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DATA DESCRIPTOR

Benthic biota of Chilean fjords and channels in 25 years of cruises of the National Oceanographic Committee

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The CIMAR program (Marine Research Cruises to Remote Areas) run by the Chilean Navy through the National Oceanographic Committee has been developed since 1995, focused on Chilean fjord and channel zones (~41–56°S; “CIMAR-Fjords”) and Chilean remote islands (“CIMAR-Islands”). Samples and data was collected on biotic and abiotic variables on all these cruises, both from the water column and benthos. Our work standardizes, compiles, and summarizes the published information on benthic organisms for twenty-one CIMAR-Fjords cruises developed in the first 25 years of the program, plus the Southern Ice Fields Cruise 1995 (precursor of the CIMAR program), which includes the distribution, abundance and geographic location of cruises sampling stations. The data set includes 8,854 records from 880 different localities, corresponding to 1,225 species from 24 different phyla (four kingdoms) and more than 150,000 individuals. Only two cruises did not record any benthic sampling. The fjords and channels of Chilean Patagonia have high biodiversity, so we hope that our data set will serve as a baseline for ecological studies and ecosystem conservation.

Background & Summary

The Marine Research Cruises in Remote Areas (CIMAR, acronym in Spanish) have been carried out continuously since 1995, covering Chilean coastal and oceanic areas that are difficult to access and far away from the main ports of the country¹. This is a research initiative by the Chilean Navy, developed through its National Oceanographic Committee (CONA, by its acronym in Spanish). CONA is an organization whose main function is to coordinate the institutions that carry out research and activities related to marine sciences in Chile. It currently has 31 member institutions—universities and various public and private organizations that develop marine sciences in Chile. This program has a specific research component in the Channels and Fjords of Patagonia in southern Chile (~41°S to ~56°S), called “CIMAR-Fjords Cruises”. These places require complex logistics to carry out research and are of great socioeconomic importance; until the mid-1990s there was little scientific information about them, except for some foreign explorations with little or no national participation^{2–7}. An exploratory marine scientific research cruise was carried out in 1995 in marine waters adjacent to the Ice Fields⁸ coordinated by the National Oceanographic Committee, to promote basic oceanographic studies.

Numerous expeditions, the majority led by foreigners, have documented benthic species in the Patagonian zone of the fjords and channels in southern Chile, including Mollusca^{9–15}, Crustacea^{16–18}, Polychaeta^{19,20}, and Foraminifera^{21–23} among others. Some studies have sought to advance our understanding of specific groups by offering reviews of specific taxa, biogeographical studies, catalogues, or lists of species^{24–27}.

Over the course of the CIMAR program’s first 25 years, 362 research projects have been completed on its cruises, resulting in more than 400 publications in scholarly journals¹, plus the publication of their data in annual cruise reports. The majority of this data was gathered during the so-called CIMAR-Fjords Voyages, which made up 21 of the 25 cruises of the CIMAR program, that focus in the fjords and channels of southern Chile (between 41°S and 56°S). Each research cruise included a significant amount of work on the benthic compartment, where

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a wide variety of benthic organisms were collected and described in both the cruise reports^{8,28–46} and several peer-review publications (e.g.^{25,47–52}).

The objective of this study was to compile all the benthic records of the CIMAR-Fjords cruises, as well as the 1996 exploratory cruise to the Southern Patagonian Ice Fields. The assembled database is anticipated to serve as a baseline for new research projects and initiatives in the area. This data descriptor presents a database with 8,854 records from 880 different localities, corresponding to 1,225 species from 24 different phyla (four kingdoms) and over 150,000 individuals.

Methods

Study area. With a long coastline and a variety of intertidal and subtidal environments, the fjords and channels of southern Chile exhibit distinctive oceanographic conditions that are mostly explained by the fluctuating influence of oceanic, glacial, and pluvial waters. These features makes these environments highly sensitive to environmental pressures (climate change, marine pollution and fishing extraction, among other stressors)⁵³. This area encompasses the Chiloense Marine and Channels and Fjords Southern Chile Ecoregions in the Magellanic Biogeographic Province⁵⁴. A significant portion of the various environments seen in the fjords and channels of southern Chile have been described in reports and publications related to the CIMAR-Fjords Cruises (Fig. 1), including biotic and abiotic aspects, demonstrating differences in diversity and abundance of various taxa. This work covers a total of 880 locations with benthic information of biota recorded in the CIMAR-Fjords Cruises, plus the Southern Ice Fields Cruise 1995 (Fig. 1). The samples cover 25-years, from August, 1995 to October, 2019 (Table 1). Five cruises covered more than half of the total sampled sites: CIMAR-2 (114 sites), CIMAR-11 (96), CIMAR-16 (91), CIMAR-3 (82) and CIMAR-7 (77). The sites cover the three southernmost administrative regions of Chile (Los Lagos, Aysén and Magallanes), and their nine provinces. The provinces with the largest number of sites were Aysén (in Aysén Region, 221 sites), Última Esperanza Province (in Magallanes Region, 178 sites) and Chiloé (in Los Lagos Region, 101 sites), accumulating 500 sites among the three provinces.

