https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Open Access Earth System Science Data Discussions

A database of net zooplankton of the Far East seas and adjacent Pacific Ocean waters

Short running title: **A database of zooplankton from Far East seas**

Igor V. Volvenko

Pacific Branch of Russian Federal Research Institute of Fisheries and Oceanography (TINRO), Vladivostok, Russia, E-mail: oknevlov@gmail.com

Abstract. This article describes the unique database of zooplankton collected by the large Juday net in 1984-2013 in the Chukchi, Bering, Okhotsk, Japan seas and the North Pacific Ocean: the sources and extent of the information contained therein, its benefits and drawbacks, the first operating experience and prospects. The information in this database has already been used to quantify the inventory of marine biological resources and appraise the waters of the North Pacific. In particular, in 2016, five tabular reference books were created and printed containing the species composition, occurrence and abundance of zooplankton in the surveyed area. The data is aggregated by species, developmental stages, size fractions, regions, vertical layers of water, light and dark time of day, four seasons of the year and perennial periods. This information has recently been verified, corrected, translated into English and from text to digital format to increase its availability to the scientific community worldwide (Volvenko, 2021 https://doi.org/10.5281/zenodo.4448646). The substantial volume and high quality of the collated data, along with the information presented in reference books and previously published data on macrofauna and the nutrition of common fish and squid, will enable the next important steps to be taken to understand the Far Eastern seas and the Pacific – one of the most productive and economically important regions of the world ocean. The scope of application of this data is fundamental to the management of marine resources, aquaculture development, nature conservation, and assessment of the damage of various anthropogenic factors on nature.

Keywords: appraisal of waters; database; knowledgebase; long-term monitoring; North Pacific and East Arctic; reference books; zooplankton

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Sections

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Introduction

Since the end of the 1970s the TINRO has adhered to the ecosystem approach to the study and management of living aquatic resources, which involves the collation and analysis of data for all groups of animals, highlights the interconnections between them and the role of the climate and hydrological regime in the fluctuations of their numbers (May, 1984; Shuntov, 1988, 1995, 2010; Shuntov et al., 1997; Lapko, 2000; Bocharov, Shuntov, 2003; Reports, 2004; Dulepova, 2005; Misund, Skjoldal, 2005; The Ecosystem, 2008; Beamish, Rothschild, 2009; Bulatov, Kotyenyov, 2012; Shuntov, Temnykh, 2013). In large-scale integrated marine expeditions all sorts of information about marine biological communities and their abiotic environment have been collated via this approach over the last 44 years in the North Pacific and adjacent Arctic. Nekton, benthos and nektobenthos are counted primarily by the trawling method, and each trawl is accompanied by the collation of oceanographic data. Since 1984 up to now, plankton samples have been taken at all measurement stations according to a common standard.

Plankton is collected using a large standard sized Juday net made of kapron sieve No. 49 (0.168 mm mesh) with a 0.1 m^2 opening (Fig. 1) from a depth of 200 m to the surface, and where the depth is less than 200 m from the bottom to the surface. For study the upper pelagic water layer additional plankton samples is collected in the 0-50 m. Other depths are sampled layer-by-layer to study the migration and of vertical distribution plankton. Samples processed by the express method (Volkov, 1984, 1996a, 2008a) with the separate analysis of three size fractions – length of 0.6-1.2 mm (fine), 1.2-3.2 mm (medium) and > 3.2 mm (large). Research groups usually work in two shifts, so the data collection takes place both day and night in order to calculate the vertical diurnal migration of euphausiids, copepods and hyperiids, which descend during the day into the deeper layers beyond the epipelagic zone. Surveys are performed all year round, if possible, and annually across standard sampling grid. They regularly cover the entire exclusive economic zone (EEZ) of Russia and sometimes the adjacent waters (Volvenko, 2015a).

All the samples of primary materials of oceanographic and trawl surveys were conducted centrally in a common format according to strictly verified rules in the laboratory of the TINRO

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

regional data center (Volvenko, 2014a, 2015d), where there is an archive office and a specialized database (DB), where the data can be openly accessed in a prescribed manner in raw or processed form. The situation is more complicated when plankton measurements were taken spontaneously and randomly by individual experts whose data was written in personal notebooks, or after the emergence of personal computers, on spreadsheets (often Microsoft® Office Excel) in an arbitrary format. This data was only accessible and understandable to one person, not comparable with similar data from other scientists, and may have been irrevocably lost in the event of his or her dismissal (or death), or simply due to negligence, improper storage, careless handling, etc. Until finally, during the implementation of the Concept of Information Support (CIS) for fundamental and applied research (Volvenko, 2015a, 2016) after the macrofauna pelagic and bottom trawl DBs (Volvenko, Kulik, 2011; Volvenko et al., 2012, 2014a, b; Volvenko, 2014b, 2015b), the new, large DB "*Net zooplankton in the North Pacific, 1984-2013*" (Volvenko et al., 2016) was created by TINRO in 2012-2014, put into trial operation 2015, and officially registered in the State Register of the Russian Federation in 2016.

Macrofauna referred to above means organisms with a body size of 1 cm to several meters and weighing from grams to hundreds of kilograms. In fact, this is all animals that are caught by trawls fitted in the cod end with a fine-meshed insert from 10-12 mm netting – representatives of nekton, benthos and macrozooplankton[1]. In contrast, *mesofauna*, the details of which are aggregated in the new DB, is caught by the plankton net. These organisms have a smaller body size and weight from hundreds to thousandths of a milligram, and are primarily the food supply for trawl macrofauna, marine birds and mammals, and also the larvae of invertebrates and fish, the so-called *net zooplankton* (hereinafter referred to as *zooplankton* for short without specifying that it is net zooplankton and without the prefix meso).

This DB contains information on the status and spatial-temporal dynamics of the planktonic part of the biotic community from the early 1990s onwards, which provides 90% of the Russian catch of fish and other marine organisms (Bocharov, 2004, 2010) during a time period in which there were

[1] Macrozooplankton usually refers to jellyfish, comb jellies, pelagic tunicates, and by some scientists to relatively small or slow-moving fish and invertebrates which are unable to swim against the current.

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

considerable transformations in the biota of the region caused by changes to global climate and oceanological and cosmic-geophysical factors (e.g.: Shuntov et al., 1993, 1997, 2007; Shuntov, 1994, 1998; Shuntov, Temnykh, 2011). Therefore, it is difficult to overestimate its role in the ecosystem, biogeographic, trophological and bioresource studies of the Far Eastern seas of Russia and adjacent waters of the Pacific Ocean.

The article provides a brief description of how this unique DB was created, the sources and volume of information contained in it, its benefits and drawbacks, some results achieved through it concerning the quantitative inventory of marine biological resources and appraisal of waters in the North Pacific, the future prospects for its utilization in applied and fundamental research.

Materials and Methods

Raw data for the DB is taken from plankton processing cards (Fig. 2), filled in (by hand on paper forms and/or in the form of spreadsheets) by TINRO employees during comprehensive ecosystem surveys in the North Pacific and the eastern sector of the Arctic. Of the many hundreds of scientific and commercial surveys only 235 were selected for data processing (Fig. 3); those where samples were taken by the same fishing gear, and processed in strict accordance with the procedures adopted by TINRO in the 1980s (see Introduction), and where all zooplankton groups were fully and thoroughly counted.

Along with other data the DB includes more than 1,100 samples collated from non-Russian ships. The fishing vessel "Sea Storm", the research ships "Oscar Dyson" (USA) and "Kaiyo Maru" (Japan) carried out simultaneous trawl and plankton surveys mostly in the central and eastern parts of the Bering Sea[2] under the international program BASIS (Bering-Aleutian Salmon International Survey), organized by the NPAFC (North Pacific Anadromous Fish Commission) member countries in 2002-2012. In the Sea of Japan 95 measurements in 1999-2007 were taken on board the Japanese fishing schooner Chokai Maru. All these ships had TINRO planktonologists who collected samples

[2] These expeditions recorded the impact of prolonged climatic fluctuations on plankton and, as a consequence, on the nutrition of fish living there, including the Pacific salmon (e.g.: Volkov et al., 2009; Volkov, 2012, 2014), which these expeditions were organized to study.

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

with the same gear and processed them following TINRO protocols. Plankton samples in the EEZ of North Korea (see Fig. 3) were taken from Russian ships, which were carrying out standard comprehensive studies of the biological resources under an intergovernmental agreement. Therefore, all the data in the DB, regardless of the place and time of its collation, are fully comparable.

In fact, the DB preparations began with the preliminary digitization of the primary data by TINRO planktonologists in Excel spreadsheets. Upon its completion, Dr. Volkov A.F. kindly gave me the file (168 MB) with four tables measuring 244 columns by 41,809 rows, which contained information about the measurements taken in the Chukchi and Bering seas, the Sea of Okhotsk and the North Pacific Ocean, with data on abundance (specimens/m^3) and biomass (mg/m^3) of plankton caught by the Juday net, calculated with corrections made for catch efficiency and information about the values of these corrections. Similar tables (14 MB) from the Sea of Japan but without data on plankton biomass were drawn up by Ph.D. Dolganova N.T. Such planktonology tables were satisfactory for many years[3]. The significant disadvantages of this approach to data storage and processing were discovered only recently as the data accumulated.

By 2014, in accordance with the plans for the implementation of the CIS, I combined and transformed these tables into a relational DB using Microsoft® Office Access. Some of the obvious benefits of this form of storage are given in Table 1.

In the development of this DB structure (Fig. 4) industry standards, standard forms, and codifiers (Fisheries 1976, Codifier 1980, Instructions 1982) were utilized, as well as previous experience in creating the DBs of trawl macrofauna (Volvenko et al., 2012, 2014a, b). While working on the raw data thousands of typos and omissions were found. In particular, coordinates, names of bodies of water and region numbers, sampling dates and times, time of day, light or dark, ship names and survey numbers, synonyms and obsolete names of species, classification of size groups in the wrong fractions, absent and/or incorrect abundance values N and biomass M were corrected; duplicate records were removed, data format errors were eliminated.

