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Literature-based trait dataset of marine holozooplankton from the European Arctic and sub-arctic regions

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Abstract

This dataset presents a region-specific compilation of functional traits for meso-holozooplankton in the European Arctic and sub-Arctic. Driven by high-latitude climate change, this resource aims to enhance ecological modeling of this vulnerable ecosystem. The database aggregates 3,425 citation-backed records structured across 30 traits, ascribed to 11 functional traits, capturing morphological, behavioral, life-history, and biochemical traits. In total, 242 unique zooplankton species spanning 87 taxonomic families (7 phyla, 13 classes, 26 orders) are covered. A crucial feature of the dataset is the inclusion of ontogenetic trait information, addressing the current knowledge gap for early developmental stages. The compilation prioritizes data from the Arctic region, utilizing a systematic literature review to ensure accuracy and reduce bias from global databases. By harmonizing trait definitions according to FAIR standards, and identifying gaps in existing knowledge, this dataset provides Arctic researchers with a valuable, traceable resource for understanding and predicting ecosystem functioning in rapidly changing high-latitude environments.

Background

The field of trait-based ecology has grown significantly over the past few decades, contributing to a deeper understanding of how organisms influence and regulate ecosystem processes and functions[1,2]. Functional traits, which are morphological, physiological, or phenological characteristics measurable at the individual level, establish a connection between an individual's performance and its biotic and abiotic surroundings[1]. In aquatic environments, the application of trait-based approaches has been particularly effective, offering a deeper understanding of ecosystem dynamics[3].

Holomesozooplankton, as a key component of marine food webs[4], play a crucial role in ocean food webs due to their abundance and essential ecological functions[5].
Their unique adaptations enable them to thrive in the Arctic's extreme environment, where primary production is concentrated in a short summer season, making them essential to the region's food web[6]. The examinations of mesozooplankton functional traits, provides invaluable insights into their ecological role and functions, including nutrient cycling, and responses to environmental changes[7,8].

However, polar marine environments are undergoing rapid transformations due to climate change, which is impacting local wildlife populations as well as the broader ecosystem functions, goods, and services[9-11]. Forecasting the manner, direction, and magnitude of these impacts

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remains challenging[11],particularly in the Arctic, where the availability of trait data is limited[12]. Although some insights into trait-function relationships can be derived from studies conducted at lower latitudes, the distinct characteristics of polar ecosystems raise doubts about the applicability of these findings in polar contexts[12]. Previous efforts to collect and compile functional trait datasets for copepods[13-17] and zooplankton species[18-2016-18] provided an invaluable source of data. However, a region-specific focus is crucial for accurately depicting the northern polar region by utilising measurements and information collected directly from these areas. This approach yields a more precise understanding than is possible with global trait datasets, which often bias results toward temperate or tropical environments and fail to account for the variability in size ranges exhibited by widely distributed species across different regions. Furthermore, data from Arctic regions are scarce due to limitations in sampling[12], especially during winter, therefore by prioritising data from the European Arctic, this dataset offers insights that are finely tuned to the environmental conditions and ecological dynamics of this unique region.

The study of zooplankton traits in the Arctic is hindered by several challenges. Much of the existing information is dispersed across older literature, stored in inaccessible formats, or remains unpublished, making it difficult to locate and utilize[21]. Furthermore, available data are often heterogeneous, with inconsistencies in the definition, measurement, and reporting of traits[21]. Existing resources frequently focus on single orders or families, complicating efforts to harmonize data across taxa[21]. These limitations highlight the need for standardized and centralized trait data to improve accessibility and comparability, facilitating a more comprehensive understanding of Arctic zooplankton and their ecological roles.

Ontogeny, the developmental changes that organisms undergo throughout their life cycle, represents another critical but underexplored aspect of trait-based research[21,22]. Including data on early developmental stages enhances the understanding of how zooplankton adapt to the Arctic's challenging environmental conditions. However, significant gaps persist in the availability of data for early life stages across many zooplankton taxa. The study of early life-stage traits is further complicated by taxon-specific criteria for defining and categorizing younger stages, such as size ranges, moulting stages, or other developmental markers.

The creation of a curated dataset focused on the functional traits of European Arctic and sub-Arctic zooplankton species addresses these challenges. This dataset aims to improve the accessibility, standardization, and comparability of functional trait data by harmonizing trait categories and definitions across multiple taxa. By prioritizing data from the European Arctic, the dataset provides region-specific insights that are better aligned with the unique environmental conditions and ecological dynamics of the Arctic. This approach also helps to address the scarcity of Arctic-specific data, which is often limited by sampling constraints, particularly during winter[12]. The dataset supports the principles of FAIR (Findable, Accessible, Interoperable, and Reusable) research[23] and serves as a valuable resource for Arctic ecologists. By offering a comprehensive collection of functional trait data, the dataset facilitates a more accurate understanding of zooplankton function and enhances the ability to predict ecosystem responses in a rapidly changing Arctic.

Methods

The traits included in the dataset were selected based on most relevant and recent zooplankton functional trait studies[8,13,15,16,18-20,24-26] and their applicability to the European Arctic region, resulting in a compilation of 30 traits, belonging to 11 functional traits in 4 overarching categories (Table1).

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Table 1. Overview of investigated traits and their categories

Functional category	Functional trait	List of investigated traits
Morphological	Body Length	meanBodyLength, minimumBodyLength, maximumBodyLength, prosomeLength
Morphological	Dry Weight	dryWeight
Behavioural	Feeding Mode	currentFeeding, cruiseFeeding, passiveAmbushFeeding, activeAmbushFeeding, particleFeeding, depositFeeding, parasitism
Behavioural	Trophic Guild	carnivore, omnivore, herbivore, detritivore
Behavioural	Spawning Strategy	freeSpawner, eggCarrier, broodPouch, asexual
Life-History	Egg Size	meanEggSize, minimumEggSize, maximumEggSize
Life-History	Clutch Size	meanClutchSize, minimumClutchSize, maximumClutchSize
Life-History	Geographic Distribution	geographicDistribution
Life-History	Environmental Position	environmentalPosition
Biochemical	Lipids	lipidContent
Biochemical	Wax Esters	waxEstersContent

The species targeted for inclusion in this dataset were those identified as the most commonly observed in the European Arctic open ocean region, with a primary focus on species from the Norwegian Arctic, including the Barents Sea, Amundsen Basin, and Nansen Basin. This selection was based on species and life stages included in the recent Arctic datasets from the multidisciplinary project The Nansen Legacy[27-32] and a dataset from the Fram Strait Area[33]. Consequently, the taxa list is largely concentrated on this region, which has a considerable Atlantic influence[34]. However, additional occurrences from the Pacific, particularly for copepod records, were found and added when encountered following a snowball method. Additional copepod species were selected from the Biodiversity of Marine Planktonic Copepods dataset[35], which includes information on morphology, geographical distribution, and biological data.

Zooplankton functional traits were compiled from the literature through systematic searches conducted primarily on Web of Science, utilizing all available databases (Web of Science Core Collection, Grants Index, KCI, Preprint Citation Index, and ProQuest™) across an unrestricted timespan and further research in case there were no record suitable was conducted with the same method in Google Scholar. The search results were manually screened for eligibility, and peer-reviewed studies were selected based on specific availability criteria: data had to be directly accessible as a dataset, website, in-text table, or supplementary material. Publications where data were only obtainable upon request were excluded. Data were gathered through an extensive literature review compiling published peer-reviewed papers, institutional databases, and academic library-archived literature. Factual trait data were extracted and synthesized under

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academic fair-use guidelines, with every individual entry explicitly linked to its original reference in the final data matrix to ensure full reproducibility and citation compliance.

To ensure comprehensive coverage, both accepted and unaccepted species names were searched in cases where species had been renamed, allowing access to the widest range of information. The taxonomical reference used for this process is WORMS[36]. Boolean combinations were applied in the topic field tag to refine the search, and keywords along with common synonyms were used to maximise the yield of eligible publications (Table 2).