Types of sampling and preservation. The database contains records of 8854 occurrences of benthic species. Samples were collected using the following methods and sampling gears: Agassiz or modified Agassiz trawl (3625 occurrences), Box corer (3010), Scuba and intertidal sampling (1097), Van Veen and other combined sampling devices (874) and undetermined sampling gears (248).

The record book of the first 25 years of the CIMAR cruises¹ was used to identify the many studies that reported benthic biota observations, from the intertidal to the deep sea (Fig. 2a). The reports of the 1995 Southern Ice Fields Cruise⁸ were also investigated to identify benthic dataset. The data were selected from official information sources (Hydrographic and Oceanographic Data Centre of the Chilean Navy and National Oceanographic Committee of Chile) by searching for articles on the World Wide Web; all information sources were downloaded, organized and systematized (Fig. 2b). In the case of the World Wide Web, the Google Scholar and Web of Science portals were used and the search strategy consisted of systematically using keyword combinations (e.g. “CIMAR-Fjords”, “CIMAR-Fiordos”, benthic, benthos, [main taxa] and any other derivations and combinations of terms that may be necessary). For each corresponding paper or report, all the records of the declared benthic biota were extracted, comparing and/or complementing the records present in both reports and papers (Fig. 2c). All occurrence records were tabulated and arranged in spreadsheets according to the DarwinCore standard^{55,56}. Then, the entire data set was analysed, and the taxonomy updated as required in accordance with the World Register of Marine Species⁵⁷. Finally, the dataset was published in GBIF through the Integrated Publishing Toolkit (Fig. 2d).

Data Records

The data were recorded under the DarwinCore standard^{55,56} in a matrix named “Benthic biota of CIMAR-Fiordos and Southern Ice Field Cruises”⁵⁸. The occurrence dataset contains direct basic information (description, scope [temporal, geographic and taxonomic], methodology, bibliography, contacts, data description, GBIF registration and citation), project details, metrics (taxonomy and occurrences classification), activity (citations and download events) and download options. The following data fields were occupied:

- Column 1: “occurrenceID” (single indicator of the biological record indicating the cruise and correlative record).
- Column 2: “basisOfRecord” (“PreservedSpecimen” for occurrence records with catalogue number of scientific collection, “MaterialCitation” for any literature record).
- Column 3: “institutionCode” (The acronym in use by the institution having custody of the sample or information referred to in the record).
- Column 4: “collectionCode” (The name of the cruise).
- Column 5: “catalogNumber” (The repository number in museums or correlative number).
- Column 6: “type” (All records entered as “text”).
- Column 7: “language” (Spanish, English or both).
- Column 8: “institutionID” (The identifier for the institution having custody of the sample or information referred to in the record).
- Column 9: “collectionID” (The identifier for the collection or dataset from which the record was derived).
- Column 10: “datasetID” (The code “CONA-benthic-biota-database” for entire database).
- Column 11: “recordedBy” (Author/s who recorded the original occurrence [publication source]).
- Column 12: “individualCount” (Number of individuals recorded).