[3] In some publications (e.g.: Dulepova, 2014; Volkov, 2015), they were called "Plankton databases", before data on them was imported into the real DB.

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

In addition, records for the Chukchi and Bering seas, the Sea of Okhotsk, the Sea of Japan and the Pacific Ocean were found and outliers for the average individual weight of specimens $W = M/N$ (mg/specimen) were corrected. The errors were due to the incorrect number values N (specimens/m^3) or biomass M (mg/m^3) species in the catch: where the values W were different from the well-known values for this species of the long-term annual average modulus[4] by more than 20%, the abundance indices were recalculated using the formulas $N = M/W$ and $M = N{\cdot}W$ based on the long-term annual average W. The fact that (according to information received from data collators) until 1988 inclusive, the processing of samples accurately assess biomass, and since 1989, number. Accordingly, in the first case, N of organisms was calculated by M, and in the second, M by N.

As already mentioned above, initially there was a lack of data on biomass in the Sea of Japan. Using the available data on N and the long-term annual average W, taken from standard tables on wet weight (Borisov et al., 2004; Mikulich, Rodionov, 1975), amended and supplemented by Dr. Dolganova, M plankton was calculated for each sample according to the formula $M = N{\cdot}W$.

Then the occurrence of every species of each of the fractions in the surveyed waters was mapped. From this process any species found extremely far beyond their well-known geographical range were corrected, and given the names of species which look similar to the former, but are common in the survey area.

Thereafter, data on the relative abundance of marine organisms classified per cubic meter was reconverted to primary measurements while factoring in catch efficiency. Now the DB does not contain the results of calculations, but the raw data for them: the data of actual measurements and the list of adopted corrections regarding catch efficiency for each species. As a result, unrequired fields were deleted from the DB, and its size decreased to 52.6 MB. The initial tables, in the form in which they were prepared by Volkov and Dolganova, only now without mistakes, are instantly accessible via simple DB queries. It is now possible to recalculate N and M, if necessary, with the adoption of other catch efficiency coefficients.

[4] They are taken from standard wet weight tables (Borisov et al., 2004) as amended and supplemented by Dr. Volkov.

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

So in this way the work on the creation of this DB was almost completed in 2014, but it was only officially registered in the State Register of the Russian Federation at the beginning of 2016. In accordance with the regulations stipulated in the CIS (Volvenko, 2015a-c, 2016) almost all of 2015 was spent on a final verification of the information contained in the DB, via its derivative knowledge bases, including not raw data but results of their mathematical processing. In tandem with this verification reference tables on plankton in the Far Eastern seas and the northwestern part of the Pacific Ocean were drawn up, which will be talked about in the next section.

For *N* and *M* of each taxonomic group of animals at each stage of development or size group in each fraction per the cubic meter (respectively in specimens/m^3, and mg/m^3), for each plankton sample (see Fig. 3) were recalculated as:

$$N = \frac{n \cdot p}{v} = \frac{n \cdot p}{0{,}1 \cdot (h_1 - h_2)} \text{ and } M = \frac{m \cdot p}{v} = \frac{m \cdot p}{0{,}1 \cdot (h_1 - h_2)},$$

where: *n* – number (specimen) and *m* – weight (mg) of this species/stage/group/fraction in the catch; *v* – volume, filtered by the net (m^3); h_1 – initial, h_2 – final catch depth (m) determined taking into account the angle of inclination of the cable (e.g. Volkov, 2008a). h_1–h_2 – net distance covered (m); *p* – dimensionless correction of catch efficiency; constant 0.1 – the net mouth area (m^2).

This formula differs from the standard ones by the correction *p*, compensating for the underestimation of *N* and *M*, due to the imperfection of the fishing gear. This correction (the need for which is recognized by many, e.g.: Clutter, Anraku, 1968; Kiselev, 1969; Grese et al., 1975; Musaeva, Nezlin, 1996; Gorbatenko, Dolganova, 2006, 2007; Volkov, 2008a), is the inverse of the catch efficiency coefficient. According to the classic definition, the catch efficiency coefficient is the ratio of the number of animals caught to the entire number of animals that were in the catch area (Baranov, 1933). It introduces a multiplier in the denominator of the formulas to calculate the density of marine macrofauna (see, for example: Shuntov, Bocharov 2003a, b, 2004a, b, 2005a, b, 2006a, b, 2012a-c, 2014a-e) and can vary from 0 to 1. The reciprocal value (the catch efficiency correction) usually used by TINRO planktonologists ($p \geq 1$) introduces a factor in the numerator. The value of *p* depend on the taxonomic affiliation, fraction, developmental stage, size of animals and vary from 1 to 10 (see

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Dolganova, Volvenko, 2016a, b; Volkov, Volvenko, 2016a-c). Comparisons of the catchability of the large Juday net with other plankton nets have been published earlier (Kiselev, 1969; Timonin, 1983; Musaeva, Nezlin, 1996; Gorbatenko, Dolganova, 2006, 2007).

Subsequently, based on the relative values of *M* we may calculated the absolute abundance of thousands of tons of each species, the individual stages of their development, size classes, supraspecific taxonomic and ecological groups, fractions, the total zooplankton for various water layers and the time periods in the standard areas of biostatistical data averaging (Fig. 5). All this was submitted to planktonologists for verification. When errors were detected the raw data was edited, and the entire procedure above was repeated. This cycle continued until all errors were eliminated and the DB acquired its final form.

The resulting DB is a consolidated, structured, carefully verified and edited compact data array[5] that is optimized for its comprehensive high-speed processing. It contains information on 25,512 plankton samples (Fig. 3) performed from 27 April 1984 to 12 September 2013 in 235 surveys, with data on 214 taxonomic groups (Table 2).

Results

During the implementation of the above-mentioned CIS, based on the DB, in 2015 five tabular reference books (Dolganova, Volvenko, 2016a, b; Volkov, Volvenko, 2016a-c) of the species composition and abundance of zooplankton in a major fishing region of Russia (Fig. 6) were prepared and submitted for publication. Three of them are devoted to the Far Eastern seas: the western part of the Bering Sea, the north-west of the Sea of Japan and the Sea of Okhotsk; one – the northwestern part of the Pacific Ocean. The increased density of the measurements is clearly visible in these areas (Fig. 3), as they were taken in an area which is constantly monitored by the TINRO, and studied much better than others. The remaining sections of the volume are dedicated to the Peter the Great Bay in the Sea of Japan. This bay has unique fauna, its coast contains much of the populace and industry of the

[5] The minimum database configuration is a Microsoft Access 52.6 MB file which contains 9 tables (see Fig. 4) and 35 queries. As new data is added and ways to process it (forms, queries, reports, macros, program modules, auxiliary tables), its size can increase indefinitely.

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Russian Far East, it has a highly promising aquaculture industry, and unlike most other areas of the Far Eastern seas, only the plankton in the neritic zone has been adequately studied here. The new tabular directories contain a total of nearly 5 thousand pages.

The tables contain information on the occurrence (number of samples in which this species/group of animals was found, and their share in percentage terms of the total number of measurements), the average abundance (specimens /m^3 and mg/m^3) and the standard error of mean with the Sheppard's correction. The species and other taxonomic groups of marine organisms are not sorted systematically but in alphabetical order, and then in ascending order of size by fraction, developmental stage and/or size. The final rows of the tables – "Entire zooplankton", "Meroplankton", "Amphipods", "Copepods", "Euphausiids" etc. (see left column in table 2) contain the corresponding total group means and standard errors calculated by the formula $m_{\sum x} = \sqrt{m_1^2 + m_2^2 + ... + m_n^2}$, where $m_{\sum x}$ is the sampling error of the sum *n* of the arithmetic means, following their errors $m_1 - m_n$.

In general the format of these tables is the same as in the previously published reference books on nekton published in 2003-2006 (Shuntov, Bocharov, 2003b, 2004b, 2005b, 2006b) as tabular annexes to nekton atlases (Shuntov, Bocharov, 2003a, 2004a, 2005a, 2006a), directories on the pelagic trawl macrofauna published in 2012 (Shuntov, Bocharov, 2012a-c), and benthic macrofauna published in 2014 (Shuntov, Bocharov, 2014a-e). Information in them is also grouped by: 56 standard biostatistical areas (see 48 light unshaded areas on the main map Fig. 5, and 8 areas in the insert in its upper left corner), which are natural systems characterized by relatively uniform waters according to the formation of their properties in specific local geographical, geomorphological, climatic and hydrological conditions. There is now a certain standard for geo-referencing spatially distributed information, ensuring the comparability of diverse environmental information and the continuity of the long-term monitoring data on the state of the waters (Volvenko, 2003d).

Besides the described zoning the reference books contain four principles relating to grouping and the selection of raw data:

1) By sampled water layer, measurements are divided into:

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Open Access Earth System Science Data Discussions

epipelagic – final catch depth 0 m, initial 100-200 m (or the bottom, if depth is ≤ 300m),

upper epipelagic – final catch depth 0 m, initial 25-50 m (or bottom, if depth is ≤ 70 m).

2) By time of day they are divided into:

day – obtained during daylight,

night – obtained in the dark or at dusk.

3) Seasonally (in this case, this means not the calendar but the biological seasons (Shuntov 2001), the measurements are divided into made:

from June 1 to September 15 – *summer*,

from September 16 to November 30 – *autumn*,

fromDecember 1 to March 31 – *winter*,

from 1 April to 31 May – *spring*.