Table 2. Overview of Boolean research terms and synonyms

Functional Traits	**Used Synonyms**	**Specified Area**
Body length & dry weight	length; body length; truck length; prosome length, total length, diameter; size; body mass; individual size; body size; dry weight	Arctic, Arctic Ocean, Polar Ocean, Polar
Feeding mode	feeding strategy; ambush feed*, current feed*, cruise feed*; particle feed*, suspension feed*, filter feed*, parasitism, swimming behaviour; prey capture; foraging strategy; passive; active	Arctic, Arctic Ocean, Polar Ocean, Polar
Trophic guild	diet, herbivore, herbivory, carnivore, carnivory, detritivore; detritivory; omnivore; omnivory; trophic position; food web role	Arctic, Arctic Ocean, Polar Ocean, Polar
Spawning strategy, egg size and clutch size	spawning; eggs; fecundity; fertility; breeding strategy; reproductive output	Arctic, Arctic Ocean, Polar Ocean, Polar
Lipids & wax esters	lipid estimates, lipid biomarker; energy reserves; fat content; wax esters	Arctic, Arctic Ocean, Polar Ocean, Polar
Biogeographical distribution	biogeography, spatial distribution; latitudinal distribution; regional occurrence	Arctic, Arctic Ocean, Polar Ocean, Polar
Environmental position	environmental position, depth range, depth, vertical distribution	Arctic, Arctic Ocean, Polar Ocean, Polar

If there were multiple sources for the functional traits, we developed a process for selecting the most representative based on the following criteria: availability of multiple life stages, geographical area of the study, with priority given to the northernmost values when available.

Due to the high number of possible choices for a few well-studied species, robust studies, clearly reported data in tables, and that were the most straightforward to interpret were prioritized. When selecting trait values, preference was given to studies where the focal trait (e.g., lipids, size) was central to the research question, ensuring that the data were both relevant and reliable. This approach aimed to balance the scientific rigor with practical considerations in compiling the

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dataset. In cases where data were unavailable for specific species, proxies from closely related congeners were cautiously used and clearly annotated.

All categorical traits were ascribed to the species and included in the row corresponding to the adult form and female sex, particularly when traits for both sexes were documented. For species without distinct moulting stages or specific larval stages, values from intermediate size classes were noted when available in the literature.

Below is a detailed list of all trait categories included in the dataset, along with the corresponding information on how each trait was defined, treated or interpreted.

1. Morphological traits

Body length is always treated as a continuous variable representing the total length of an organism, typically measured along its longest axis. For example, in copepods, body size is measured from the front of the head to the end of the caudal ramus. However, there are exceptions: for appendicularians, body size refers to the length of the trunk, excluding the tail, and for medusae, it often refers to height, but for some species, only the bell diameter, excluding tentacles and cilia, was reported due to a lack of information for the height. This is specified in the dedicated comment column. Body length is consistently expressed in millimetres (mm). When a species did not have any reliable mean length available, a mean value was calculated as the midpoint of a range when given (average of the minimum and maximum values), possibly from the same sources, and included a note in the comment section indicating this adjustment. For copepods the prosome length was included when available and is consistently expressed in millimetres (mm).

Individual dry weight data was included in the dataset whenever available and, for consistency, was converted into micrograms (µg). This standardisation ensures comparability across species and studies, facilitating broader analyses. Where dry weight values were not explicitly reported, they were excluded from the dataset to maintain data accuracy and reliability.

2. Behavioural traits

Feeding mode is reported as a presence/absence variable that captures most of the different strategies adopted by different species. Coding this trait as a multi-column representation of the variable when each species can be assigned to more than one category provides flexibility to partially account for possible plasticity in the feeding behaviour of certain species. The behavioural functional traits in this dataset, specifically feeding modes and trophic guilds were scored using a robust, evidence-based data matrix framework. For each individual variable, a score of 1 was assigned if a specific trait or strategy was explicitly documented and confirmed for the organism by the compiled literature. Conversely, a score of 0 was strictly reserved for cases where a specific literature source had explicitly investigated and excluded the presence of that trait or behaviour, thereby establishing a verified biological exclusion. Crucially, when no direct empirical evidence was available to either confirm or rule out a trait, the entry was designated as NA (Not Available); rather than assuming an unverified absence and introducing artificial zeros into the matrix, these data-deficient gaps were preserved as non-asserted parameters to protect the statistical integrity of the dataset for future modelling applications. This binary representation deliberately maximizes database adaptability. By providing unweighted, verified binary indicators, the framework remains fully prepared for user-defined fuzzy coding, allowing downstream researchers to assign custom, context-specific weights to the categories based on their own

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distinct modelling frameworks. This approach builds upon the data architecture foundations laid out by Brun et al. (2016) [9], while maximizing flexibility for ecological modelling.

The zooplankton feeding mode is based largely on the definitions by Kiørboe, 2011[37]with some adaptations to encompass the challenge of maintaining a reasonable number of categories while considering many different taxa.
Deposit feeding was broadened to include cryopelagic species when their observed feeding behaviour resembled that of typical deposit feeders, regardless of the physical substrate (e.g., whether feeding occurred on marine snow aggregated near the ice or directly on the seabed). This allowance was made to accurately reflect the organism's functional role in consuming aggregated particulate matter, which is characteristic of deposit feeding behaviour. The particle feeding category was included as a functional trait, recognizing its complexity and nuanced relationship with detritivory and other related strategies. To maintain consistency and comparability with previous zooplankton datasets, we adhered to established definitions but expanded the category to incorporate organisms that colonize particulate matter (e.g., marine snow). This comprehensive approach classifies species that interact with and derive nutrients from particulate matter, either through direct consumption or colonization, under a single integrated trait. This methodological decision was made to ensure a practical outcome, facilitating a broader understanding of particulate matter consumption across diverse taxa in the absence of fine-scale behavioural data.

Furthermore, trophic guild was included as broad categories, recognising that many zooplankton species exhibit flexible diets that are context-dependent and often shift with ontogeny. However, these dietary shifts are frequently overlooked in the current literature and are not adequately acknowledged. To acknowledge this, the classifications are binary coded, reflecting, at best of our current knowledge, the inherent variability and overlap in dietary behaviours across species. Nonetheless, they were selected to provide general guidance regarding the trophic position of each species and are not intended to represent the full extent of current knowledge on species-specific diets. For the purposes of this dataset, we define the trophic guild classifications as follows: herbivore, omnivore, detritivore, and carnivore.

The functional trait spawning strategy is categorised into four distinct groups based on reproductive behaviour. The first category, free spawning, includes organisms that release their eggs freely into the water column, allowing external fertilization to occur. The second category, egg-carrier, encompasses organisms that carry their eggs for a period of time. This category also includes organisms that produce an egg mass. The third category, brood-pouch, refers to organisms that carry their eggs or embryos within a specialised pouch, providing additional protection during development. Finally, the fourth category, asexual, includes organisms that reproduce without the involvement of eggs or sperm, employing methods such as budding or fragmentation. These categories collectively capture the diversity of reproductive strategies observed across different species.

3. Life-history traits

Egg size was recorded as the diameter of the egg in micrometres (µm). The data is presented as the mean, minimum, and maximum diameter recorded.
Clutch size was recorded as the number of eggs. This measurement varied based on the organism's reproductive strategy. For organisms producing an egg sac or masses, clutch size was the number of eggs contained within the sac or pouch. While for free spawners, clutch size was the number of eggs released freely in one reproductive event. The data is presented as the mean, minimum, and maximum number of eggs.

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Environmental position refers to the vertical or sedimentary zone in which organisms spend the majority of their life cycle, as documented in the literature. Depth ranges follow the classification from Wold et al. 2025[38] (based on Kosobokova et al., 2011[39]) and the The Arctic Traits database[40] have been categorized according to the Trait Thesaurus (https://doi.org/10.48373/sa6p-ta25).
This trait is specified only for adult females or undetermined adults and refers to the entire life cycle of the species, as it was challenging to provide detailed ontogenetic information for lesser-known species.
Distribution data were systematically extracted from the World Register of Marine Species (WoRMS) (www.marinespecies.org) and cross-referenced with information from the Arctic Register of Marine Species (ARMS) (www.arcticspecies.ca) as well as the Biodiversity of Marine Planktonic Copepods (https://copepodes.obs-banyuls.fr/en/index.php) for copepod species.
The classification process was guided by the International Hydrographic Organization (IHO) definition of the Arctic Ocean, which encompasses the Central Arctic Basin and connected marginal seas such as the Barents Sea, Greenland Sea, Canadian Arctic Archipelago, Beaufort Sea, Chukchi Sea, Hudson Bay, Hudson Strait, and the northern part of Davis Strait (north of 60°N). Key oceanographic features, including the Atlantic Water inflow (North Atlantic Drift) and Pacific Water inflow (Bering Strait Current), were considered in interpreting species' distributional ranges.