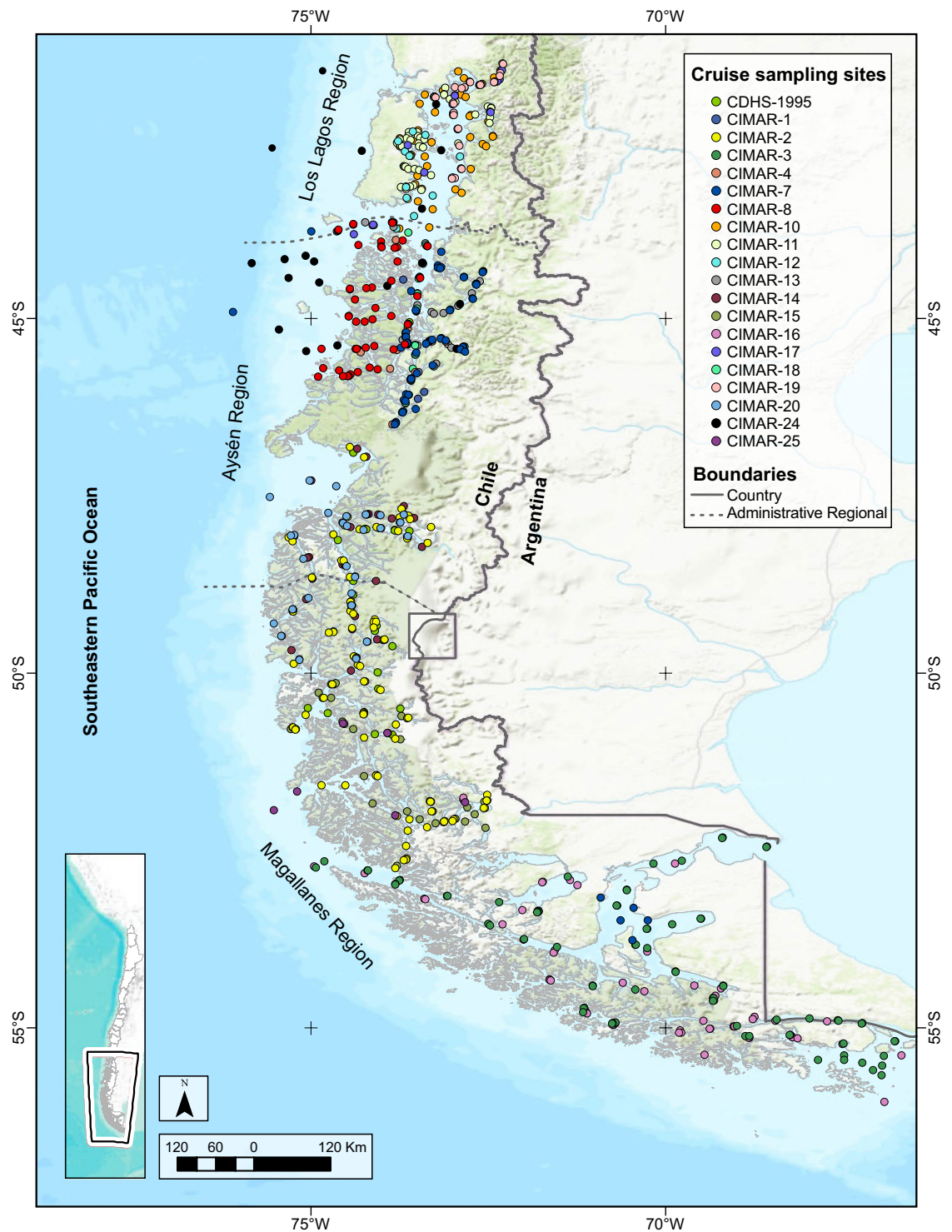


Fig. 1 Fjords and channels in southern Chile where the CIMAR-Fjords cruises and the 1995 Southern Ice Fields Cruise (CDHS) have taken place. The study sites of each cruise are differentiated with different colours.

Column 13: “associatedReferences” (Publication source [report and/or paper/s] for each record).
 Column 14: “samplingProtocol” (The sampling gear for each record).
 Column 15: “eventDate” (The date-time or interval during which the record occurred).
 Column 16: “eventRemarks” (Comments or notes about the event).
 Column 17: “continent” (Location).
 Column 18: “country” (Location).
 Column 19: “countryCode” (The standard code for the country in which the location occurs).

Cruise	Dates (y/m)	Latitudinal range	Longitudinal range	Sites
CDHS-1995	1995/08 to 1995/09	−45.06 to −50.87	−73.61 to −75.04	2 (AP-AR); 6 (CP-AR); 15 (UE-MR)
CIMAR-1	1995/11 to 1996/06	−44.29 to −46.14	−73.19 to −73.70	4 (AP-AR)
CIMAR-2	1996/10 to 1996/11	−45.21 to −52.75	−72.51 to −75.42	3 (AP-AR); 27 (CP-AR); 84 (UE-MR)
CIMAR-3	1997/10	−52.32 to −55.67	−66.77 to −74.93	2 (UE-MR); 28 (MP-MR); 24 (TF-MR); 28 (AC-MR)
CIMAR-4	1999/02 to 1999/03	−43.90 to −46.50	−73.10 to −74.30	8 (AP-AR)
CIMAR-7	2001/07	−43.65 to −53.77	−70.25 to −76.10	2 (CH-LR); 70 (AP-AR); 3 (MP-MR)*; 2 (TF-MR)*
CIMAR-8	2002/07 to 2002/09	−43.65 to −45.83	−73.35 to −74.90	2 (CH-LR); 44 (AP-AR)
CIMAR-9	WBS			
CIMAR-10	2004/08 to 2004/11	−41.51 to −43.74	−72.33 to −74.13	15 (LP-LR); 25 (CH-LR); 17 (PP-LR); 5 (AP-AR)
CIMAR-11	2005/07 to 2005/11	−41.41 to −43.87	−72.30 to −74.12	21 (LP-LR); 53 (CH-LR); 20 (PP-LR); 2 (AP-AR)
CIMAR-12	2006/07 to 2006/11	−41.55 to −44.66	−72.33 to −73.80	8 (LP-LR); 9 (CH-LR); 5 (PP-LR); 2 (AP-AR)
CIMAR-13	2007/07 to 2007/11	−43.65 to −46.20	−72.61 to −74.63	1 (CH-LR); 41 (AP-AR)
CIMAR-14	2008/10 to 2008/11	−46.84 to −50.16	−73.43 to −75.41	2 (AP-AR); 21 (CP-AR); 18 (UE-MR)
CIMAR-15	2009/10 to 2009/11	−50.11 to −52.75	−72.53 to −75.28	39 (UE-MR)
CIMAR-16	2010/10 to 2010/11	−51.75 to −56.04	−66.68 to −74.96	1 (UE-MR); 25 (MP-MR); 19 (TF-MR); 46 (AC-MR)
CIMAR-17	2011/10	−41.42 to −43.82	−72.29 to −74.40	12 (LP-LR); 2 (CH-LR); 4 (PP-LR); 2 (AP-AR)
CIMAR-18	2012/06 to 2012/07	−43.79 to −46.48	−72.83 to −73.80	17 (AP-AR)
CIMAR-19	2013/07	−41.42 to −43.03	−72.29 to −73.27	17 (LP-LR); 2 (CH-LR); 6 (PP-LR)
CIMAR-20	2014/10	−47.29 to −49.81	−73.63 to −75.57	24 (CP-AR); 13 (UE-MR)
CIMAR-23	WBS			
CIMAR-24	2018/09 to 2018/10	−41.51 to −45.47	−72.57 to −75.83	2 (LP-LR); 5 (CH-LR); 19 (AP-AR)
CIMAR-25	2019/09 to 2019/10	−50.71 to −52.01	−72.83 to −75.52	6 (UE-MR)