4) There are 4 perennial periods:

1984-1990 – "Sardine and pollock fish abundance",

1991-1995 – "Transitional period of sharp decline in abundance",

1996-2005 – "Period of low-level new fish productivity growth",

2006-2013 – "Salmon period".

These principles of grouping, selection and averaging data are implemented in the majority of the TINRO ecological studies (e.g.: Shuntov, Bocharov, 2003a-b, 2004a-b, 2005a-b, 2006a-b, 2012a-c, 2014a-e; Volvenko, 2003a-c, 2004a-c, 2005a, b, 2007, 2008b, 2013a-b, 2016a; Shuntov et al., 2007; Shuntov, Temnykh, 2008; Volkov, 2014 and many others).

Discussion

The data in these tables enable evaluation of the total stock plankton biological resources of the Far Eastern seas of the North Pacific. With the use of the so-called volume method, the absolute abundance of marine organisms is calculated by multiplying their average density (specimens/m^3 or mg/m^3) by the corresponding volume of water (thousand km^3). The result gives, respectively, trillions of specimens and thousands of tons. For this, the standard morphometric characteristics of the areas

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

listed in every reference book should be used. (Note that many opponents of applying corrections to catch efficiency can easily recalculate the data published in books in their own way, by divide any of the density parameters – abundance or biomass – by the correction factor given in each row. Those who wish to use different correction factors, can also easily recalculate the density by dividing it by our correction, and then multiplying it by their own).

With these same tables it is easy to recalculate the volumetric characteristics of density into areal characteristics. To do this, multiply the average abundance or biomass by volume of water corresponding to the water area, and then divide it by its area. The result will be in the billions of specimens/km^2 or t/km^2. From the tables it is easy to calculate the plankton content in the middle and lower epipelagic, i.e. from 50-200 m (based on the difference of concentrations from 0-200 m and 0-50 m) and the average individual weight of animals (by dividing their biomass by number), and using previously published tables on calorific value and the chemical composition of zooplankton (e.g. Borisov et al., 2004), you can obtain its energy characteristics, etc.

In this way a significant contribution to the new quantitative inventory of aquatic biological resources and appraisal of the waters of the North Pacific has been made. A series of these monographs is recommended not only to planktonologists, but also to ecologists, biogeographers, hydrobiologists, ichthyologists, teachers and students of related disciplines. In the scope of their application is the management of living aquatic resources, aquaculture development, and nature conservation, because they can be used to assess the effects of various anthropogenic factors on nature (pollution, the construction of hydraulic structures, oil and gas extractions, tanker accidents, nuclear reactors, etc.).

However, in the process of testing the DBs, when creating the table directories some irremovable shortcomings were found.

Firstly, it is the incomplete coverage of the surveyed area. The overwhelming majority of plankton collections were conducted in the Russian EEZ (see Fig. 3). Of the four Far Eastern seas only Okhotsk was almost entirely located within it, so the measurements, and thus the data produced in our surveys only this particular area is covered almost entirely, and even then with the exception of coastal

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

waters. Nearly all the planktonic work was carried out before or immediately after macrofauna trawls, and because of this, the vast majority of measurements were taken at depths of at least 25-30 m (corresponding to the minimum vertical opening of the majority of midwater trawls). In addition to this, conducting surveys near the coast and far out at sea in large research vessels has always been impeded by the red tape associated with the repeated crossing of maritime borders, and smaller vessels do not work at a considerable distance from their ports. As a consequence, plankton belonging to the coastal (neritic) biotope is covered only by its seaward periphery. Only in the Sea of Japan is much of the data collected using small tonnage seiners and boats, which are capable of working off the coast in shallow waters. Therefore, the plankton neritic zone in the Sea of Japan (especially in the Peter the Great Bay, and in the Northern Primorye) is studied more fully than in the Okhotsk, Bering and, especially, Chukchi seas.

The second drawback is the very uneven distribution of measurements in space and time (see Figs 3, 7). The more or less regular study of plankton in the Sea of Okhotsk began in 1984, in the Sea of Japan in 1985, in the Bering Sea in 1986, and in the Pacific in 1987. Since then, the intensity of plankton research as a whole increased, reaching its peak in 2009, after which it sharply declined, mainly due to the reduced number of surveys in the Sea of Japan and in the ocean. When preparing the above tabular reference books, it was found that ocean area 11 (see Fig. 5) was left practically unstudied, and there were very few samples in the southern half of area 12. In addition, it was found that in areas 1-4 sufficient samples were rarely taken for statistical processing, in autumn only areas 5-7, and in spring only the epipelagic in areas 9, 12 and 13 were fully studied. Another example: in the most studied part of the Sea of Japan, the Peter the Great Bay, very few samples were taken in winter or in the dark, regardless of the season, or in 1991-1995. For this reason, the composition and abundance of plankton in “sardine and pollock fish abundance” – 1988-1990 completely drop out of consideration. Therefore, for the 49% of the tabular directories, out of those that was planned for the Bay in accordance with the principles of regionalization and the four data categories (see above), insufficient data was collated. In the Sea of Okhotsk there was insufficient for 24%, in the Bering Sea for 40%, in the Sea of Japan for almost 50%, and in the North-West Pacific Ocean for 60% of the

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

tables (see Dolganova, Volvenko, 2016a, b; Volkov, Volvenko, 2016a-c). So even for waters that were continuously monitored there is no data for many regions on all seasons for long time periods. (For the rest of the waters, there are even less. For example, in the Chukchi Sea only 2 plankton samples were taken, probably by accident, and in 2004-2006, 2009, and 2011-2013 none were taken. Therefore, information about the regions, shaded in Fig. 5, was not included in the reference books).

This of course makes it difficult to study the seasonal and long-term dynamics of ecosystems. The regular study at least of the EEZ of the Russian Federation with standard, uniform net measurements is not possible for a few reasons. One of them is relatively[6] objective, and that is the ice conditions in the cold season. The rest relate solely to the work of officials, and mostly to their desire to save money on integrated ecosystem surveys to the detriment of the quality and quantity of information collected.

The third drawback is the side effect or the "flip side" of the express method of processing plankton samples, through which a huge amount of data has been collated in the DB. At sea, primary processing occurs daily around the clock immediately before the next sample batch is caught, and when the vessel returns to the port a scientific report is submitted to the TINRO archives office with detailed analyses of all the data collated during the survey. Only common representatives of plankton are identified by species, with others identified only by genus or family, cumaceans and isopods only by group, ostracods by class, and rotifers, for example, are not counted. Due to minor morphological differences between the individual surveys, copepods were not distinguished which in the DB are listed as *Calanus glacialis + marshallae* and *Neocalanus plumchrus + flemingeri*[7]. As a result, according to the tables published by M.S. Kun (1975), who counted 288 species[8] of plankton in the Far Eastern seas and the north-western part of the Pacific Ocean, more than 1/4 of them are not included in

[6] "Relatively" because, if necessary, plankton samples can be taken from under the ice even in the Arctic and Antarctic using ice-breakers, from the ice surface in natural or artificial ice clearings. This is, however, not as beneficial for TINRO as it is expensive.
[7] There is reason to believe that there are really 2 rather than 4 species (Volkov, 2016b), but this hypothesis needs further verification.
[8] This is without two squid species, which we, in contrast to M.S. Kun, refer to not as plankton but as nekton, and not as meso- but as macrofauna.

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

the DB (see table 2). The underestimation by seas[9] is as follows: the Bering Sea – 9%, the Okhotsk Sea – 30%, the Sea of Japan – 38% of the species. The biggest positive in this respect is the situation in the Bering Sea, but if we take more recent information, there are not 104 (according to Kun, 1975), but 177 (according to Kulikov, 1993) zooplankton species. So the shortfall in this sea is not 9% but 46%. So without too much optimism we can assume that for each body of water we have counted, at best, only 50-70% of the species; only the most common of them. However, it is known (Volkov, 1996b) that in all the surveyed waters the first 2-3 dominant species of plankton account for more than 50%, and the top 10 no less than 85-90% of the total biomass of zooplankton. With such a low species evenness, the 50 and especially 150 most common species give much more than 99% of this value. Therefore, the shortcomings of the DBs discussed here may be important for taxonomists and fauna scientists studying rare or very scant species, but in most other studies are not of importance.

At the end of this section, let me give a few examples of my first experience in operating this DB to investigate the geographical patterns of marine life distribution.

Using this DB, the mean annual concentration and total biomass of zooplankton in the epipelagic layer for the Bering, Okhotsk, Japan seas, and the northwestern Pacific Ocean were estimated (Shuntov, Volvenko, 2017). Significant differences are shown for spatial distribution and temporal dynamics of the small-, medium- and large-sized zooplankton abundance and its daily vertical migrations in different areas. Zooplankton stocks in all these regions are evaluated as high; their bulks are formed by large-sized fraction. Interannual fluctuations of the zooplankton abundance could be considerable in certain areas, but its total resource within the Far Eastern basin does not change much: the abundance decline in some areas is compensated by its growth in other ones. A comparison was also made (Volvenko, 2017) of all these large marine areas for various plankton characteristics.

In the next publication (Volvenko, 2019) were compiled and analysed maps of the spatio-temporal distribution of plankton; a hypothesis was made regarding the negative correlation of the

[9] For the ocean M.S. Kun (1975) gives species richness only for the Kuril-Kamchatka region and she provides no data at all on the Chukchi Sea.

plankton size with temperature; and revealed that some fluctuations in the abundance of zooplankton in the Bering Sea and the ocean occur synchronously and unidirectionally, whereas in the Sea of Japan and the Sea of Okhotsk the fluctuations are opposite (out of phase): during the transition from the day to the night in the Okhotsk and Japan seas, the density of plankton throughout the epipelagic zone increases; in the same time in the Bering Sea and the ocean, over large parts of the area, it decreases[10].