Species were then assigned to one of the following categories based on their documented occurrences:

- Arctic: Species with documented occurrences exclusively or overwhelmingly within the IHO-defined Arctic Ocean area, with no or negligible records from temperate or tropical latitudes of the Atlantic or Pacific Oceans. Some species might be considered bipolar but are ascribed as Arctic.
- Boreal with a widespread distribution across both major northern ocean basins, i.e., the North Atlantic Ocean and the North Pacific Ocean, and extending into the Arctic Ocean. These species are generally absent from tropical and Southern Hemisphere waters.
- Boreal-Atlantic: Species primarily distributed in the North Atlantic Ocean (e.g., Norwegian Sea, North Sea) with significant extensions into the IHO-defined Arctic Ocean, particularly in areas influenced by the North Atlantic Drift (e.g., Barents Sea, Svalbard region, deep Atlantic water layer).
- Boreal-Pacific: Species primarily distributed in the North Pacific Ocean (e.g., Bering Sea) with significant extensions into the IHO-defined Arctic Ocean via the Bering Strait (e.g., Chukchi Sea, Beaufort Sea).
- Widely Distributed: Species with extensive documented occurrences across multiple major oceanic basins and climatic zones, including the Arctic Ocean, Atlantic Ocean (temperate and/or tropical regions), and Pacific Ocean, even if sparse. The presence of a species in a distinct temperate region dataset, such as OBIS, served as a strong indicator for this classification, prompting further confirmation of global distribution via WoRMS.

4 . Biochemical composition

The physiological trait of lipid content is expressed as a percentage of dry mass (%DM). To ensure consistency during the literature search, only values expressed in this standardized form were included. We included values expressed in this unit regardless of the method originally used to measure lipids. We believe that expressing lipid content as a percentage of dry mass allows for reasonable comparability among values, even if measured using different methods, due to its standardized expression. Wax ester content is expressed as a percentage of total lipid (%TL).

During the literature search, only values expressed in this standardized form were included. Values that were difficult to trace or did not meet these criteria were excluded.
Lipid content can vary significantly across taxa due to seasonal fluctuations, which are challenging to fully capture. Since most studies were conducted during the summer, the values in this dataset primarily reflect summer conditions. However, in cases where studies reported values across multiple seasons, these were averaged to provide a more comprehensive representation. Additional details, including instances where seasonal values were averaged, are provided in the *occurrenceRemarks* section.

Data Record

The complete dataset is publicly available on LifeWatch Italy data portal https://dataportal.lifewatchitaly.eu/data with their respective DOI https://doi.org/10.48372/zzwt-r154[41].
The dataset is formatted as column-oriented tables with data reported in semicolon_separated values format (.csv). The associated metadata are described using the Ecological Metadata Language (EML 2.2.0) standard in extensible markup language (.xml) format to ensure data understanding and long-term control.

The table structure includes columns for taxonomic classification and all the investigated traits followed by two columns denoted as *bibliographicCitation* and *occurrenceRemarks* reporting references and comment or additional information related to the specific trait. Each of these columns is preceded by the trait name followed by an underscore for standardization purposes. Data variables included in the dataset are both numeric and categorical and are expressed in text and numeric formats. Semantic harmonization was conducted by using the Traits Thesaurus (https://doi.org/10.48373/sa6p-ta25) and Darwin Core Standards (https://dwc.tdwg.org/terms/), as outlined in Table 3.

Table 3. Description of dataset metadata with URIs

Column Name	**URI**	**Standard Terminology**
catalogNumber	http://rs.tdwg.org/dwc/terms/catalogNumber	An identifier (preferably unique) for the record within the data set or collection.
kingdom	http://rs.tdwg.org/dwc/terms/kingdom	The full scientific name of the kingdom in which the dwc:Taxon is classified.
phylum	http://rs.tdwg.org/dwc/terms/phylum	The full scientific name of the phylum or division in which the dwc:Taxon is classified.
class	http://rs.tdwg.org/dwc/terms/class	The full scientific name of the class in which the dwc:Taxon is classified.
order	http://rs.tdwg.org/dwc/terms/order	The full scientific name of the order in which the dwc:Taxon is classified.
family	http://rs.tdwg.org/dwc/terms/family	The full scientific name of the family in which the dwc:Taxon is classified.
genus	http://rs.tdwg.org/dwc/terms/genus	The full scientific name of the genus in which the dwc:Taxon is classified.
specificEpithet	http://rs.tdwg.org/dwc/terms/specificEpithet	The name of the first or species epithet of the dwc:scientificName.
acceptedNameUsage	http://rs.tdwg.org/dwc/terms/acceptedNameUsage	The full scientific name, with authorship and date information if known, of the accepted (botanical) or valid (zoological) name in cases where the

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		provided dwc:scientificName is considered by the reference indicated in the dwc:nameAccordingTo property, or of the content provider, to be a synonym or misapplied name. When applied to a dwc:Organism or dwc:Occurrence, this term should be used in cases where a content provider regards the provided dwc:scientificName to be inconsistent with the taxonomic perspective of the content provider. For example, there are many discrepancies within specimen collections and observation datasets between the recorded name (e.g., the most recent identification from an expert who examined a specimen, or a field identification for an observed dwc:Organism), and the name asserted by the content provider to be taxonomically accepted.
acceptedNameUsageID	http://rs.tdwg.org/dwc/terms/acceptedNameUsageID	An identifier for the name usage (documented meaning of the name according to a source) of the currently valid (zoological) or accepted (botanical) taxon.
scientificNameAuthorship	http://rs.tdwg.org/dwc/terms/scientificNameAuthorship	The authorship information for the dwc:scientificName formatted according to the conventions of the applicable dwc:nomenclaturalCode.
sex	https://kos.lifewatch.eu/thesauri/traits/c_9822141d	The sex of an organism.
Male	https://kos.lifewatch.eu/thesauri/traits/c_940c5444	Denoting sex of a male individual.
Female	https://kos.lifewatch.eu/thesauri/traits/c_c4a93913	Denoting sex of a female individual.
Undetermined sex	https://kos.lifewatch.eu/thesauri/traits/c_4965dcfd	Condition in which the sex of an individual organism cannot be identified or assigned, generally due to the absence of distinguishable sexual characteristics at a given developmental stage, or because such features are not externally apparent.
lifeStage	https://kos.lifewatch.eu/thesauri/traits/c_f4d8fb0a	The developmental stage of life of an organism.
Adult	https://kos.lifewatch.eu/thesauri/traits/c_ac9342d2	An organism that is fully grown or sexually mature.
Juvenile	https://kos.lifewatch.eu/thesauri/traits/c_8cb0c56c	An organism that is not fully grown or sexually mature.
Larval stage	https://kos.lifewatch.eu/thesauri/traits/c_8c0c4803	A distinct juvenile form many animals undergo before metamorphosis into adults.
Naupliar stage	https://kos.lifewatch.eu/thesauri/traits/c_06b3adb5	Earliest larval stage of many crustaceans, with three pairs of appendages, a median eye, and little or no segmentation.