Table 1. Benthic sampling statistics by research cruise from oldest to newest, and by province and region from north to south. Key: Los Lagos Region (LR), Aysén Region (AR), Magallanes Region (MR), Llanquihue Province (LP), Chiloé Province (CH), Palena Province (PP), Aysén Province (AP), Capitán Prat Province (CP), Última Esperanza Province (UE), Magallanes Province (MP), Tierra del Fuego Province (TF), Antártica Chilena Province (AC); WBS (Without benthic samples reported). More information about the cruises in the book of 25 years of CIMAR cruises¹. *Sampling sites in another locality different from the study area of the cruise.

Column 20: “stateProvince” (Location, refers to the Administrative Region of Chile).
Column 21: “county” (Location, refers to the Administrative Province of Chile).
Column 22: “municipality” (Location, refers to the Administrative Commune of Chile).
Column 23: “locality” (The specific name of the place).
Column 24: “verbatimLocality” (The original textual description of the place).
Column 25: “verbatimDepth” (The original description of the depth).
Column 26: “minimumDepthInMeters” (The shallowest depth of a range of depths).
Column 27: “maximumDepthInMeters” (The deepest depth of a range of depths).
Column 28: “locationRemarks” (The name of the sample station of the cruise).
Column 29: “verbatimLatitude” (The verbatim original latitude of the location).
Column 30: “verbatimLongitude” (The verbatim original longitude of the location).
Column 31: “verbatimCoordinateSystem” (The coordinate format for the “verbatimLatitude” and “verbatimLongitude” or the “verbatimCoordinates” of the location).
Column 32: “verbatimSRS” (The spatial reference system [SRS] upon which coordinates given in “verbatimLatitude” and “verbatimLongitude” are based).
Column 33: “decimalLatitude” (The geographic latitude in decimal degrees).
Column 34: “decimalLongitude” (The geographic longitude in decimal degrees).
Column 35: “geodeticDatum” (The spatial reference system [SRS] upon which the geographic coordinates given in “decimalLatitude” and “decimalLongitude” was based).
Column 36: “coordinateUncertaintyInMeters” (The horizontal distance from the given “decimalLatitude” and “decimalLongitude” describing the smallest circle containing the whole of the location).
Column 37: “georeferenceRemarks” (Notes about the spatial description determination).
Column 38: “identifiedBy” (Responsible for recording the original occurrence [publication source]).
Column 39: “dateIdentified” (The date-time or interval during which the identification occurred.)
Column 40: “identificationQualifier” (A taxonomic determination [e.g., “sp.”, “cf.”]).
Column 41: “scientificNameID” (An identifier for the nomenclatural details of a scientific name).
Column 42: “scientificName” (The name of species or taxon of the occurrence record).
Column 43: “kingdom” (The scientific name of the kingdom in which the taxon is classified).
Column 44: “phylum” (The scientific name of the phylum or division in which the taxon is classified).
Column 45: “class” (The scientific name of the class in which the taxon is classified).