Later (Volvenko, 2020) the spatial distribution patterns of 6 integral characteristics of zooplankton are studied at different levels of the spatial scale using GIS and statistical analysis – abundance N, biomass M, diversity H', species richness S, evenness J, and the mean individual body weight of animals W. It is shown that these characteristics are subject to circum-continental zonation, which manifested as an increase in W and a decrease in N, M and J corresponding with the distance from land to the open sea. In the same direction, the variability of all the integral characteristics decrease. Classical manifestations of the latitudinal zonation of zooplankton are observed to an even higher degree: Humboldt-Wallace's law, Bergman's rule, and the increase of biomass from the equator to the poles with decreasing temperature and increasing mineral nutrient concentrations. Several particular additions to Zenkevich-Bogorov's concept of the biological structure of the Ocean were formulated[11].

The free wide international use of the data published in the five reference books has so far been hampered by three circumstances. 1) They are published in Russian and not translated into English. 2) They are published in text (pdf) format and not digitized. 3) The data collectors used outdated species identification guides, so there are many outdated species names in the tables (Table 3).

To eliminate these shortcomings, I:

- wrote this article detailing the origin of the data and methods of its processing;
- digitized the data of reference tables from five books (Fig. 6) and saved them in xlsx and csv formats;

[10] This means that the common practice by trophologists of attempting to replace the day-time catch in plankton nets with the night-time catches to assess the food reserves for fish will yield significantly different results in these waters.
[11] In the supplementary material to this paper are given maps of the spatial distribution of these integral characteristics of net zooplankton in the Far Eastern seas and North Pacific.

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

- translated the Russian text into English;
- fixed species names to modern (Table 3);
- summed up the characteristics of abundance where synonyms were considered as different species;
- prepared a shape-file with polygons of the standard regions (Fig. 5) by which data is summarized;
- accompanied the polygons with information about surface areas and water volumes in each of them.

Data availability. Volvenko (2021) https://doi.org/10.5281/zenodo.4448646

Conclusions

Despite the shortcomings described above, the substantial volume and high quality of the collated data gives hope that these DB and the information presented in the five reference books together with previously published data on pelagic and benthic macrofauna and data on the nutrition of common fish and squid, which is now being compiled in the TINRO laboratories, will enable the next important steps to be taken in the understanding of the nature of the Far Eastern seas and the Pacific.

The author of this article is the co-author of the table guides (Shuntov, Bocharov, 2003b, 2004b, 2005b, 2006b, 2012a-c, 2014a-e; Dolganova, Volvenko, 2016a, b; Volkov, Volvenko, 2016a-c), atlases (Shuntov, Bocharov, 2003a, 2004a, 2005a, 2006a) and DBs (Volvenko, Kulik, 2011; Volvenko et al., 2012, 2014a, b, 2016; Volvenko, 2014b, 2015b) mentioned above, but not the owner of the original data. On the use of the plankton DB primary data and for purchase hard copy of reference books (their electronic versions are freely available now at the links in the list of references) one should contact the Directorate of the Pacific Branch of Russian Federal Research Institute of Fisheries and Oceanography (TINRO) at the address 4 Shevchenko Ave., Vladivostok, 690091, Russia; or Directorate of the Russian Federal Research Institute of Fisheries and Oceanography (VNIRO) at the address 17 V. Krasnoselskaya, Moscow, 107140, Russia.

Examples of 5 large tables from (Volkov, Volvenko, 2016a) are given in the Supplement (Online Resource) to this article. They contain long-term average data about the plankton of regions No 1-5 (see Fig. 5) of the Bering Sea.

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Competing interests. I am declare no competing interests and no potential conflict of interest.

References

Baranov, F.I. 1933. *Commercial fishing techniques*. Kogiz, Moscow, Leningrad. (In Russian).

Beamish, R.J. and Rothschild, B.J., ed., 2009. *The Future of Fisheries Science in North America*. Springer Science + Business Media, Dordrecht.

Bocharov, L.N. 2004. The Perspective Approach to the Problem of People Supply with Fishery Products. *Izvestiya TINRO*, **138**, 3-18. (In Russian).

Bocharov, L.N. 2010. Development of Fishery Science in the Far East. Tasks and Peculiarities of the Present-Day Stage. In *TINRO-85, Results of the Decade. 2000-2010*. TINRO-Center, Vladivostok, pp. 3-24. (In Russian).

Bocharov, L.N., Shuntov, V.P. 2003. State and Tasks of the Present-Day Stage of Ecosystem Researches of Biological Resources of the Far Eastern Seas of Russia. In: *Rational Environmental Management and Management of Marine Bioresources: Ecosystem Approach*. TINRO-Center, Vladivostok, pp. 3-8. (In Russian).

Borisov, B.M., Volkov, A.F., Gorbatenko, K.M., Koval, M.V., Shershneva, V.I. 2004. Standard tables of the wet weight and some biochemical parameters (calorie content, fats, proteins, carbohydrates, and the mineral rest) of zooplankton in the Far East Seas. *Izvestiya TINRO*, **138**, 355-367. (In Russian).

Bulatov, O.A., Kotyenyov, B.N. 2012. Prospects of the Ecosystem Management of Fishery. In: *Proceedings of All-Russia Scientific Conference Sustainable Use of Biological Resources of the Seas of Russia: Problems and Prospects*. VNIRO, Moscow, pp. 10-11. (In Russian).

Clutter, R.I., Anraku, M. 1968. Avoidance of samplers in zooplankton sampling. In: *UNESCO monographs on oceanographic methodology*. No. 2: Zooplankton sampling. UNESCO Press, Paris, pp. 57-76.

Codifier of zooplankton species. 1980. VNIRO, Moscow, PINRO. (In Russian).

Dolganova, N.T., Volvenko, I.V.. 2016a. *Net Zooplankton of the Northwestern Part of Japan (East)*

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Sea: Occurrence, Abundance, and Biomass. 1985-2013. TINRO-Center, Vladivostok. https://www.researchgate.net/publication/329076424_Net_zooplankton_of_the_northwestern_part_of_Japan_East_sea_occurrence_abundance_and_biomass_1985-2013 (In Russian).

Dolganova, N.T., Volvenko, I.V. 2016b. *Net Zooplankton of Peter the Great Bay (Japan/East Sea): Occurrence, Abundance, and Biomass. 1988-2013*. TINRO-Center, Vladivostok. https://www.researchgate.net/publication/329076283_Net_zooplankton_of_Peter_the_Great_Bay_JapanEast_Sea_occurrence_abundance_and_biomass_1988-2013 (In Russian).

Dulepova, E.P. 2005. Ecosystem Researches of TINRO-Center in the Far Eastern Seas. *Izvestiya TINRO*, **141**, 3-29. (In Russian).

Dulepova, E.P. 2014. Dynamics of production parameters for zooplankton as the main component of forage base for nekton in the western Bering Sea. *Izvestiya TINRO*, **179**, 236-249. (In Russian).

Fisheries commercial and biological data unified registration forms (completion and perforation instructions). 1976. VNIRO, Moscow. (In Russian).

Gorbatenko, K.M., Dolganova, N.T. 2006. Compared catch efficiency of different types of plankton nets in the Far East Seas. *Izvestiya TINRO*, **146**, 213-225. (In Russian).

Gorbatenko, K.M., Dolganova, N.T. 2007. Comparing the catch efficiency with different types of plankton nets in the high production zones of the Pacific Ocean. *Oceanology*, **47**, 205-212. (In Russian).

Grese, V.N., Balandina, E.P., Bileva, O.K., Makarova, N.P. 1975. Efficiency of devices for the collection of plankton and its real density. *Hydrobiologicheskyi Jurnal (Kiev)*, **11**, 108-111. (In Russian).

Instructions for completing the unified commercial and biological data registration forms. 1982. VNIRO, Moscow. (In Russian).

Kiselev, I.A.. 1969. *Plankton of seas and continental water bodies*. V. 1. Leningrad: Nauka. (In Russian).

Kulikov, A.S. 1993. *Zooplankton of the Bering Sea and its role in the functioning of plankton community*. D. Ph. thesis. IGCE, Moscow. (In Russian).

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Kun, M.S. 1975. *Zooplankton of the Far Eastern seas*. Pischevaya promyshlennost, Moscow. (In Russian).

Lapko, V.V. 2000. Ecosystem Studies of Biological Resources in TINRO-Center. In: *TINRO-75 Years (from TONS to TINRO-Center)*. TINRO, Vladivostok, pp. 146-154. (In Russian).

May, R.M., ed. 1984. *Exploitation of marine communities*. Springer-Verlag, Berlin ets.

Mikulich, L.V., Rodionov, N.A. 1975. Weight Characteristics of Some Zooplankters of the Sea of Japan. Hydrobiological Investigations in the Sea of Japan and in the Pacific Ocean. In: *Trudy Tikhookeanskogo Okeanologicheskogo Instituta*. V. 9. DVNTs AN SSSR, Vladivostok, pp. 75-87. (In Russian).

Misund, O.A., Skjoldal, H.R. 2005. Implementing the ecosystem approach: experiences from the North Sea, ICES, and the Institute of Marine Research, Norway. *Marine Ecology Progress Series*, **300**, 260-265.

Musaeva, E.I., Nezlin, N.P. 1996. Comparison of various zooplankton sampling tools based on catches in the Bering Sea. *Oceanology*, **35**, 857-861. (In Russian).

Reports of the International Conference "Environmental Management and Management of Marine Bioresources: Ecosystem Approach". 2004. *Izvestiya TINRO*, **137**. (In Russian).

Shuntov, V.P. 1988. Biological Resources of Far Eastern Seas: Prospects of Research and Exploitation. *Biologiya Morya (Marine Biology)*, **3**, 3-14. (In Russian).