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Veliger stage	https://kos.lifewatch.eu/thesauri/traits/c_767b8b35	Free-swimming larval stage of molluscs.
Copepodite stage I	https://kos.lifewatch.eu/thesauri/traits/c_f1e7113a	A development stage of copepods which immediately follows the nauplius stage. It is characterized by the presence of 2 swimming legs.
Copepodite stage II	https://kos.lifewatch.eu/thesauri/traits/c_18e5695a	A development stage of copepods which immediately follows copepodite stage 1. It is characterized by the presence of 3 swimming legs.
Copepodite stage III	https://kos.lifewatch.eu/thesauri/traits/c_8d7ed007	A development stage of copepods which immediately follows copepodite stage 2. It is characterized by the presence of 4 swimming legs.
Copepodite stage IV	https://kos.lifewatch.eu/thesauri/traits/c_361ffb10	A development stage of copepods which immediately follows copepodite stage 3. It is characterized by the presence of 5 swimming legs.
Copepodite stage V	https://kos.lifewatch.eu/thesauri/traits/c_17748669	A pre-adult stage of copepods which immediately follows copepodite stage 4. It is characterized by enlargement of the urosome and development of sexual organs.
Naupliar stage I	https://kos.lifewatch.eu/thesauri/traits/c_b74f6c9a	The first stage of development of crustaceans, after hatching from the egg.
Naupliar stage II	https://kos.lifewatch.eu/thesauri/traits/c_89fa76a2	The second sub-stage of the nauplius larval development stage of crustaceans.
Naupliar stage III	https://kos.lifewatch.eu/thesauri/traits/c_05405c0d	The third sub-stage of the nauplius larval development stage of crustaceans.
Naupliar stage IV	https://kos.lifewatch.eu/thesauri/traits/c_375766c8	The fourth sub-stage of the nauplius larval development stage of crustaceans.
Naupliar stage V	https://kos.lifewatch.eu/thesauri/traits/c_41569653	The fifth sub-stage of the nauplius larval development stage of crustaceans.
Naupliar stage VI	https://kos.lifewatch.eu/thesauri/traits/c_7fbab17a	The sixth and last sub-stage of the nauplius larval development stage of crustaceans.
Zoea stage I	https://kos.lifewatch.eu/thesauri/traits/c_7dafb0f5	The first planktonic larval stage of certain decapod crustaceans, particularly crabs and some Anomura. It represents the earliest zoeal stage following the nauplius.
Zoea stage II	https://kos.lifewatch.eu/thesauri/traits/c_d24444ea	The second planktonic larval stage of certain decapod crustaceans, particularly crabs and some Anomura.
Megalopa stage	https://kos.lifewatch.eu/thesauri/traits/c_b50aa35b	Post-larval stage in the development of decapod crustaceans, such as crabs and some lobsters. It follows the zoea stage and precedes the juvenile stage. The megalopa exhibits a broader, more flattened body compared to earlier larval stages, with its eyes becoming more developed. Key features like the carapace (shell) and more defined appendages begin to appear. The megalopa gains the ability to crawl and move in a way similar to juvenile crabs or lobsters, marking an important transition toward adulthood.

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Calyptopis stage	https://kos.lifewatch.eu/thesauri/traits/c_35ebfc80	The larval stage of euphausiids. This stage follows the nauplius and metanauplius stages and precedes the furcilia stage. During this stage, the larva begins to resemble the adult form more closely. It develops segmented body parts and functional appendages, and starts to feed actively on plankton. The calyptopis stage is characterised by the development of a carapace, the elongation of the abdomen, the differentiation of somites and the development of eyes under the carapace. There are three stages in this phase: calyptopis I, II and III.
Calyptopis stage I	https://kos.lifewatch.eu/thesauri/traits/c_2625230a	The first substage of the calyptopis larval phase in the development of Euphausiacea. It follows the nauplius II stage and marks a transition toward a more recognizable crustacean form.
Calyptopis stage II	https://kos.lifewatch.eu/thesauri/traits/c_2ea8a9b5	The second substage of the calyptopis larval phase in the development of Euphausiacea. It follows calyptopis stage I and represents further morphological development toward the adult form.
Calyptopis stage III	https://kos.lifewatch.eu/thesauri/traits/c_d8c9acc9	The final substage of the calyptopis larval phase in the development of Euphausiacea. It follows calyptopis stage II and marks significant morphological advancements as the larva transitions toward the furcilia stage
Furcilia stage	https://kos.lifewatch.eu/thesauri/traits/c_f59486c2	A larval stage in Euphausiacea, following the calyptopis stage, characterized by movable compound eyes that project beyond the carapace, progressive development of thoracic and abdominal somites, and the sequential appearance of pleopods. During this phase, the second antennae shift from natatory to primarily sensory function, photophores and setose pleopods develop, and the number of telson spines is gradually reduced until the juvenile form is reached. The number of stages varies among and within species.
Furcilia stage I	https://kos.lifewatch.eu/thesauri/traits/c_e7a0ae2b	Earliest substage of the furcilia phase in Euphasiacea, generally marked by the emergence of stalked compound eyes beyond the carapace, the appearance of pleopod rudiments as small uniramous buds without setae, and incomplete development of thoracic appendages.
Furcilia stage II	https://kos.lifewatch.eu/thesauri/traits/c_646c0a16	Second substage of the furcilia phase in Euphausiacea, generally marked by elongation and initial segmentation of pleopod rudiments (still non-setose), further differentiation of thoracic somites and appendages, and continuing

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		abdominal development.
Furcilia stage III	https://kos.lifewatch.eu/thesauri/traits/c_a8c02b96	Third substage of the furcilia phase in Euphausiacea, generally marked by the first pleopods becoming setose and functional, while others remain rudimentary, progressive shift of the second antennae from natatory to sensory function, and initial appearance of photophores.
Furcilia stage IV	https://kos.lifewatch.eu/thesauri/traits/c_549ebf2d	Fourth substage of the furcilia phase in Euphausiacea, generally marked by additional pleopods becoming setose, increased functionality of thoracic legs, progressive reduction of telson spines, and fully movable compound eyes.
Furcilia stage V	https://kos.lifewatch.eu/thesauri/traits/c_8a985f4a	Fifth substage of the furcilia phase in Euphausiacea, generally marked by nearly all pleopods being setose and functional, thoracic appendages approaching adult form, second antennae primarily sensory, and photophores more evident.
Furcilia stage VI	https://kos.lifewatch.eu/thesauri/traits/c_390d3651	Sixth substage of the furcilia phase in Euphausiacea, generally marked by a full complement of five setose pleopods, a telson with one terminal spine and two pairs of postero-lateral spines (juvenile pattern), and overall body form closely resembling the juvenile.
Mysis stage	https://kos.lifewatch.eu/thesauri/traits/c_5a95e765	Free-swimming planktonic larval forms of certain decapod crustaceans (especially shrimps,prawns, and some krill species) with three recognised development sub-stages. First sub-stage produced from protozoeae by moulting. It follows the nauplius or zoea stages and is characterized by a more advanced and recognizable form. The mysis larva has a more elongated, segmented body compared to earlier stages. It develops thoracic legs and often shows the presence of compound eyes.
Metanauplius stage	https://kos.lifewatch.eu/thesauri/traits/c_272bb5b8	Larval stage in Crustacea that follows the nauplius, generally marked by retention of the first three naupliar appendages together with the appearance of additional body segments and rudiments of further appendages. In euphausiacea it represents the stage between nauplius and calyptopis, typically with a vestigial abdomen and developing labrum, maxillules, maxillae, and first thoracopods.
Mean body length	https://kos.lifewatch.eu/thesauri/traits/c_88d07ed1	The mean value in a range of body length values. It is calculated as the sum of the body length values of all organisms divided by the number of organisms measured.

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Minimum body length	https://kos.lifewatch.eu/thesauri/traits/c_35a45f59	The minimum value in a range of body length values.
Maximum body length	https://kos.lifewatch.eu/thesauri/traits/c_c64288a6	The maximum value in a range of body length values.
prosomeLength	https://kos.lifewatch.eu/thesauri/traits/c_fdda62ec	Distance of anterior part of the body in some invertebrates. For Copepoda, prosome length is usually measured in lateral view from the anteriormargin of cephalosome to the posterior margin of the fifth pedi-gerous somite.
dryWeight	https://kos.lifewatch.eu/thesauri/traits/c_4d66d52a	The weight of an organism after removal of body fluids drying at 50-70 °C (typically at 60 °C) in a drying oven for 24 hours or until constant weight is reached.
lipidContent	https://kos.lifewatch.eu/thesauri/traits/c_6b4ee8b2	The amount and composition of lipids present in an organism. Lipid content can be expressed as a percentage of lipids in the organism or as a concentration per unit mass.
waxEstersContent	https://kos.lifewatch.eu/thesauri/traits/c_10573120	The amount and composition of wax esters present in an organism. Wax esters can be measured as a percentage of the total fatty acids in the organism or as a concentration per unit mass.
currentfeeding	https://kos.lifewatch.eu/thesauri/traits/c_41595f0d	Feeding mechanisms in which feeders generate a feeding current and retrieve prey either by directly intercepting it, by straining/filtering the prey out of the feeding current, or by perceiving and capturing individual prey that arrive in the feeding current.
cruiseFeeding	https://kos.lifewatch.eu/thesauri/traits/c_a83989c5	An organism that actively moves through the water column in search of food. This strategy involves continuous or intermittent swimming to maximize encounters with prey, often relying on sensory cues such as mechanosensory, chemosensory, or visual signals.
activeAmbushFeeding	https://kos.lifewatch.eu/thesauri/traits/c_adbace0f	Active Ambush Feeding refers to an ambush mechanism where feeders encounter and intercept food items that come within their reach. Once detected, typically through mechanosensory, chemosensory cues, or by hydrodynamic disturbances, the feeder rapidly strikes to capture the food.
passiveAmbusFeeding	https://kos.lifewatch.eu/thesauri/traits/c_baa698ef	Passive Ambush Feeding refers to an ambush mechanism where feeders passively encounter and intercept food items based on their movement. There is no remote detection of food, and no active responses from the feeder, other than processing the food item once it has been encountered.
particleFeeding	https://kos.lifewatch.eu/th	Particle feeding refers to a feeding strategy where