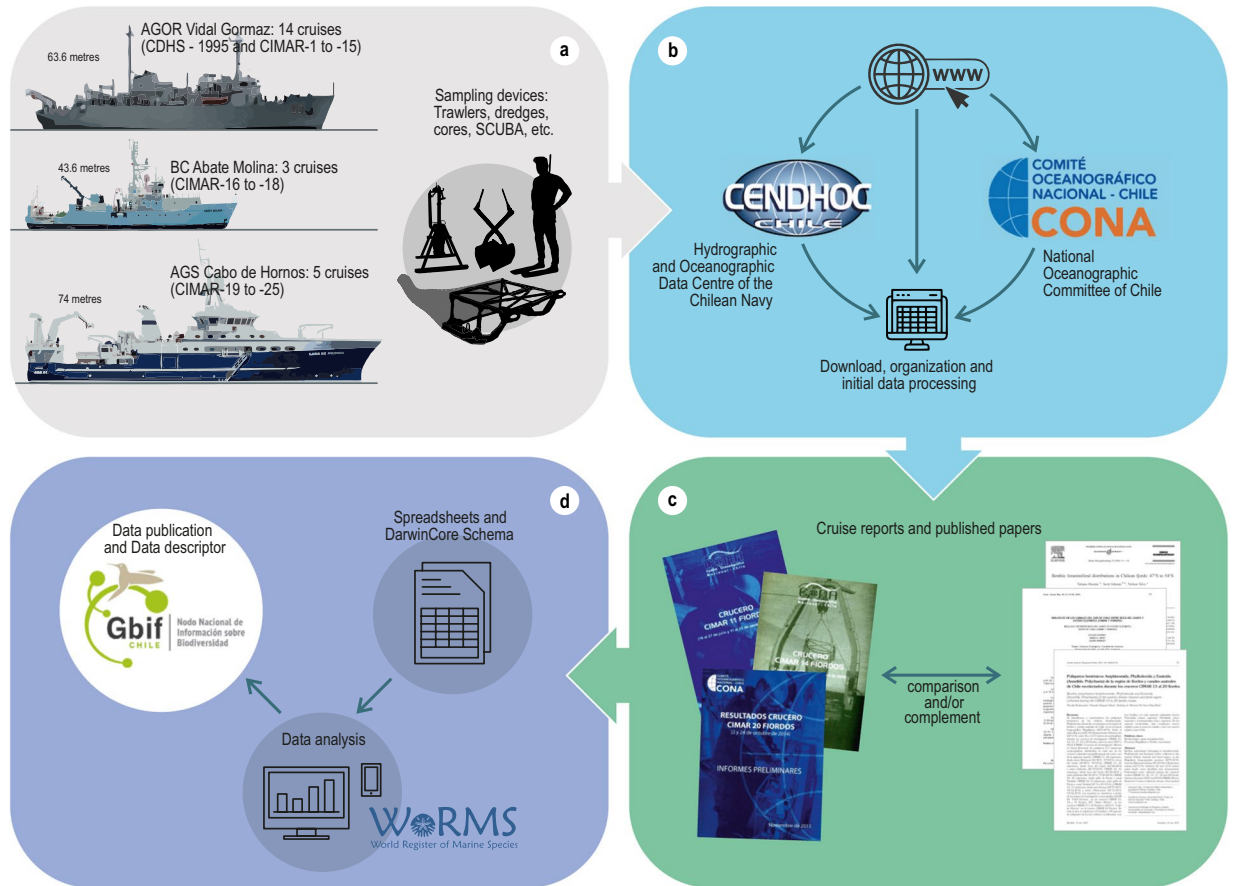


Fig. 2 Stages of information processing from raw cruise data: (a), information sources and initial treatment; (b), data extraction from cruise reports and scientific papers; (c) DarwinCore standardization, analysis and publication of the database (d).

Column 46: “order” (The scientific name of the order in which the taxon is classified).
 Column 47: “family” (The scientific name of the family in which the taxon is classified).
 Column 48: “genus” (The scientific name of the genus in which the taxon is classified).
 Column 49: “subgenus” (The scientific name of the subgenus in which the taxon is classified).
 Column 50: “specificEpithet” (The name of the first or species epithet of the “scientificName”).
 Column 51: “infraspecificEpithet” (The name of the lowest or terminal infraspecific epithet of the “scientificName”).
 Column 52: “taxonRank” (The taxonomic rank of the most specific name in the “scientificName”).
 Column 53: “scientificNameAuthorship” (The authorship information for the “scientificName” formatted according to the conventions of the applicable nomenclatural Code).
 Column 54: “verbatimIdentification” (A string representing the taxonomic identification as it appeared in the original record).

The information sources (see Fig. 2b) provided a total of 107 publications (22 cruise reports and 85 scientific papers; see Fig. 2c). Nineteen of the 22 cruise reports reviewed provided species occurrence records^{8,28–30,32–46}, one provided qualitative or descriptive data, with no recorded occurrences³¹, and two did not provide information on benthic biota (CIMAR-9 and –23 cruises). Of all the scientific papers reviewed, 74 provided records of species occurrences (Table 2), while 11 did not provide any record, as they were data without occurrences of geographically referenced species or with descriptive or qualitative information: Foraminifera^{59–62}, Annelida^{63–66}, Fishes⁶⁷, Mollusca⁶⁸ and Echinodermata⁶⁹. The phyla with the highest number of publications were the following: Annelida (present in 18 reports and 21 papers), Mollusca (in 14 and 20), Arthropoda (in 10 and 18), Echinodermata (in 10 and 9), Chordata (in 10 and 9) and Foraminifera (in 4 and 10).