Shuntov, V.P. 1994. New Data on Alterations in Pelagic Ecosystems of Far Eastern Seas. *Vestnik DVO RAN*, **2**, 59–66. (In Russian).

Shuntov, V.P. 1995. TINRO's Ecosystem Studies of the Far Eastern Seas Biological Resources. In: *TINRO-70 (Vladivostok: TINRO)*. TINRO, Vladivostok, pp. 20-31. (In Russian).

Shuntov, V.P. 1998. Reorganizations in the Okhotsk sea pelagic ecosystems – real fact. *Rybnoye Khozyaistvo (Fisheries)*, **1**, 25-27. (In Russian).

Shuntov, V.P. 2001. *Biology of the Far Eastern Seas of Russia*. V. 1. TINRO-Center, Vladivostok. (In Russian).

Shuntov, V.P. 2010. Some results of ecosystem studies of biological resources of the Far Eastern seas

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

in connection with problems for further research. In: *Bulletin N 5 implementation of "Concept of the Far Eastern basin program of Pacific salmon study"*. TINRO-Center, Vladivostok, pp. 186-195. (In Russian).

Shuntov, V.P, Bocharov, L.N., ed. 2003a. *Atlas of Quantitative Distribution of Nekton Species in the Okhotsk Sea*. National Fish Resources, Moscow. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2003b. *Nekton of the Okhotsk Sea. Tables of Abundance, Biomass and Species Ratio*. TINRO-Center, Vladivostok. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2004a. *Atlas of Quantitative Distribution of Nekton Species in the Northwestern Part of the Japan/East Sea*. National Fish Resources, Moscow. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2004b. *Nekton of the Northwestern Part of the Japan/East Sea. Tables of Abundance, Biomass and Species Ratio*. TINRO-Center, Vladivostok. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2005a. *Atlas of Quantitative Distribution of Nekton Species in the Northwestern Part of the Pacific Ocean*. National Fish Resources, Moscow. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2005b. *Nekton of the Northwestern Part of the Pacific Ocean. Tables of Abundance, Biomass and Species Ratio*. TINRO-Center, Vladivostok. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2006a. *Atlas of Quantitative Distribution of Nekton Species in the Western Part of the Bering Sea*. National Fish Resources, Moscow. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2006b. *Nekton of the Western Part of the Bering Sea. Tables of Abundance, Biomass and Species Ratio*. TINRO-Center, Vladivostok. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2012a. *Pelagic Macrofauna of the Western Part of the Bering Sea: Tables of Occurrence, Abundance and Biomass. 1982-2009*. TINRO-Center, Vladivostok. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2012b. *Pelagic Macrofauna of the Okhotsk Sea: Tables of Occurrence, Abundance and Biomass. 1984-2009*. TINRO-Center, Vladivostok. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2012c. *Pelagic Macrofauna of the Northwestern Part of the Pacific Ocean: Tables of Occurrence, Abundance and Biomass. 1979-2009*. TINRO-Center, Vladivostok. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2014a. *Benthic Macrofauna of the Peter the Great Bay (Japan/East Sea): Tables of Occurrence, Abundance and Biomass. 1978-2009*. TINRO-Center, Vladivostok. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2014b. *Benthic Macrofauna of the Western Part of the Bering Sea: Tables of Occurrence, Abundance and Biomass. 1977-2010*. TINRO-Center, Vladivostok. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2014c. *Benthic Macrofauna of the Sea of Okhotsk: Tables of Occurrence, Abundance and Biomass. 1977-2010*. TINRO-Center, Vladivostok. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2014d. *Benthic Macrofauna of the Northwestern Part of the Pacific Ocean: Tables of Occurrence, Abundance and Biomass. 1977-2008*. TINRO-Center, Vladivostok. (In Russian).

Shuntov, V.P., Bocharov, L.N., ed. 2014e. *Benthic Macrofauna of the Northwestern Part of the Japan/East Sea: Tables of Occurrence, Abundance and Biomass. 1978-2010*. TINRO-Center, Vladivostok. (In Russian).

Shuntov, V.P., Dulepova, E.P., Radchenko, V.I., Temnykh, O.S. 1993. On the beginning of large reformations in communities of plankton and nekton of the Far-Eastern Seas. In: *North. Pac. Mar. Sci. Org. (PICES), Second Annual Meeting Abstracts*. Seattle, pp. 35.

Shuntov, V.P., Dulepova, E.P., Temnykh, O.S., Volkov, A.F., Naydenko, S.V., Chuchukalo, V.I., Volvenko, I.V. 2007. State of Biological Resources in Connection with Dynamics of Macroecosystems in the Far Eastern Economic Zone of Russia. In: *Dynamics of Marine Ecosystems and Contemporary Issues in Conservation of Biological Potential of Russian Seas*. Dalnauka, Vladivostok, pp. 75-176. (In Russian).

Shuntov, V.P., Radchenko, V.I., Dulepova, E.P., Temnykh, O.S. 1997. Biological Resources of Economic Zone: The Structure of Pelagic and Benthic Communities, Contemporary Status, and Trends of Long Dynamics. *Izvestiya TINRO*, **122**, 3-15. (In Russian).

Shuntov, V.P., Temnykh, O.S. 2008. *Pacific salmon in marine and ocean ecosystems*. V. 1. TINRO-Center, Vladivostok. (In Russian).

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Shuntov, V.P., Temnykh, O.S. 2011. Modern restructuring in marine ecosystems in Association with climatic changes: the priority of global or regional factors? In: *Bulletin N 6 implementation of "Concept of the Far Eastern basin program of Pacific salmon study"*. TINRO-Center, Vladivostok, 49-64. (In Russian).

Shuntov, V.P., Temnykh, O.S. 2013. Illusions and Realities of Ecosystem Approach to Study and Management of Marine and Oceanic Biological Resources. *Russian Journal of Marine Biology*, **39**, 455-473.

Shuntov, V.P., Volvenko, I.V. 2017. Supplements to quantitative assessments of zooplankton in the Far Eastern Seas and adjacent waters of the North Pacific. *Izvestiya TINRO*, **191**, P. 130–146. https://doi.org/10.26428/1606-9919-2017-191-130-146 (in Russian).

The Ecosystem Approach to Fisheries. 2008. Food and Agriculture Organization of the United Nations, Wallingford, UK; Cambridge, MA; CABI; Rome.

Timonin, A.G. 1983. Closing plankton nets for vertical mesoplankton catches. In: *Modern methods for quantifying the distribution of marine plankton*. Nauka, Moscow, 158-173. (In Russian).

Volkov, A.F. 1984. *Recommendations on Express Processing of Net Plankton in the Sea.* TINRO, Vladivostok. (In Russian).

Volkov, A.F. 1996a. Concerning the Technique of Plankton Sampling. *Izvestiya TINRO*, **119**, 306–311. (In Russian).

Volkov, A.F. 1996b. *Zooplankton in the Epipelagic of Far Eastern Seas: Composition of Communities, Annual Dynamics and Significance for Foraging of Nekton*. Doctoral (Biol.) Dissertation thesis. DVGU, Vladivostok. (In Russian).

Volkov, A.F. 2008a. Technique of collecting and processing the samples of plankton and the samples on nekton feeding (step-by-step instructions). *Izvestiya TINRO*, **154**, 405-416. (In Russian).

Volkov, A.F. 2008b. Quantitative parameters of zooplankton communities in the Okhotsk and Bering Seas and North-east Pacific (biomass, composition, dynamics). *Izvestiya TINRO*, **152**, 255-270. (In Russian).

Volkov, A.F. 2012. Results of the studies on zooplankton in the Bering Sea under NPAFC program

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

(expedition BASIS). Part 2. Western areas. *Izvestiya TINRO*, **170**, 151-171. (In Russian).

Volkov, A.F. 2013a. Seasonal and long-term dynamics of epipelagic plankton in Kamchatka waters of the Okhotsk Sea. *Izvestiya TINRO*, **175**, 206-233. (In Russian).

Volkov, A.F. 2013b. Seasonal and long-term dynamics of epipelagic plankton in Sakhalin waters, the Okhotsk Sea. *Izvestiya TINRO*, **174**, 170-186. (In Russian).

Volkov, A.F. 2014. State of forage base for pacific salmons in the Bering Sea in 2003-2012 (by results of surveys of the international expeditions BASIS-1 and 2). *Izvestiya TINRO*, **179**, 250-271. (In Russian).

Volkov, A.F. 2015. Integral values of biomass and stock of zooplankton in the epipelagic layer of the area 71 in the North Pacific, including the Bering and Okhotsk Seas, and patterns of distribution for mass species. *Izvestiya TINRO*, **180**, 140-160. (In Russian).

Volkov, A.F. 2016a. Tables and diagrams on trophology of walleye pollock in the western Bering Sea. *Izvestiya TINRO*, **185**, 175-184. (In Russian).

Volkov, A.F. 2016b. Elementary trophic ecology of pacific salmons in the Bering Sea. Species and regional differences. Provision with food in different environments. *Izvestiya TINRO*, **187**, 162-186. (In Russian).

Volkov, A.F., Volvenko, I.V. 2016a. *Net Zooplankton of the Western Part of the Bering Sea: Occurrence, Abundance, and Biomass. 1986-2013*. TINRO-Center, Vladivostok. https://www.researchgate.net/publication/329139755_Net_zooplankton_of_the_western_part_of_the_Bering_Sea_occurrence_abundance_and_biomass_1986-2013 (In Russian).

Volkov, A.F., Volvenko, I.V. 2016b. *Net Zooplankton of the Okhotsk Sea: Occurrence, Abundance, and Biomass. 1984-2013*. TINRO-Center, Vladivostok. https://www.researchgate.net/publication/329118214_Net_zooplankton_of_the_Okhotsk_Sea_occurrence_abundance_and_biomass_1984-2013 (In Russian).

