetIndex = 1)

taxon\_list\_original <- read.csv("Pelagic\_Benthic\_atlas\_Species\_For\_Maddie.csv")

taxon\_list <- taxon\_list\_original %>%

filter(!is.na(ScientificName\_accepted) & ScientificName\_accepted != "" & !is.na(Species) & Species != "")

# join the occurrence data with the species list

data\_joined <- data\_merged %>%

left\_join(taxon\_list, by = c("species" = "ScientificName\_accepted"))

# again some statistics

stats <- data\_joined %>%

group\_by(Group) %>%

summarize(records = n())

stats

# filter the Group

Benthic <- filter(data\_joined, Group == 'Benthic')

**Creating the map**

The map template from measoshapes-master available on the Measo Github page (<https://github.com/AustralianAntarcticDivision/measoshapes>) was used to map the distribution points.

The following code to create the map from the filtered Benthic species list in R.

library(dplyr)

library(ggplot2)

library(rnaturalearth)

library(rnaturalearthdata)

library(sf)

library(devtools)

stats <- data\_joined %>%

group\_by(Group) %>%Benthic <- filter(data\_joined\_Benthic, Group == 'Benthic')

# map

ggplot() +

geom\_sf(data = measo, aes(fill = fill)) + geom\_sf(colour = NA) + scale\_fill\_identity() + geom\_sf(data = coast, aes(fill = NULL)) +

geom\_sf(data = df, aes(color = (Group == "Benthic")), size = 0.9) +

scale\_color\_brewer(palette = "RdGy")

1. **Functional groups represented in Figure 8 network diagram.**

Adapted from Barnes and Sands (2017).

|  |  |
| --- | --- |
| **Group** | **Description and example taxa** |
| Small particulates | Particles <1 mm in size, including phytoplankton species, detritus, suspended material and eggs etc. |
| Large particulates | Particles >1mm in size, including large plankton species, detritus, suspended material and eggs etc. |
| Macroalgae | Seaweeds, macroscopic, multicellular, marine algae. |
| Carcasses | Food falls of large marine species e.g. whales and seals. Create productive island, like habitats within an energy limited system such as the deep sea. |
| Detritus | Dead organic matter including fragments of bodies of dead organisms and faecal material. |
| Grazers | Animals that feed on algae and organic particulates. Including regular urchins and limpets. |
| Epifaunal deposit feeders | Animals that live on the seafloor but not in the sediment, they feed on organic material within the sediment. For example: sea cucumbers, some polychaetes |
| Infaunal deposit feeders | Animals that are within the sediment and feed on organic material within the sediment. Including some polychaetes, echiurans, sipunculans, bivalves, irregular sea urchins |
| Sessile/Sedentary filter feeders | Animals with no or limited mobility that feed by straining organic particles from seawater. For example: ascidians, encrusting bryozoans, polychaetes, demosponges, glass sponges, brachiopods, some polychaetes |
| Sessile/Sedentary suspension feeders | Animals with no or limited mobility that feed by collecting and selecting organic particles from seawater. For example: basket stars, valviferan isopods, some polychaetes, some brittle stars, crinoids, |
| Sessile/Sedentary soft bodied predator/scavengers | Animals with no or limited mobility that feed or other marine organisms. Sea pens, soft corals, anemones, hydroids, sea spiders, gastropods, sea stars, brittle stars, urchins |
| Mobile predator/scavengers | Highly mobile animals that feed on other animals. Octopus, shrimp and amphipods |
| Bentho-pelagic fish | Fish that live on the seafloor or in the water column just above, for this model this group refers only to those fish that feed on benthic species/organic material. |
| Shell crushing predators | Predators capable of crushing the exoskeleton of other organisms, at present such species are rare or absent from the high Antarctic. For example: spider crabs. |