The information registry includes data on occurrences and number of individuals for 8,854 records (files in the database), representing 1,225 species (Fig. 3). The main taxa in terms of occurrence and number of species were Annelida (mainly Polychaeta), Foraminifera, Mollusca and Arthropoda (mainly Crustacea), together accumulating ~70% of total occurrences and ~73% of the total species (Fig. 3). The large number of recorded

“RecordedBy” in database	Main taxa	Occurrences
Hromic <i>et al.</i> (2006) ²⁵ **	Foraminifera	988
Thatje & Brown (2009) ⁴⁸ ***	Annelida, Arthropoda, Mollusca, others	431
Arellano <i>et al.</i> (2011) ⁴⁹ ***	Foraminifera	407
Rodríguez-Villegas <i>et al.</i> (2021) ⁵² *	Myzozoa	375
Rozbaczyllo <i>et al.</i> (2017) ⁵¹ *	Annelida	357
Seguel <i>et al.</i> (2015) ⁵⁰	Myzozoa	297
Mutschke (2006) ⁷⁰ ***	Echinodermata, Annelida, Mollusca, others	288
Ríos <i>et al.</i> (2005) ⁷¹ ***	Echinodermata, Annelida, Mollusca, others	286
Zapata-Hernández <i>et al.</i> (2016) ⁷² *	Echinodermata, Annelida, Mollusca, others	227
Valdovinos <i>et al.</i> (2008) ⁷³ ***	Mollusca	220
Cárdenas <i>et al.</i> (2008) ⁴⁷ ***	Mollusca	197
Mansilla <i>et al.</i> (2013) ⁷⁴ **	Ochrophyta, Rhodophyta, Chlorophyta	195
Mutschke <i>et al.</i> (2017) ⁷⁵	Echinodermata	179
Osorio <i>et al.</i> (2006) ⁷⁶ ***	Mollusca	150
Ríos <i>et al.</i> (2013) ⁷⁷ *	Echinodermata, Mollusca, Arthropoda, others	138
Soto <i>et al.</i> (2012) ⁷⁸ ***	Rhodophyta, Ochrophyta, Mollusca, others	118
Osorio & Reid (2004) ⁷⁹ ***	Mollusca	108
Hromic (2011a) ⁸⁰ **	Foraminifera	103
Retamal (2007a) ⁸¹ ***	Arthropoda	103
Montiel San Martín (2005) ²⁴ **	Annelida	101

Table 2. Publications with >100 occurrences, indicating the main recorded taxa. *Occurrences also partially recorded in corresponding cruise reports^{8,28–30,32–46}. **Occurrences also partially recorded in other publications. ***Occurrences also partially recorded in corresponding cruise reports^{8,28–30,32–46} and other publications.