	esauri/traits/c_252cff60	organisms consume particulate organic matter, such as detritus, plankton, or suspended particles, from the surrounding environment. This strategy involves the detection and capture of particles using hydromechanical or chemical cues. The interaction with particles is often brief and transient, as organisms may visit aggregates, consume what they can, and then leave. The feeding behavior may be independent of particle concentration, relying instead on sensory mechanisms to locate and process the particles.
depositFeeding	https://kos.lifewatch.eu/thesauri/traits/c_1a260ee8	An organism that feeds on organic particles on or in a substratum.
parasitism	https://kos.lifewatch.eu/thesauri/traits/c_059f2729	An organism that lives and feeds in/on or with another organism (the host), and which is typically detrimental to the host to a greater or lesser extent.
carnivore	https://kos.lifewatch.eu/thesauri/traits/c_a0775f94	An organism that feeds on animal tissues.
herbivore	https://kos.lifewatch.eu/thesauri/traits/c_a827a4e2	An organism that feeds primarily on autotrophic organisms: plants, microalgae, cyanobacteria, periphyton and phytoplankton.
omnivore	https://kos.lifewatch.eu/thesauri/traits/c_42952c24	An organism that eats a mixed diet, including plants, animals, fungi and bacteria.
detritivore	https://kos.lifewatch.eu/thesauri/traits/c_32e4af95	An organism that consumes decomposing organic matter, known as detritus, which includes dead plant and animal material, as well as associated microorganisms.
freeSpawner	https://kos.lifewatch.eu/thesauri/traits/c_794c8011	Any organism releasing their eggs freely into the water column, after fertilization.
eggCarrier	https://kos.lifewatch.eu/thesauri/traits/c_c7f6dfd5	Any organism carrying their eggs on their bodies until the nauplii hatch.
broodPouch	https://kos.lifewatch.eu/thesauri/traits/c_3d345b4d	Any organism that carries developing eggs or embryos inside a specialized anatomical structure (brood pouch), offering physical protection.
asexual	https://kos.lifewatch.eu/thesauri/traits/c_396cf0b1	Reproduction which does not involve formation and fusion of gametes and results in progeny with an identical genetic constitution to the parent and to each other.
meanEggSize	https://kos.lifewatch.eu/thesauri/traits/c_a8d52a04	The mean value in a range of egg size values. It is calculated as the sum of the egg size values of all organisms divided by the number of eggs measured.
minimumEggSize	https://kos.lifewatch.eu/thesauri/traits/c_6ce19ae0	The minimum value in a range of egg size values.
maximumEgg	https://kos.lifewatch.eu/th	The maximum value in a range of egg size values.

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Size	esauri/traits/c_13c10872	
meanClutchSize	https://kos.lifewatch.eu/thesauri/traits/c_5facc6c4	The mean value in a range of clutch size values. It is calculated as the sum of the clutch size values of all organisms divided by the number of organisms measured.
minimumClutchSize	https://kos.lifewatch.eu/thesauri/traits/c_1225bac5	The minimum value in a range of clutch size values.
maximumClutchSize	https://kos.lifewatch.eu/thesauri/traits/c_a4f92984	The maximum value in a range of clutch size values.
geographicDistribution	https://kos.lifewatch.eu/thesauri/traits/c_6119f861	Refers to the relationship between a species and a specific geographical region (e.g. Arctic, Mediterranean, Atlantic).
Epipelagic	https://kos.lifewatch.eu/thesauri/traits/c_6478ee9d	An organism living or feeding up to depths of 200 m.
Mesopelagic	https://kos.lifewatch.eu/thesauri/traits/c_53cde937	An organism living or feeding at midwater, at depths between 200 m and 1000 m.
Abyssopelagic	https://kos.lifewatch.eu/thesauri/traits/c_2d1aa5b8	An organism living or feeding in ocean open waters at greater depths, typically ranging from 3000 or 4000 m to 6000 or 7000 m.
Bathypelagic	https://kos.lifewatch.eu/thesauri/traits/c_37b181dc	An organism living or feeding in ocean open waters at intermediate depths, typically ranging between 1000 and 3000 or 4000 m.
Hyperbenthic	https://kos.lifewatch.eu/thesauri/traits/c_2a106434	An organism that lives in the water layer close to the surface of the bottom substrates in aquatic environments, both marine and freshwater and regularly enters the overlying water column.
Endobenthic	https://kos.lifewatch.eu/thesauri/traits/c_89cb6a61	An organism that lives within the sediment in aquatic environments (marine or freshwater habitats), typically burrowing to various depths below the surface.
Cryopelagic	https://kos.lifewatch.eu/thesauri/traits/c_ef81f951	An organism living or feeding in association with sea ice within the upper ocean, typically just below or around the ice-covered surface waters.
Epibenthic	https://kos.lifewatch.eu/thesauri/traits/c_462f49d4	An organism that lives on the surface of the bottom substrates in aquatic environments, both marine and freshwater.
Epi-mesopelagic	https://kos.lifewatch.eu/thesauri/traits/c_65c2c6b3	An organism living or feeding across the epipelagic and mesopelagic zones, from the surface down to 1000 m.
Epi-bathypelagic	https://kos.lifewatch.eu/thesauri/traits/c_5810336e	An organism living or feeding across the epipelagic, mesopelagic, and bathypelagic zones, from the surface down to about 4000 m depth.
Meso-bathypelagic	https://kos.lifewatch.eu/thesauri/traits/c_7e00e94c	An organism living or feeding across the mesopelagic and bathypelagic zones, from 200

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		m down to 4000 m
Bathy-abyssopelagic	https://kos.lifewatch.eu/thesauri/traits/c_0fc034d0	An organism living or feeding across the bathypelagic and abyssopelagic zones, from 1000 m down to 6000 m
Endobenthic	https://kos.lifewatch.eu/thesauri/traits/c_89cb6a61	An organism that lives within the sediment in aquatic environments (marine or freshwater habitats), typically burrowing to various depths below the surface.
Hyper-epibenthic	https://kos.lifewatch.eu/thesauri/traits/c_5eabcac4	An organism living or feeding across the hyperbenthic and epibenthic zones.
Hyper-endobenthic	https://kos.lifewatch.eu/thesauri/traits/c_c3b2b6a7	An organism living or feeding across the hyperbenthic and endobenthic zones.
environmentalPosition	https://kos.lifewatch.eu/thesauri/traits/c_f7a0e7bc	The position of an organism in relation to its substrate or to the water column.
bibliographicCitation	http://purl.org/dc/terms/bibliographicCitation	A bibliographic reference for the resource.
occurrenceRemarks	http://rs.tdwg.org/dwc/terms/occurrenceRemarks	Comments or notes about the dwc:Occurrence.

These standardized terms, along with their corresponding URIs and definitions, were adopted to ensure semantic clarity and alignment with international data standards. The unit of measurement of numeric variables has been standardised according to the Trait Units in the Trait thesaurus.

Data Overview

The spatial coverage of the dataset includes 1,548 records sourced from Arctic studies. When specific data were unavailable within the Arctic context, measurements were occasionally sourced from other regions, including temperate areas (8 records from the Mediterranean Sea), tropical regions (3 records from the Indian Ocean), and the Southern Ocean (14 records). Additionally, the dataset comprises 602 records from the Atlantic Ocean and 289 records from the Pacific Ocean. A total of 961 records could not be ascribed to any specific location and were therefore classified as “Unspecified”. In total, the database aggregates 3,425 citation-backed trait observations extracted from literature. (Figure 1).

