RUSSIAN ARCTIC SEAS ATLASES: CONCEPT AND COMPOSITION

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Abstract
This paper presents the Russian seas ecological atlases series development results. Now there are published The Kara Sea and The Laptevy Sea atlases. Both atlases include six chapters. They cover geographical aspects of the water areas, biodiversity, economic development, specially protected areas, and coastal environmental sensitivity. First five chapters feature detailed maps with legends and infographics. Unlike these chapters, the sixth chapter has two sections. The first one describes the ESI coastal categorization principles, and the last contains maps. Both conventional and advanced cartography visualization procedures are used. Particularly, the water areas biodiversity maps are represented with a hexagonal grid that clearly shows the quantity and structure of the water area types.

Keywords*: atlas, Arctic, ecology mapping*

INTRODUCTION

Over fifteen centuries cartography has evolved from huge paper tomes to advanced publicly accessible electronic media. Atlases are complex editions representing state-of-the-art cartography. The Russian complex atlas cartography has boosted in Soviet Union, when the reference atlases publishing has started. The first such atlases were developed in the 1930s. These editions included complete map packages covering individual natural system components, and detailed population and economic data. They also included mineral, evaluation, and forecast maps.

Since the mid-1950s marine atlases have been developed (e.g., Morskoj atlas…, 1950-1958, Atlas okeanov…, 1974-1982). These cover the history of water areas, seabed and ocean floor exploration, the maps of bathymetry, hydrology,

hydrochemistry, and biogeography. However, these atlases lack marine environmental status assessment. Still, the global ocean resource development requires new approaches to categorization of current water areas status information to prevent environmental disasters. For this reason, the development of ecological marine atlases is very relevant.

For the last decades, the world cartography has been producing more and more comprehensive marine environmental atlases. For example, The Bering Sea, Chukchi Sea, and Beaufort Sea Atlas (Smith et al., 2017) aggregates the general geographical information, biodiversity, and economic activity data. The Beaufort Sea Atlas is yet another specialized ecological atlas representing the oil spill sensitivity of certain coast types. The atlas includes a package of large-scale maps categorized under ESI.

At the present time, the electronic atlases are developed rapidly. These atlases have a user web-interface enabling to obtain the certain visual information interactively. For example, European Atlas Of The Seas, (http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas).

Advanced geoinformation systems significantly reduce cartographic edition development period. The marine atlases are in high demand by both researchers and marine professionals. A number of books covering the seas washing the Russian shores have been published (Ekologicheskij Atlas. Karskoe more, 2016; Ekologicheskij Atlas. More Laptevyh, 2017). Its specific feature is the unification of the volume information collecting, processing and visualization basic principles, and methods of the tome inner composition.

Water areas cartography data sources

The seas are complex entities in terms of single map and map package development. Huge area and complex shore-line configuration translates into specific requirements to map projection, format, and layout. Besides, seas are evolving varying its surface and volume properties. Intense development of coastal processes (extremely intense in northern water areas) leads to continuous shore-line shifts (shore retreat). Even more, some islands can completely disappear and be replaced with shallow water areas of the same name.

These water area features result in unusual requirements for data sources used in map development and updating. All marine cartographic data sources can be categorized into four basic groups:

survey results

remote research materials

references

available cartographic materials of the entire water area or its sectors.

Surveys provide the most accurate values of the water surface, mid-water, and bottom waters properties are obtained. These measurements are discrete. They reflect the water area status at the regular survey station mesh nodes. Thus, such an information source is unable to provide continuous water area property distribution over the same period of time. This restricts the applicability of such data for continuous water area cartography.

On the other hand, remote study materials simultaneously provide a data array covering the entire water area or most of it. This group includes remote studies of bottom waters (with geophysical survey methods such as sonar detection, echo sounding, etc.), and space survey (various spectral range imagery, scope and resolution), and satellite tracking of marked animals.

Remote bottom waters survey provides the images required some special skills to handle. However, it is a valuable source of deep water, floor relief morphology and bottom features. Space imagery enables to analyze some sea surface derivative properties. For example, they are the temperature, the chlorophyll concentration, the ice-lead and ice-edge locations, etc. However, the remote survey methods also have their restrictions. They are clouds, very common for Russian seas and polar night (restricts space imagery in the optical band.) Animal satellite tracking often provides random data useless for visualization, but still they contain important data on the species migration routes. Data preprocessing is required for visual representation on low-scale maps. An example of such preprocessing is represented in Figure 1.