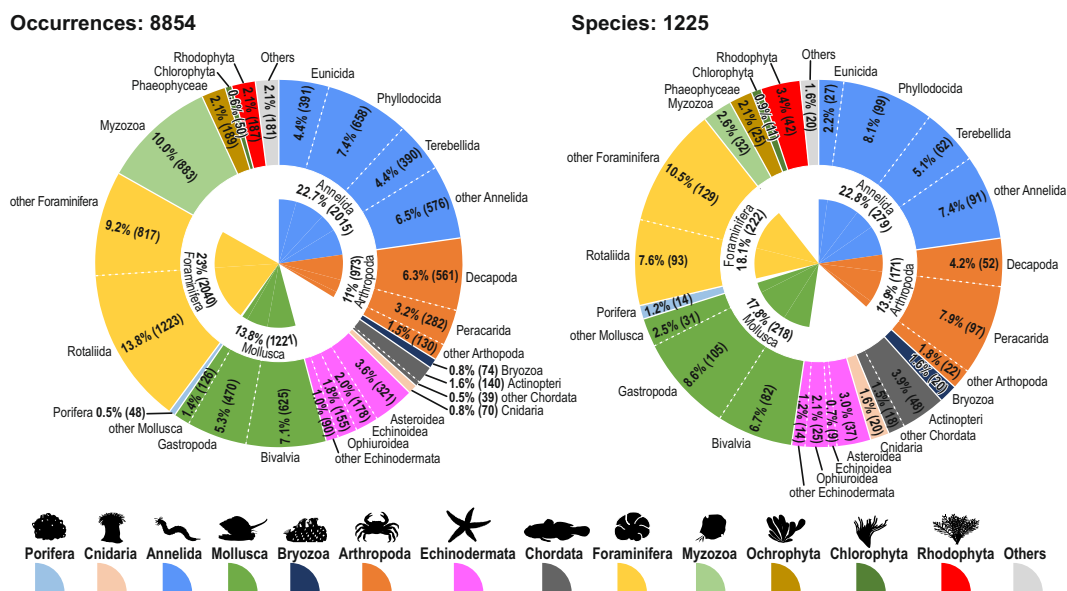


Fig. 3 Occurrences and total species by taxon, considering large taxonomic groups of the benthic biota recorded in the CIMAR 1 to 25 and CDHS-1995 cruises. The absolute values of occurrences and species are represented in parentheses.

occurrences of Myzozoa (10%) should be highlighted, which, however, only represent about 32 species. Echinodermata represented ~8% of occurrences and 7% of species.

The cruises with the highest number of occurrences were CIMAR-2 (with 1,424), followed by CIMAR-8 (1,040) and CIMAR-16 (813) (Fig. 4). Three dominant taxonomic groups were recorded in most cruises, except for cruises CIMAR-1, CIMAR-4, CIMAR-17, CIMAR-18 and CIMAR-24 (Fig. 4). The cruises with the highest number of species recorded were CIMAR-2 (with 335), CIMAR-3 (328) and CIMAR-8 (323) (Fig. 5). Three or fewer dominant taxonomic groups were recorded only in the CIMAR-1, CIMAR-4, CIMAR-17, CIMAR-18 and CIMAR-24 cruises (Fig. 5).

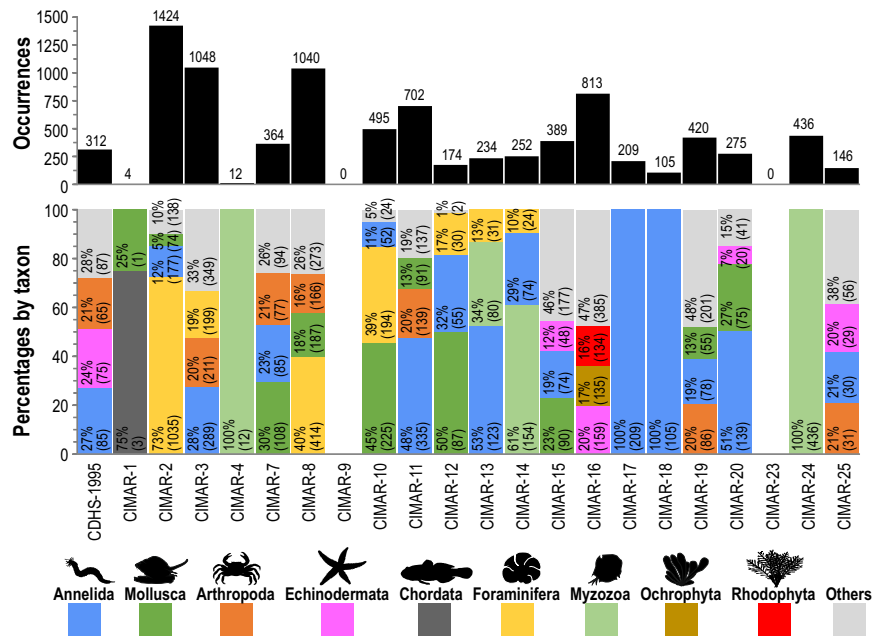


Fig. 4 Total occurrences and percentages per dominant taxon recorded in each of the CIMAR 1 to 25 and CDHS-1995 cruises. The absolute values of occurrences per dominant taxon are represented in parentheses.