Volkov, A.F., Volvenko, I.V. 2016c. *Net Zooplankton of the Northwestern Pacific: Occurrence, Abundance, and Biomass*. 1985-2013. TINRO-Center, Vladivostok. https://www.researchgate.net/publication/329162877_Net_zooplankton_of_the_northwestern_

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Pacific_occurrence_abundance_and_biomass_1985-2013 (In Russian).

Volkov, A.F., Kuznetsova, N.A., Farley, E.V., Murphy, J.M. 2009. Structure and distribution of zooplankton and a feeding of pacific salmons in the eastern Bering Sea in the fall of 2003-2008 (results of survey under BASIS program). *Izvestiya TINRO*, **158**, 275-292. (In Russian).

Volvenko, I.V. 2003a. *Data Base and GIS Technologies in Studying Nekton of the Northwest Pacific: The First Results and Perspectives*. NPAFC Doc. 730.

Volvenko, I.V. 2003b. *GIS and Atlas of Salmons spatial-temporal distribution in the Okhotsk Sea*. NPAFC Doc. 729.

Volvenko, I.V. 2003c. New GIS for spatial-temporal dynamics analysis of Okhotsk Sea nekton. In: *Abstracts of PICES 12th Annual Meeting.* Seoul, pp. 111-112.

Volvenko, I.V. 2003d. Morphometric characteristic of standard biostatistical regions for the biocenological researches of Russian fishing zone on Far East*. Izvestiya TINRO*, **32**, 27-42. (In Russian).

Volvenko, I.V. 2004a. *GIS and Atlas of Salmons spatial-temporal distribution in the northwestern part of Japan (East) Sea*. NPAFC Doc. 812.

Volvenko, I.V., 2004b. GIS for Spatial-Temporal Dynamics Analysis of the Okhotsk Sea Nekton. *Izvestiya TINRO*, **137**, 144-176. (In Russian).

Volvenko, I.V. 2004c. Analysis of the rate of alternativeness in abundance dynamics of different species in the case of absent continuous long time series data: an example of the Okhotsk Sea nekton. *Izvestiya TINRO*, **139**, 78-90. (In Russian).

Volvenko, I.V. 2005a. *GIS and Atlas of Salmons Spatial-Temporal Distribution in the Northwestern Part of the Pacific Ocean*. NPAFC Doc. 879.

Volvenko, I.V. 2005b. *GIS and Atlas of Salmons spatial-temporal distribution in the western part of the Bering Sea*. NPAFC Doc. 880.

Volvenko, I.V. 2007. New GIS of the Pelagic Macrofauna Integrative Characteristics for the North-West Pacific. *Izvestiya TINRO*, **149**, 3-20. (In Russian).

Volvenko, I.V. 2014a. Regional Data Center (RDC) of FSUE “TINRO-Center”: Its Principal Activities

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

and Role in the Prediction of Fisheries Resource State. *Izvestiya TINRO*, **176**, 3-15. (In Russian).

Volvenko, I.V. 2014b. The New Large Database of the Russian Bottom Trawl Surveys in the Far Eastern Seas and the North Pacific Ocean in 1977-2010. *International Journal of Environmental Monitoring and Analysis*, **2**, 302-312.

Volvenko, I.V. 2015a. Dataware Support of Comprehensive Studies of Northwestern Pacific Aquatic Biological Resources. Part 1. Concept, Background, Beginning of Implementation. *Trudy VNIRO*, **156**, 38-66. (In Russian).

Volvenko, I.V. 2015b. Dataware Support of Comprehensive Studies of Northwestern Pacific Aquatic Biological Resources. Part 2. Databases, Knowledge Bases, Automated Workplaces. *Trudy VNIRO*, **157**, 71-99. (In Russian).

Volvenko, I.V. 2015c. Dataware Support of Comprehensive Studies of Northwestern Pacific Aquatic Biological Resources. Part 3. GIS, Atlases, Reference Books, Further Prospects of the Concept. *Trudy VNIRO*, **157**, 100-126. (In Russian).

Volvenko, I.V. 2015d. The role of the Regional Data Center (RDC) of the Pacific Research Fisheries Center (TINRO-Center) in North Pacific ecosystem and fisheries research. *International Journal of Engineering Research & Science*, **1**, 47-54.

Volvenko, I.V. 2016. The concept of information support for bioresource and ecosystem research in the North-West Pacific: Theory and practical implementation. *Natural Resources*, **7**, 40-50.

Volvenko, I.V. 2017. A comparative study of the Far Eastern Seas and the Northern Pacific Ocean based on integral parameters of net zooplankton in the Epipelagic Layer. *Russian Journal of Marine Biology*, **43**(7), 568–582. DOI: 10.1134/S1063074017070069

Volvenko, I.V. 2019. New net zooplankton geographical information system in the Far East seas and adjacent waters of the Pacific Ocean. *Global Ecology and Biogeography*, **28**, 1735-1748. https://doi.org/10.1111/geb.13002

Volvenko, I.V. 2020. Geographical zonation in the distribution of the integral characteristics of net zooplankton in Far Eastern seas and in the North Pacific. *Science of the Total Environment*.

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

715, 136961. https://doi.org/10.1016/j.scitotenv.2020.136961

Volvenko, I.V. 2021. Digitized, corrected and supplemented data on net zooplankton of the Far East seas and adjacent Pacific Ocean waters from five rare reference books published in Russian in limited editions. Zenodo, https://doi.org/10.5281/zenodo.4448646

Volvenko, I.V., Kulik, V.V. 2011. Updated and Extended Database of the Pelagic Trawl Surveys in the Far Eastern Seas and North Pacific Ocean in 1979-2009. *Russian Journal of Marine Biology*, **37**, 513-532.

Volvenko, I.V., Kulik, V.V., Shuntov, V.P. 2014a. *Database "Pelagic trawl macrofauna of the North Pacific 1979-2009"*. Copyright certificate No. 2014620536, Russia. (In Russian).

Volvenko, I.V., Kulik, V.V., Shuntov, V.P., Nadtochiy, V.A., Il'insky, V.N., Tuponogov, V.N., Savin, A.B., Gerasimov, N.N., Shevtsov, G.A. 2014b. *Database "Bottom trawl macrofauna of the North Pacific 1977-2010"*. Copyright certificate No. 2014620535, Russia. (In Russian).

Volvenko, I.V., Kulyk, V.V., Shuntov, V.P., Ivanov, O.A., Starovoytov, A.N., Shevtsov, G.A., Chuchukalo, V.I. 2012. *Database "Pelagic trawl macrofauna of the North Pacific 1979–2005"*. Copyright certificate No. 2012620963, Russia. (In Russian).

Volvenko, I.V., Volkov, A.F., Dolganova, N.T. 2016. *Database "Net zooplankton of the North Pacific 1984-2013"*. Copyright certificate No. 2016620026, Russia. (In Russian).

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Table 1. Comparison of the two forms of storage of plankton cards – before and after the creation of the database

Initial spreadsheet	Final relational database
A huge number of columns (variables) in which most of the values are zero for species that were not found	No extra variables or zeros
For each measurement the "header" of the card is duplicated seven times	No repeats – all records are unique
Lots of text values	The text is replaced by numerical codes (less space and faster processing)
Contains data and calculation results	Only raw data is stored
Typos "." instead of "," or suchlike give errors	It is impossible to make a mistake in the data format or make a typo in Latin (scientific) species names
There are restrictions on the number of rows and columns	The amount of stored data is not limited
Only the simplest options are available for sorting and retrieval of data at low speed with a large size of the file	The file is much smaller, there are more options and the speed of data processing is much faster

Table 2. Composition of mesofauna found in the surveyed water area (Fig. 3) whose details are in the database

Taxonomic/environmental group	Species number in database	Including water bodies				
		Chukchi Sea	Bering Sea	Sea of Okhotsk	Sea of Japan	Pacific Ocean
Copepods	94	25	47	43	61	75
Gelatinous (jellyfish, comb jellies, pelagic tunicates)	29	4	8	8	17	16
Amphipods	22	4	9	7	8	18
Euphausiids	18	5	9	7	7	17
Mysida	11	1	1	1	11	1
Chaetognaths	8	1	2	2	1	8
Cladocera	8	3	3	3	6	3
Pteropods	6	2	2	2	3	5
Protozoa	4	0	2	2	4	2
Planktonic polychaetes	1	1	1	1	0	1
Cumaceans*	1	1	1	1	1	1
Ostracods*	1	1	1	1	1	1
Isopods*	1	0	0	0	1	0
Meroplankton (larvae of animals)	10	7	9	7	9	9
In total no less than	214	55	95	85	130	157

Note: The asterisk marks 3 groups which are not identified by species.