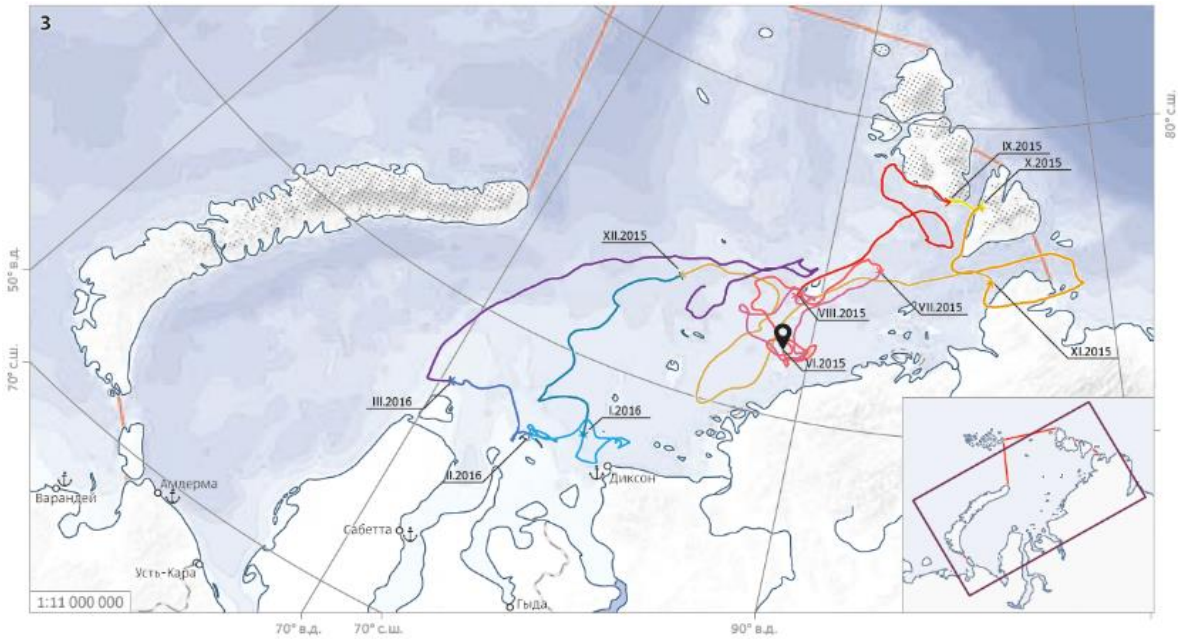

Figure 1 The route of a polar bear with a satellite tracker

RUSSIAN SEAS ECOLOGICAL ATLASES COMPOSITION

The Ecological Atlases Composition

The ecological atlases series consists of books covering each Russian sea. The Kara Sea and The Laptevy Sea atlases have already been published. Each book includes six chapters: physiographic sea characteristic oceanographic characteristic biodiversity area economic development specially protected natural areas environmental coastal sensitivity. The section composition is shown in Table 1.

Table 1. Ecological marine atlases composition

Chapter 1. Physiographic characteristic of the Kara Sea	1.1 General overview 1.2 Climate 1.3 Geology and geomorphology
Chapter 2. Oceanographic characteristic of the Kara Sea	2.1. Hydrological structure of the Kara Sea 2.2. Ice conditions 2.3. Thermohaline structure of sea water 2.4. Hydrochemical structure of sea water 2.5. Directions of Currents In Surface Water Layers 2.6. Tides and Other Fluctuations of The Sea Level
Chapter 3. Biodiversity of the Kara Sea	3.1. Pelagic communities of the Kara Sea 3.2. Macrophytobenthic communities of the Kara Sea 3.3. Macrozoobenthic communities of the Kara Sea 3.4. Fish fauna of The Kara Sea 3.5. Birds of The Kara Sea 3.6. Marine Mammals of The Kara Sea 3.7. Plant Complex of The Kara Sea Shores
Chapter 4. The Kara Sea and Shores Human Impact	4.1. The Region Economic Activity 4.2. Transportation Infrastructure
Chapter 5. Areas With The Special Protection Status	5.1. Specially Protected Natural Areas 5.2. Wetlands (Ramsar sites)

Chapter 6. The Kara Sea Shore-line Environmental Sensitivity Assessment	6.1. The Shore-line Environmental Sensitivity Assessment Methods 6.2. The Kara Sea Shore-line Categorization 6.3. The Kara Sea Environmental Sensitivity Assessment Findings

The first chapter represents the study sea physiographic characteristics: climatic, geological, and geomorphological area conditions. The second chapter represents the water area oceanographic criteria distribution: the stream conditions, the ice conditions, the thermohaline and hydrochemical characteristics, the constant flows directions and level regime specificities. The third chapter represents the marine biodiversity characteristic, including the plankton community, macrophytobenthic, macrozoobenthic, fisheries, ornithofauna, theriofauna, and coastal plant complex. The fourth chapter describes the area economic development and transportation infrastructure features. The fifth chapter describes the nearest areas with the special protection status and wetlands included into Ramsar Site. Finally, the sixth chapter provides the coastal categorization by the oil spill sensitivity factor (according to the ESI).

The first five chapters include the maps with the legends and infographics. The sixth chapter contains two parts: the first part describes the principles of ESI coastal categorization, and the second part includes the maps set represented the categorization of the certain large-scale coastal areas according to ESI. This maps set includes the map division at the beginning.