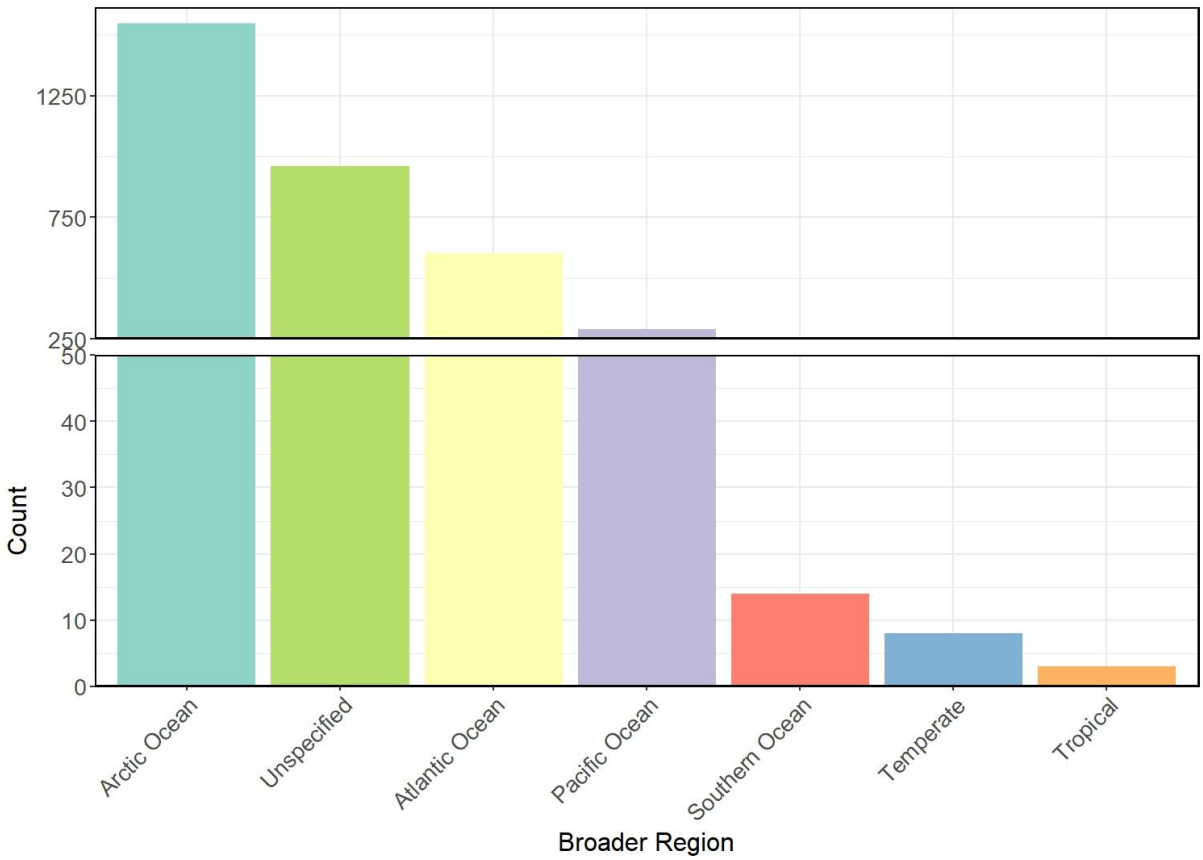

Figure 1. Distribution of Records Across Broader Geographic Regions. The Y-axis is broken into two segments (0-1375 and 0-50) to allow for clear visualization of the record counts in regions with very low coverage (Southern Ocean, Temperate, and Tropical).

The temporal coverage of the dataset spans from the oldest records, dating back to 1903, to the most recent data collected up to 2025. This range reflects both the historical depth and contemporary relevance of the literature-based research conducted on the subject, while also highlighting the need for updated research in light of recent changes in this delicate ecosystem.

Literature data were comprehensively compiled for 242 unique zooplankton species across different life stages, spanning a complete taxonomic hierarchy of 7 phyla, 13 classes, 26 orders, and 87 families (Figure 2).

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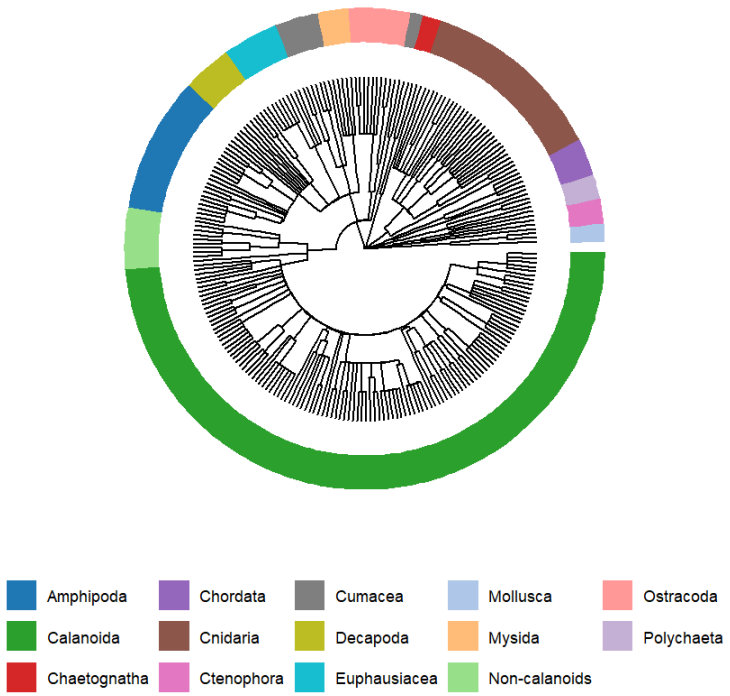

Figure 2. Circular Phylogenetic Tree of the zooplankton species included in the dataset. The outer colored ring denoting the distribution according to their traditional taxonomic classification.

In the compilation of this dataset, 272 distinct citations were referenced, ensuring that all data were traceable to primary sources. Any references that could not be verified or traced back to an original reliable source, were excluded to maintain the integrity and accuracy of the dataset. A list of references can be found in Supplementary Table 1.

The trait coverage for all recorded 236 adult species, as illustrated in Figure 3, highlights the extent of data availability and completeness.

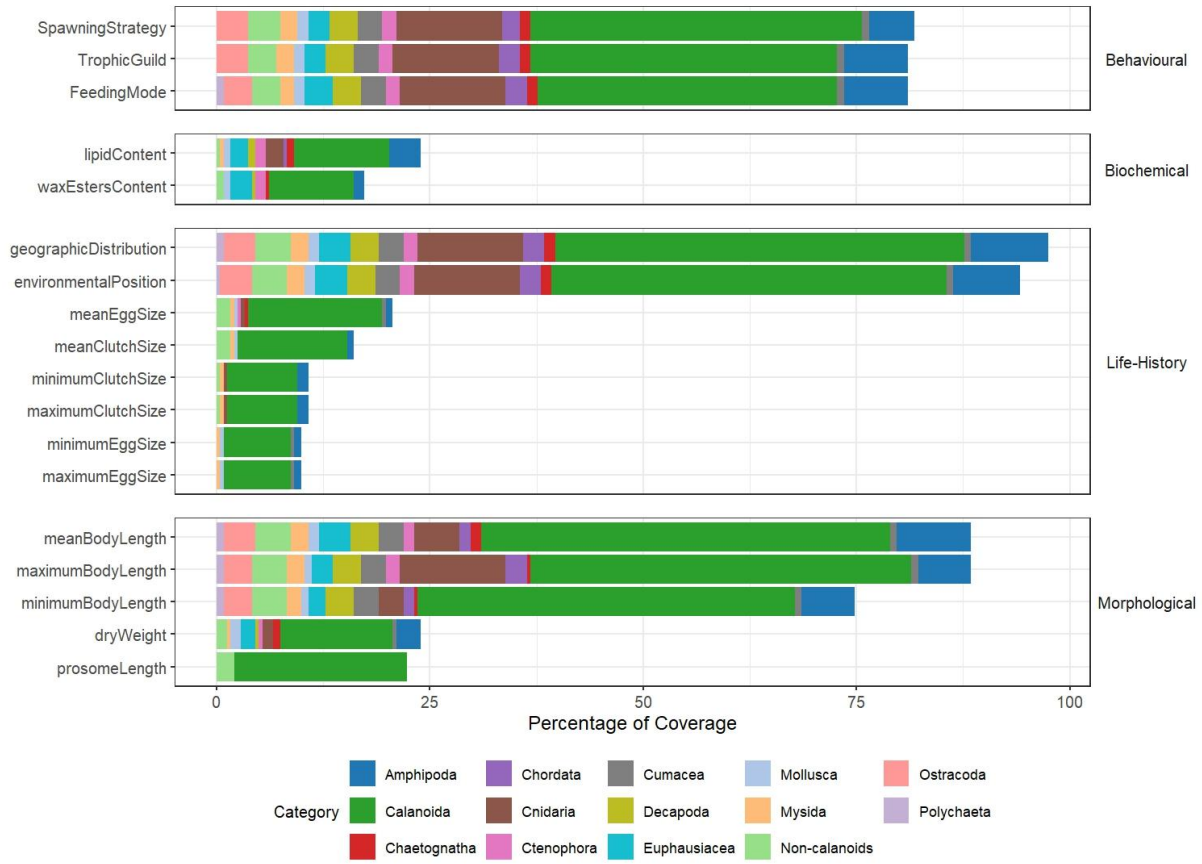

Figure 3. Record coverage by groups for adults.