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Open Access Earth System Science Data Discussions

Table 3. Replacement of species names in the new data array

Old or wrong scientific name of the species used in the reference books	The new accepted name of the species according to information from WoRMS	Where changes were needed
Corymorpha aurata	*Euphysa aurata*	Jap, PGB
Corymorpha flammea	*Euphysa flammea*	Jap, PGB
Tubularia chistinae	*Hybocodon prolifer*	Jap, PGB
Tubularia prolifer	*Hybocodon prolifer*	Jap, PGB
Siphonophora gen. sp.	Siphonophorae gen. sp.	Jap, PGB
Hydractinia carnea	*Podocoryna carnea*	Jap, PGB
Evadne tergestina	*Pseudevadne tergestina*	Jap, PGB
Podon leuckarti	*Podon leuckartii*	Ber, Okh, Jap, PGB, Pac
Acartia clausi	*Acartia (Acartiura) clausi*	Ber, Okh, Jap, PGB, Pac
Acartia longiremis	*Acartia (Acartiura) longiremis*	Ber, Okh, Jap, PGB, Pac
Acartia pacifica	*Acartia (Odontacartia) pacifica*	Jap, PGB, Pac
Acartia stelleri	*Acartia (Acanthacartia) steueri*	Jap, PGB
Acartia tumida	*Acartia (Acanthacartia) tumida*	Ber, Okh, Jap, PGB, Pac
Aetideus pacificus	*Pseudochirella pacifica*	Ber, Okh, Jap, Pac
Derjuginia tolli	*Jaschnovia tolli*	Jap
Epilabidocera amphitrites	*Epilabidocera longipedata*	Ber, Okh, Jap, PGB, Pac
Eucalanus elongatus	*Eucalanus elongatus elongatus*	Pac
Eucalanus pseuoattenuatus	*Pareucalanus attenuatus*	Pac
Eucalanus subcrassus	*Subeucalanus subcrassus*	Pac
Eucalanus subtenius	*Subeucalanus subtenuis*	Jap, Pac
Euchirella brevis	*Euchirella amoena*	Ber, Pac
Gaidius sp.	*Gaetanus* sp.	Ber, Okh, Pac
Gaidius variabilis	*Gaetanus minutus*	Ber, Okh, Jap, PGB, Pac
Labidocera bipinnata	*Labidocera rotunda*	Jap, PGB
Megacalanus longicornis	*Megacalanus princeps*	Pac
Paracalanus parvus	*Paracalanus parvus parvus*	Okh, Jap, PGB, Pac
Pareuchaeta sp.	*Paraeuchaeta* sp.	Ber, Okh, Pac
Pareuchaeta japonica	*Paraeuchaeta elongata*	Ber, Okh, Jap, PGB, Pac
Pleuromamma abdominalis	*Pleuromamma abdominalis abdominalis*	Pac
Pleurommama xiphias	*Pleuromamma xiphias*	Pac
Pseudochirella polyspina	*Pseudochirella obtusa*	Pac
Scolecithricella ovata	*Pseudoamallothrix ovata*	Ber, Okh, Pac
Sinocalanus tenullus	*Sinocalanus tenellus*	Jap, PGB
Tortanus discaudatus	*Tortanus (Boreotortanus) discaudatus*	Ber, Okh, Jap, PGB, Pac
Undinula darwini	*Cosmocalanus darwinii darwinii*	Pac
Oithona brevicornis	*Oithona brevicornis brevicornis*	Jap, PGB
Oncaea borealis	*Triconia borealis*	Ber, Okh, Jap, PGB, Pac
Oncaea conifera	*Triconia conifera*	Jap, PGB
Acanthomysis borealis	*Exacanthomysis borealis*	Jap, PGB
Acanthomysis dimorphastelleri	*Hemiacanthomysis dimorpha*	Jap, PGB
Disacanthomysis dybovskii	*Disacanthomysis dybowskii*	Jap, PGB
Meterythrops microphtalma	*Meterythrops microphthalmus*	Jap, PGB
Neomysis chernianskii	*Neomysis czerniavskii*	Jap, PGB
Neomysis japonicus	*Neomysis japonica*	Jap, PGB
Paracanthomysis schikotensis	*Paracanthomysis shikhotaniensis*	Jap, PGB

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Tessarobrachion oculeatus	*Tessarabrachion oculatum*	Ber, Pac
Thecosomata (Pteropoda) gen. sp.	Tectipleura (Pteropoda) gen. sp.	Jap, PGB
Cavolinia pyramidata	*Clio pyramidata*	Pac
Euclio sp.	*Clio* sp.	Pac
Ferrosagitta ferox	*Ferosagitta ferox*	Pac
Ferrosagitta bipunctata	*Sagitta bipunctata*	Pac
Sagitta elegans	*Parasagitta elegans*	Ber, Okh, Jap, PGB, Pac
Flaccisagitta maxima	*Pseudosagitta maxima*	Okh, Pac
Sagitta nagae	*Zonosagitta nagae*	Pac
Oikopleura vanhoeffeni	*Oikopleura (Vexillaria) vanhoeffeni*	Ber, Okh, Jap, PGB, Pac
Doliolium sp.	*Doliolum* sp.	Okh, Pac
Mysidacea gen. sp.	Mysida gen.sp.	Ber, Okh, Jap, PGB, Pac

Note: WoRMS – World Register of Marine Species http://www.marinespecies.org, Ber – Bering Sea, Jap – The Sea of Japan, Okh – The Sea of Okhotsk, Pac – Pacific Ocean, PGB – Peter the Great Bay.

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Open Access Earth System Science Data Discussions

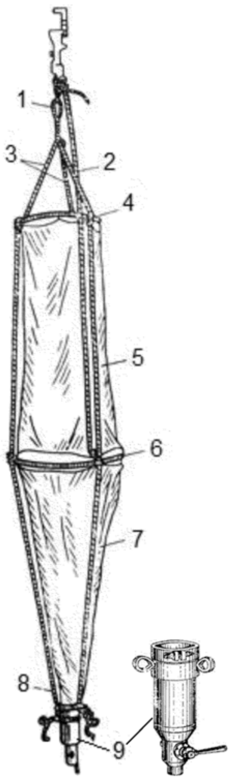


Fig. 1. Large Juday plankton net: 1 – cord loop, 2 – cord that connects the net to the closing device, 3 – cords on the upper ring, 4 – upper ring, 5 – cloth cone, 6 – lower ring, 7 – silk net, 8 – cord that holds the tub, 9 – tub

Longitude	Latitude		TINRO			Rev. of the counter		Collector/Processor	
Sea (region)	Station	Sample	Ship	Date	Time	Net	Layer		m^3
						BJN			
Species	Length, mm	SF(ind.)	MF(ind.)	LF(ind.)	Species	Length, mm	SF	MF	LF
		Breeding (x times)					Breeding (x times)		

Fig. 2. One of the standard forms for processing plankton samples (from Volkov, 2008a). There the zooplankton size fractions are designated by the abbreviations: SF – small (fine), MF – mean and LF – large (coarse) fraction

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

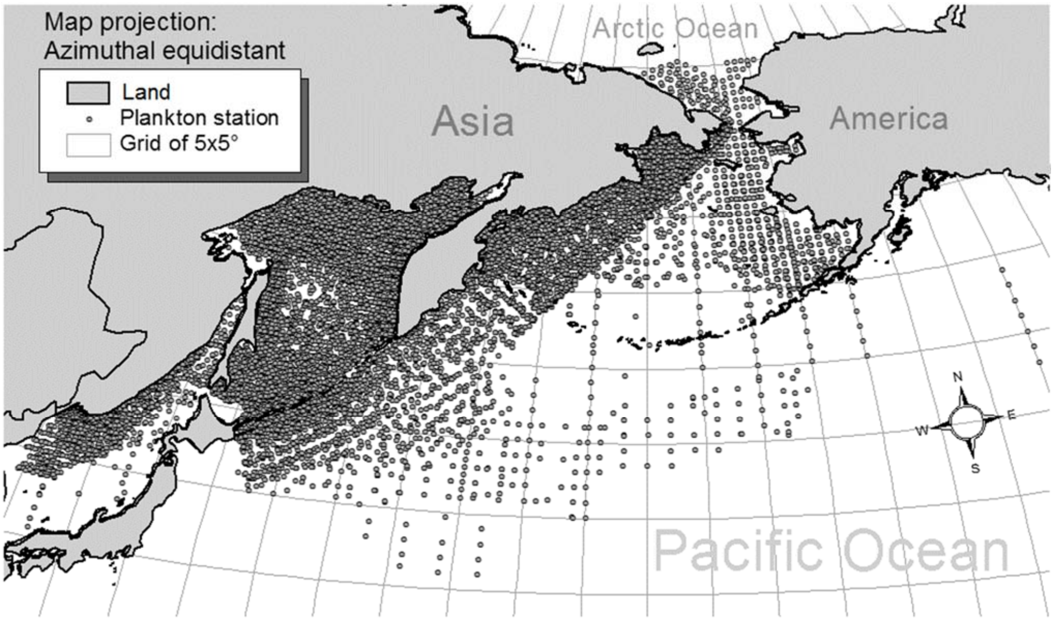


Fig. 3. Spatial distribution across the surveyed waters of 25,512 plankton measurement stations, from which the data obtained, has been entered into the database