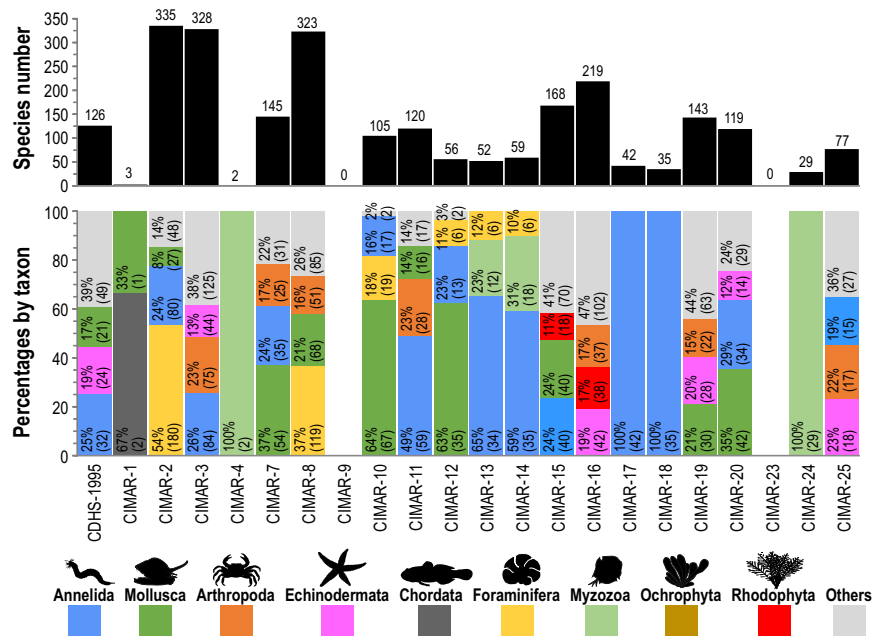


Fig. 5 Total species and percentages per dominant taxon recorded in each of the CIMAR 1 to 25 and CDHS-1995 cruises. The absolute values of species per dominant taxon are represented in parentheses.

The latitudinal bands 42°S and 45°S are those with the highest number of occurrences (Fig. 6), while the 56°S and 46°S bands had the fewest. The highest number of species was recorded in the 52°S and 50°S latitudinal bands, while, as with the occurrences, the lowest values corresponded to the 56°S and 46°S latitudinal bands (Fig. 6).

Technical Validation

The biodiversity data was formatted according to the Darwin Core standard^{55,56} of the GBIF platform. Each occurrence was entered according to its record in all the sources of information present: cruise reports and/or publications. Then each occurrence checked against the original coordinates published in the cruise reports. The depth data, sampling gear, individual count and –when applicable– the biological collection repository number were also compared between the primary information sources (cruise reports) and publications. A considerable number of occurrences were corrected after this comparison (total: 302 occurrences), mainly by adjusting their

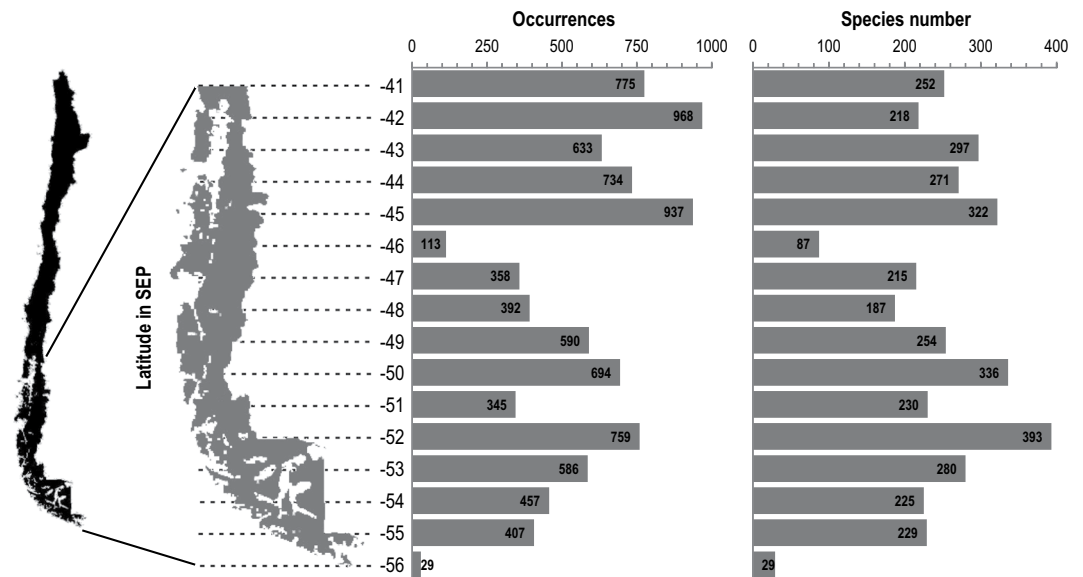


Fig. 6 Occurrences and number of species recorded by latitudinal band from the CIMAR 1 to 25 and CDHS-1995 cruises. SEP: South-eastern Pacific.

coordinates or other location data; these modifications were noted in the database in the “georeferenceRemarks” or “eventRemarks” column, depending on the nature of the modification. A total of 77 occurrences did not record geographic location (latitude and longitude) and could not be inferred from any source. Finally, all the nomenclature was verified by using World Register of Marine Species⁵⁷, “WoRMS Taxon match” tool.

Code availability

No custom code was used.

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Author contributions

C.A. gathered and systematized the literature, obtained the original sources of information, prepared and transformed the original data to GBIF standards and created dataset metadata. He also wrote the Data Descriptor. L.N. collaborated directly in the entire process developed by C.A., especially in preparing and transforming the original data to GBIF standards. M.P.A. supervised data management and publication as well as metadata and Data Descriptor writing and figure editing. I.A. collaborated in the technical validation of the data. F.B. supervised data management and publication as well as metadata and Data Descriptor writing.

Competing interests

The authors declare no competing interests.

Additional information

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