While some groupings exhibit extensive trait data, others have more limited representation, reflecting potential gaps in research focus or data collection. This distribution underscores the importance of targeted efforts to enhance trait documentation for underrepresented taxa to ensure a more balanced and inclusive dataset.

Technical Validation

Data curation and technical validation steps were carried out to ensure the accuracy of the data and metadata. Manual verification was conducted to ensure all data were traceable to their original sources as well as identifying missing values, outliers, or inconsistencies. All compiled data were inspected to ensure that the data were contained within the methods and the DOI links provided as reference were correct. By applying these rigorous validation steps, the dataset was designed to be robust, reliable, and suitable for ecological research, while acknowledging the limitations and gaps that remain for certain taxa and life stages.

To ensure taxonomic accuracy, all species names were cross-referenced with the World Register of Marine Species (WoRMS)[36] (last accessed 01/10/2025) to confirm their validity and current nomenclature. Functional trait values were cross-checked against primary sources to ensure consistency in units and measurement methods, such as expressing body size in millimetres and lipid content as a percentage of dry mass. Categorical traits, including feeding mode and spawning strategy, were aligned with standardised trait definitions, such as those provided by the LifeWatch Trait Thesaurus, to explicitly define each trait, its description, and the corresponding units.

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Usage Notes

The taxonomic coverage of the dataset is extensive but not exhaustive, primarily reflecting European Arctic species influenced by the Atlantic inflow. Consequently, it does not encompass the full biodiversity of the Arctic region. While some taxonomic groups are well-represented with extensive trait data, others have limited representation, highlighting gaps in research focus and data collection. This underscores the need for targeted efforts to document traits of underrepresented species, ensuring a more balanced and inclusive dataset.

To maintain relevance to high-latitude environments, priority was given to trait information from northern regions (e.g., the Barents Sea) when available. However, due to a significant lack of information, data for meroplanktonic stages were generally excluded, resulting in limited coverage of taxa for which relevant values were not encountered.

Several limitations regarding individual traits must also be acknowledged. In cases where Arctic-specific values were unavailable, records from other regions were included to expand coverage. Specific data for life stages and sexes are scarce, so categorical traits primarily reflect adult forms. Additionally, representative mean size is often regionally specific and varies seasonally, but such values were frequently missing in the literature. Lipid content, in particular, remains one of the least consistently reported traits, with values influenced by various factors. Despite these limitations, the dataset aims to provide a broad indication of traits suitable for taxonomic comparisons. Users are encouraged to verify whether the reported trait values are appropriate for their specific studies.

Categorical traits, especially those related to feeding modes, posed additional challenges due to the scarcity of high-resolution behavioural data and the historical use of multiple, sometimes conflicting, definitions in the scientific literature.

While this dataset offers a valuable resource for understanding traits across taxa, it is important to recognize that the included traits are not exhaustive. This reflects both the inherent complexity and diversity of zooplankton traits and the evolving, open-ended nature of trait measurements, definitions, and descriptions.

Data Availability

The dataset and associated metadata can be accessed openly through LifeWatchItaly Dataportal at this link: https://doi.org/10.48372/zzwt-r154. The main trait dataset is provided as a comma-separated values (CSV) file. To safely open this file in Microsoft Excel without corrupting data formats or special characters, open a blank Excel file, navigate to the Data tab, click “From Text/CSV”, select the downloaded main table, and choose UTF-8 encoding and a comma delimiter before clicking Load.
Usage licence is under Creative Commons Attribution 4.0 International (CC-BY-4.0)

Code Availability

No custom code was used to generate the data described in the paper. Data curation and data visualization were realised using R version 4.5.1[42] and the tidyverse package version 2.0.0[43] as well as packages cluster v. 2.1.8.1 [44], ape v.5.8.1[45], ggtree v. 4.1.1[46] and ggtreeExtra v.1.21.0 [47] for further visualization purposes.

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T.D. conceived the study, conducted the literature search, collected, harmonized, and curated the initial data, and wrote the first draft of the manuscript. J.T. curated additional data and performed manuscript revisions.

No competing interests are declared for this work.

References

1 Violle, C. *et al.* Let the concept of trait be functional! *Oikos* **116**, 882-892 (2007). https://doi.org/10.1111/j.0030-1299.2007.15559.x

2 De Bello, F., Carmona, C. P., Dias, A. T., Götzenberger, L., Moretti, M. & Berg, M. P. Handbook of trait-based ecology: from theory to R tools. (Cambridge University Press, 2021).

3 Martini, S. *et al.* Functional trait-based approaches as a common framework for aquatic ecologists. (2021). https://doi.org/10.3929/ETHZ-B-000458312

4 Botterell, Z. L. R., Lindeque, P. K., Thompson, R. C. & Beaumont, N. J. An assessment of the ecosystem services of marine zooplankton and the key threats to their provision. *Ecosystem Services* **63**, 101542 (2023). https://doi.org/https://doi.org/10.1016/j.ecoser.2023.101542

5 Lomartire, S., Marques, J. C. & Gonçalves, A. M. M. The key role of zooplankton in ecosystem services: A perspective of interaction between zooplankton and fish recruitment. *Ecological Indicators* **129**, 107867 (2021). https://doi.org/https://doi.org/10.1016/j.ecolind.2021.107867

6 Saint-Béat, B., Darnis, G., Leclerc, M., Babin, M. & Maps, F. Same mesozooplankton functional groups, different functions in three Arctic marine ecosystems. *Functional Ecology* **36**, 3161-3174 (2022). https://doi.org/https://doi.org/10.1111/1365-2435.14179

ARTICLE IN PRESS

7 Barnett, A. J., Finlay, K. & Beisner, B. E. Functional diversity of crustacean zooplankton communities: towards a trait-based classification. *Freshwater Biology* **52**, 796-813 (2007). https://doi.org/10.1111/j.1365-2427.2007.01733.x

8 Barton, A. D. *et al.* The biogeography of marine plankton traits. *Ecology Letters* **16**, 522-534 (2013). https://doi.org/10.1111/ele.12063

9 Brun, P., Payne, M. R. & Kiørboe, T. Trait biogeography of marine copepods - an analysis across scales. *Ecology Letters* **19**, 1403-1413 (2016). https://doi.org/10.1111/ele.12688

10 Dalpadado, P. *et al.* Climate effects on Barents Sea ecosystem dynamics. *ICES Journal of Marine Science* **69**, 1303-1316 (2012). https://doi.org/10.1093/icesjms/fss063

11 Michel, C. *et al.* Biodiversity of Arctic marine ecosystems and responses to climate change. *Biodiversity* **13**, 200-214 (2012). https://doi.org/10.1080/14888386.2012.724048

12 Degen, R. *et al.* Trait-based approaches in rapidly changing ecosystems: A roadmap to the future polar oceans. *Ecological Indicators* **91**, 722-736 (2018). https://doi.org/10.1016/j.ecolind.2018.04.050

13 Benedetti, F., Vogt, M., Righetti, D., Guilhaumon, F. & Ayata, S.-D. Do functional groups of planktonic copepods differ in their ecological niches? *Journal of Biogeography* **45**, 604-616 (2018). https://doi.org/10.1111/jbi.13166

14 Benedetti, F., Gasparini, S. & Ayata, S.-D. Identifying copepod functional groups from species functional traits. *J. Plankton Res.* 38, 159–166 (2016). Data available at: https://doi.org/10.1594/PANGAEA.854331

15 Benedetti, F., Gasparini, S. & Ayata, S. D. Identifying copepod functional groups from species functional traits. *J Plankton Res* **38**, 159-166 (2016). https://doi.org/10.1093/plankt/fbv096