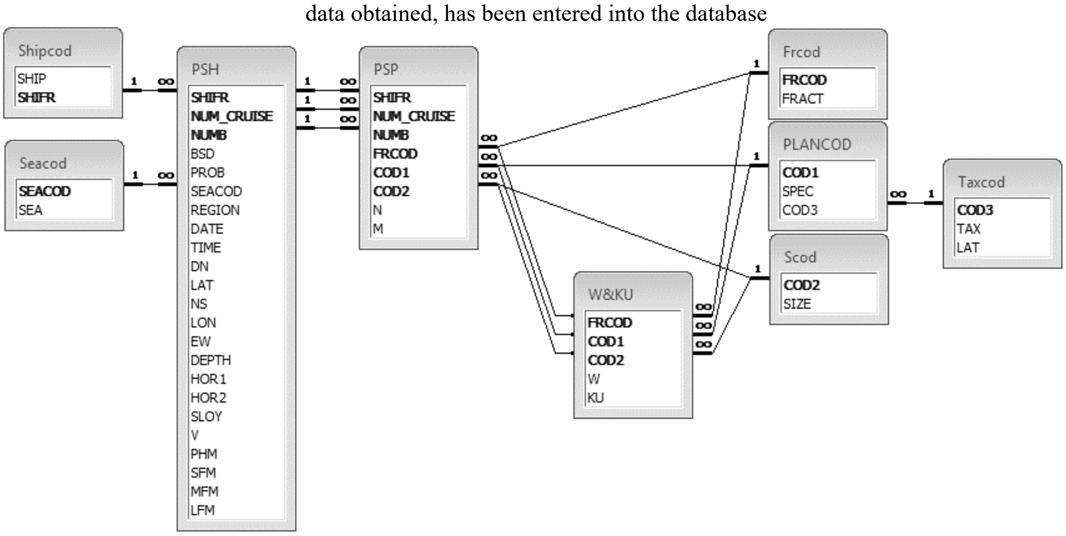


Fig. 4. Structure of the database. The PSH table contains the "headers" of plankton cards (see Fig. 2): vessel call-sign (SHIFR), voyage number (NUM_CRUISE), sequential sample number from the beginning of the voyage (NUMB), station number recorded in the card (BSD), number of sample at the given station (PROB), reservoir code (SEACOD), region number (REGION), date (DATE) and time (TIME) of sampling, light or dark time of day (DN), latitude (LAT), northern or southern hemisphere (NS), longitude (LON), eastern or western hemisphere (EW), depth of area (DEPTH), initial (HOR1) and final (HOR2) catch depth, catch layer (SLOY), caught water volume (V), total biomass of phytoplankton (PHM), small (SFM), medium (MFM) and large (LFM) zooplankton fractions. The PSP table contains data from the card rows: in addition to the first three mentioned above it includes the fraction (FRCOD), species (COD1), size group or developmental stage (COD2) codes, data on abundance (N) and biomass (M). The W&KU table contains data on the average weight of specimens (W) and the catch efficiency coefficients (KU). All the other tables – codifiers: Shipcod – ships, Seacod – reservoirs, Frcod – fractions, PLANCOD – species, Taxcod – supraspecific taxonomic units, Scod – size groups and developmental stages of specimens. Key fields are highlighted in bold. All the links between the tables are "one-to-many"

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

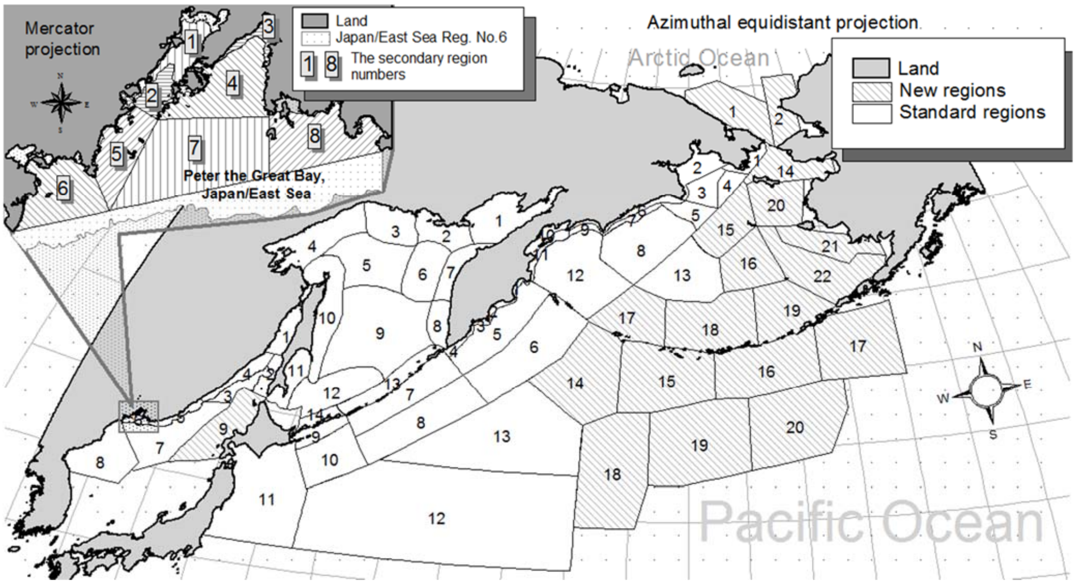


Fig. 5. Standard regions in which averaging of biostatistical information in the waters of permanent (light) and periodic (shaded) monitoring is performed. In the upper left tab – secondary regions, which the 6th region of the Sea of Japan is divided into

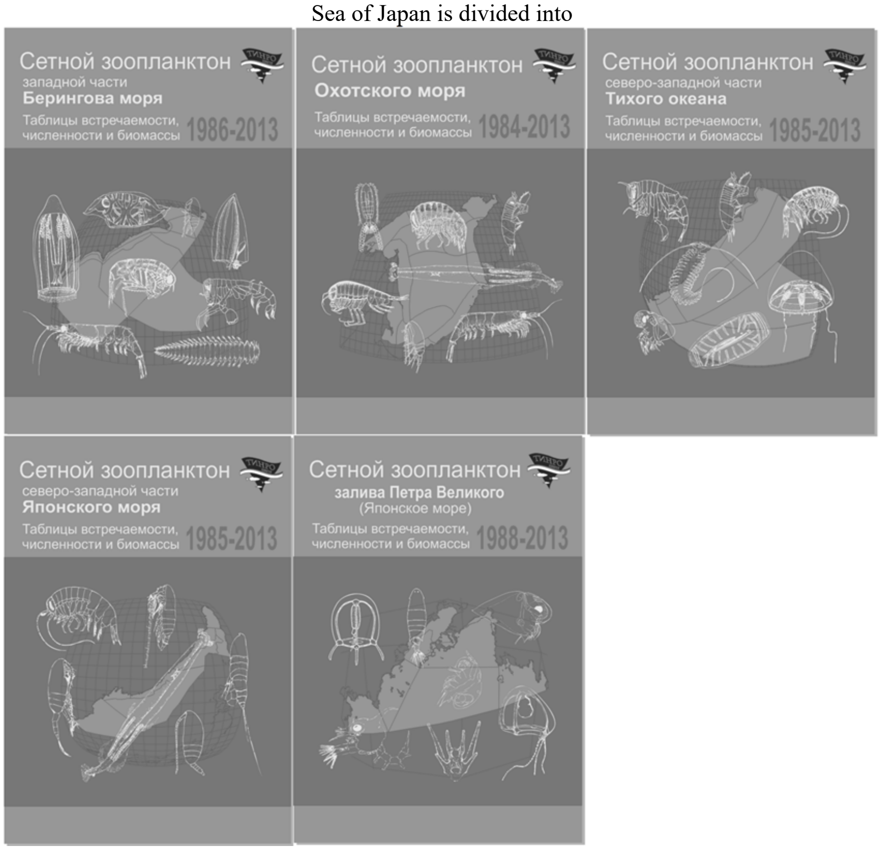
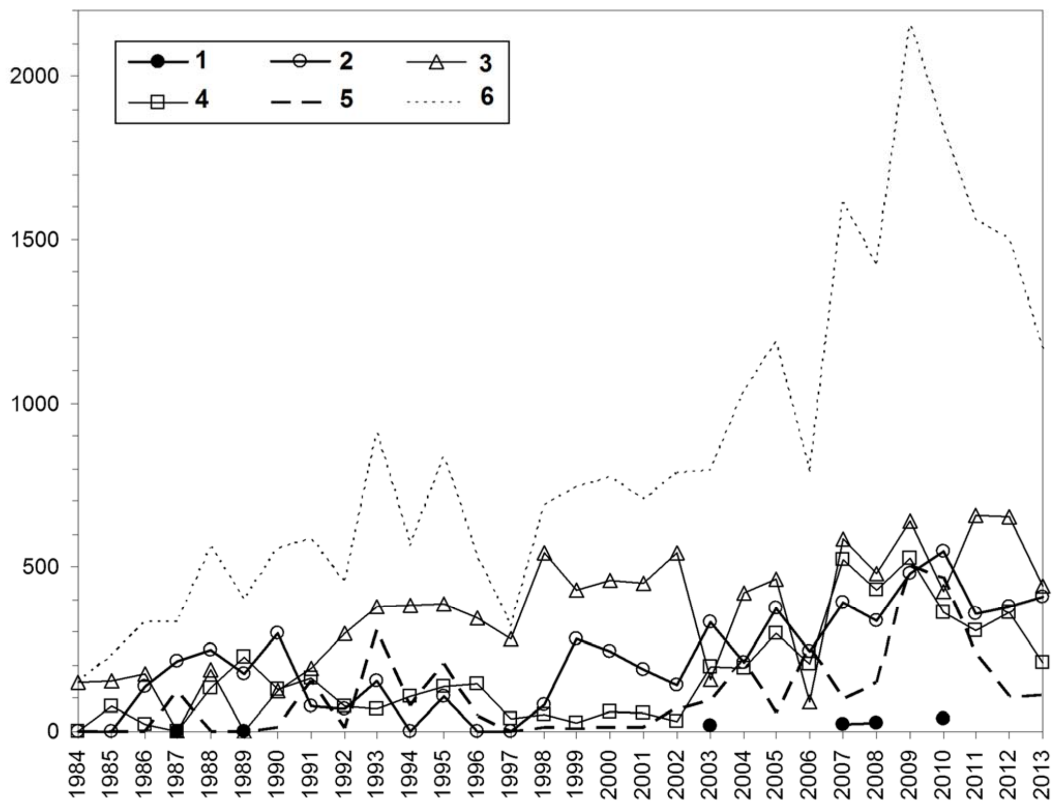


Fig. 6. Five monographs – tabular directories on plankton in the Far Eastern seas and the north-western Pacific, prepared based on data in the new net zooplankton database

https://doi.org/10.5194/essd-2021-29
Preprint. Discussion started: 1 February 2021

Open Access Earth System Science Data Discussions



712
713 **Fig. 7**. The inter-annual fluctuations of survey intensity: 1 – Chuchki Sea, 2 – Bering Sea, 3 - the Sea of
714 Okhotsk, 4 – the Sea of Japan, 5 - ocean waters, 6 - the entire area. X axis – years, Y axis - number of plankton
715 samples