16 Benedetti, F., Wydler, J. & Vogt, M. Copepod functional traits and groups show divergent biogeographies in the global ocean. *Journal of Biogeography*, jbi.14512 (2022). https://doi.org/10.1111/jbi.14512

17 Brun, P., Payne, M. R. & Kiørboe, T. A trait database for marine copepods. *Earth System Science Data* **9**, 99-113 (2017). https://doi.org/10.5194/essd-9-99-2017

18 Pata, P. R. & Hunt, B. P. V. Harmonizing marine zooplankton trait data toward a mechanistic understanding of ecosystem functioning. *Limnology and Oceanography* **70**, S8-S27 (2025). https://doi.org/https://doi.org/10.1002/lno.12478

19 Venello, T. A., Sastri, A. R., Galbraith, M. D. & Dower, J. F. Zooplankton functional group responses to environmental drivers off the west coast of Vancouver Island, Canada. *Progress in Oceanography* **190**, 102482 (2021). https://doi.org/https://doi.org/10.1016/j.pocean.2020.102482

20 Pomerleau, C., Sastri, A. R. & Beisner, B. E. Evaluation of functional trait diversity for marine zooplankton communities in the Northeast subarctic Pacific Ocean. *Journal of Plankton Research* **37**, 712-726 (2015). https://doi.org/10.1093/plankt/fbv045

ARTICLE IN PRESS

21 Titocci, J. *et al.* Pathways for converting zooplankton traits to ecological insights are paved with findable, accessible, interoperable, and reusable (FAIR) data practices. *ICES Journal of Marine Science* **82** (2025). https://doi.org/10.1093/icesjms/fsaf017

22 Zhang, Z. *et al.* Trait-based approach revealed the seasonal variation of mesozooplankton functional groups in the South Yellow Sea. *Mar Life Sci Technol* **5**, 126-140 (2023). https://doi.org/10.1007/s42995-022-00156-9

23 Wilkinson, M. D. *et al.* The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data* **3**, 160018 (2016). https://doi.org/10.1038/sdata.2016.18

24 Kenitz, K. M., Visser, A. W. & Andersen, K. H. Response to comment: “What drives plankton seasonality in a stratifying shelf sea? Some competing and complementary theories”. *Limnology and Oceanography* **63**, 2885-2886 (2018). https://doi.org/10.1002/lno.11034

25 Litchman, E. *et al.* Global biogeochemical impacts of phytoplankton: a trait-based perspective. *Journal of ecology* **103**, 1384-1396 (2015). https://doi.org/10.1111/1365-2745.12438

26 Vogt, R. J., Peres-Neto, P. R. & Beisner, B. E. Using functional traits to investigate the determinants of crustacean zooplankton community structure. *Oikos* **122**, 1700-1709 (2013). https://doi.org/https://doi.org/10.1111/j.1600-0706.2013.00039.x

27 Wold, A., Søreide, J. E., Svensen, C., Halvorsen, E., Hop, H., Kwasniewski, S. & Ormanczyk, M. Mesozooplankton biodiversity Nansen Legacy Q3 [Dataset]. Norwegian Polar Institute. https://doi.org/10.21334/NPOLAR.2022.F7FD75BC (2022).

28 Wold, A., Søreide, J. E., Svensen, C., Halvorsen, E., Hop, H., Kwasniewski, S. & Ormanczyk, M. Mesozooplankton biodiversity Nansen Legacy Q4 [Dataset]. Norwegian Polar Institute. https://doi.org/10.21334/NPOLAR.2022.97DE88EF (2022).

29 Wold, A., Søreide, J. E., Svensen, C., Halvorsen, E., Hop, H., Kwasniewski, S. & Ormańczyk, M. Mesozooplankton biodiversity Nansen Legacy Q1 [Dataset]. Norwegian Polar Institute. https://doi.org/10.21334/NPOLAR.2022.914B8DE1 (2022).

30 Wold, A., Søreide, J. E., Svensen, C., Halvorsen, E., Hop, H., Kwasniewski, S. & Ormańczyk, M. Mesozooplankton biodiversity Nansen Legacy Q2 [Dataset]. Norwegian Polar Institute. https://doi.org/10.21334/NPOLAR.2022.33385AB0 (2022).

31 Wold, A., Søreide, J. E., Svensen, C., Halvorsen, E., Hop, H., Kwasniewski, S. & Ormańczyk, M. Mesozooplankton biodiversity Nansen Legacy JC2-1 [Dataset]. Norwegian Polar Institute. https://doi.org/10.21334/NPOLAR.2022.BB4E2203 (2022).

32 Wold, A., Søreide, J. E., Svensen, C., Hop, H., Kwasniewski, S. & Ormańczyk, M. Mesozooplankton biodiversity Nansen Legacy JC2-2 [Dataset]. Norwegian Polar Institute. https://doi.org/10.21334/NPOLAR.2024.667911E4 (2024).

33 Giordano, P. *et al.* Composition and morpho-functional traits of zooplankton swimmers and sinkers collected by "Mooring Dirigibile Italia" sediment trap. v. 1.12. Consiglio

ARTICLE IN PRESS

Nazionale delle Ricerche, Istituto di Scienze Polari. Samplingevent dataset. https://ipt.vliz.be/cnr-isp/resource?r=kairos_dto_bioflow&v=1.12 (2025).

34 Ingvaldsen, R. B. *et al.* Physical manifestations and ecological implications of Arctic Atlantification. *Nature Reviews Earth & Environment* 2, 874-889 (2021). https://doi.org/10.5194/essd-11-301-2019

35 Razouls, C., Desreumaux, N., Kouwenberg, J. & de Bovée, F. Biodiversity of Marine Planktonic Copepods (morphology, geographical distribution and biological data). Sorbonne University, CNRS. http://copepodes.obs-banyuls.fr/en (2005–2025).

36 WoRMS Editorial Board. World Register of Marine Species. https://doi.org/10.14284/170

37 Kiørboe, T. How zooplankton feed: mechanisms, traits and trade-offs. *Biological Reviews* **86**, 311-339 (2011). https://doi.org/10.1111/j.1469-185X.2010.00148.x

38 Wold, A. *et al.* Zooplankton communities across the Nansen and Amundsen Basins of the Arctic Ocean. *ICES Journal of Marine Science* **82** (2025). https://doi.org/10.1093/icesjms/fsaf184

39 Kosobokova, K. N., Hopcroft, R. R. & Hirche, H.-J. Patterns of zooplankton diversity through the depths of the Arctic's central basins. *Marine Biodiversity* **41**, 29-50 (2011). https://doi.org/10.1007/s12526-010-0057-9

40 Degen, R. & Faulwetter, S. The Arctic Traits Database – a repository of Arctic benthic invertebrate traits. *Earth System Science Data* **11**, 301-322 (2019). https://doi.org/10.5194/essd-11-301-2019

41 Durazzano T, Titocci J. Literature-based trait dataset of marine holoplankton from the European Arctic and sub-Arctic regions [Internet]. LifeWatch ERIC; 2025. Available from:https://metadatacatalogue.lifewatch.eu/srv/eng/catalog.search#/metadata/f230ec6b-e0aa-4bfc-ab55-e7a956c287c3

42 R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

43 Wickham, H. a. A., Mara and Bryan, Jennifer and Chang, *et al.* Welcome to the tidyverse. *J. Open Source Softw.* **4**, 1686 (2019). https://doi.org/2475-9066

44 Maechler, M. R., Peter; Struyf, Anja; Hubert, Mia and Hornik, Kurt cluster: Cluster Analysis Basics and Extensions. (2025).

45 Pardis, E. S., Klaus. ape 5.0: an environment for modern phylogenetics and evolutionary analyses in {R}. *Bioinformatics* **35**, 526-528 (2019). https://doi.org/10.1093/bioinformatics/bty633

46 Yu, G., Smith, D. K., Zhu, H., Guan, Y. & Lam, T. T.-Y. ggtree: an r package for visualization and annotation of phylogenetic trees with their covariates and other associated data. *Methods in Ecology and Evolution* **8**, 28-36 (2017). https://doi.org/https://doi.org/10.1111/2041-210X.12628

ARTICLE IN PRESS

47 Xu, S. *et al.* ggtreeExtra: compact visualization of richly annotated phylogenetic data. *Molecular biology and evolution* **38**, 4039-4042 (2021). https://doi.org/10.1111/2041-210x.12628

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