The atlas mathematical basis

The Albers equal-area conic projection is used. The central meridian and standard parallels are selected in accordance with the study area location. Thus, the Kara Sea atlas has the central meridian at 70o e.l. and the Laptevy Sea atlas – at 120o e.l.

The scales was selected in accordance with shown parameters. The biggest scale (1:1500000) was selected for the map-charts of place-names and map-charts of oil spill sensitivity factor coastal categorization. They are based on particular materials, such as aerial survey or space survey high resolution images. The second scale factor (the main level, 1:7500000) is used for representation of map-charts at broadside (the Kara Sea atlas). The third scale factor is used for block of four maps and approximately twice as small as main factor. The inset-maps are composed with 1:20000000 scale factor.

Composition

The several water area research levels require several main scale factors. This requires for several compositions development. There are five composition types in Russian seas atlases: broadside map-chart, page map-chart, map-chart with inset-map, map-charts block with three maps, map-chart block with four maps. Herewith, all composition types have following maps location (excluding broadside): the map field is located at left side, and the legends – at neighbor page (Fig. 2). Herewith, for ease of use the common geographical content legends are printed in separate bookmark. We should note, that the all atlases maps legend are represented at both Russian and English languages.

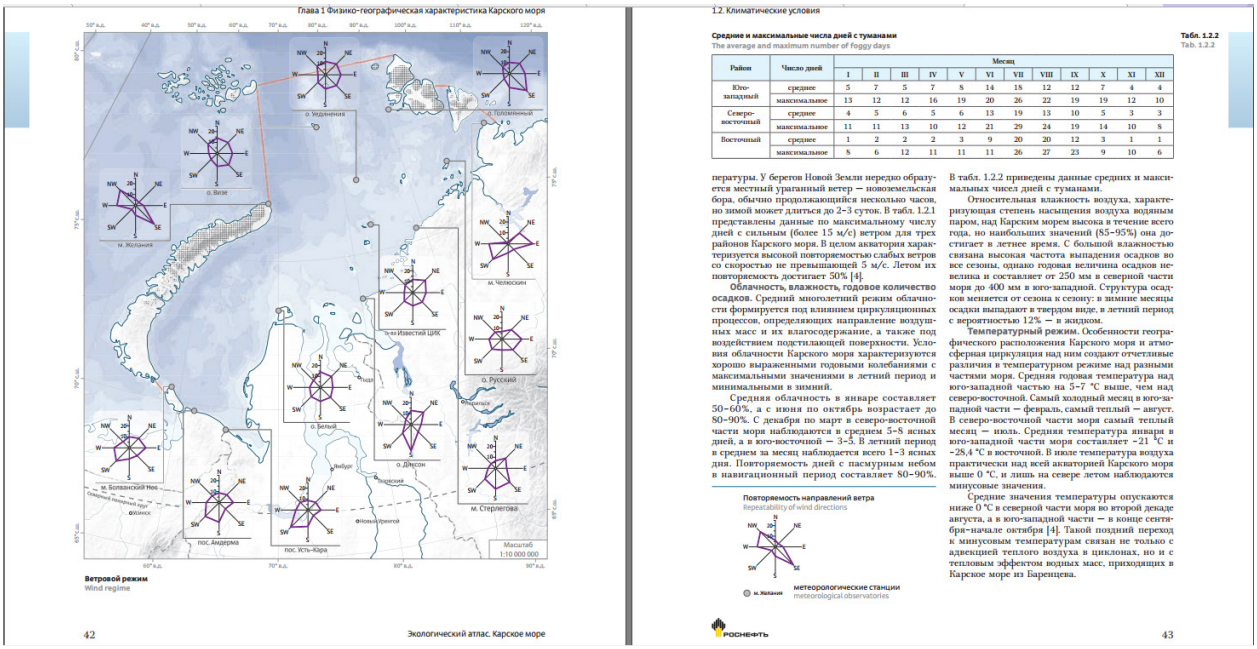

Figure 2 Atlas broadside. The map at the left side, and the legend at the right side.

The hardest problem was a positioning of the map symbol scale for the four maps block. The scales location at maps bottom caused the block not fitted in the broadside page, and scales location all-together at the page bottom or in the legend content caused poor maps readability. The problem had been solved through the scales positioning between the neighboring map blocks (Fig. 3).

ATLASES MAPS GENERAL GEOGRAPHICAL BASIS

All atlases are created at the unified general geographical basis including following content elements: shore-line location, land and sea bottom relief, hydrographical items, population centers and main components of transportation infrastructure. The key objective of the general geographical basis development is a collecting and verification of the shore-line location data. Its location information is verified and elaborated in the base of open and commercial (if necessary) data sources (for example, high resolution space imagery). The hypsometric tints selection is important problem also. It must correctly represent the relief plastic of a region.

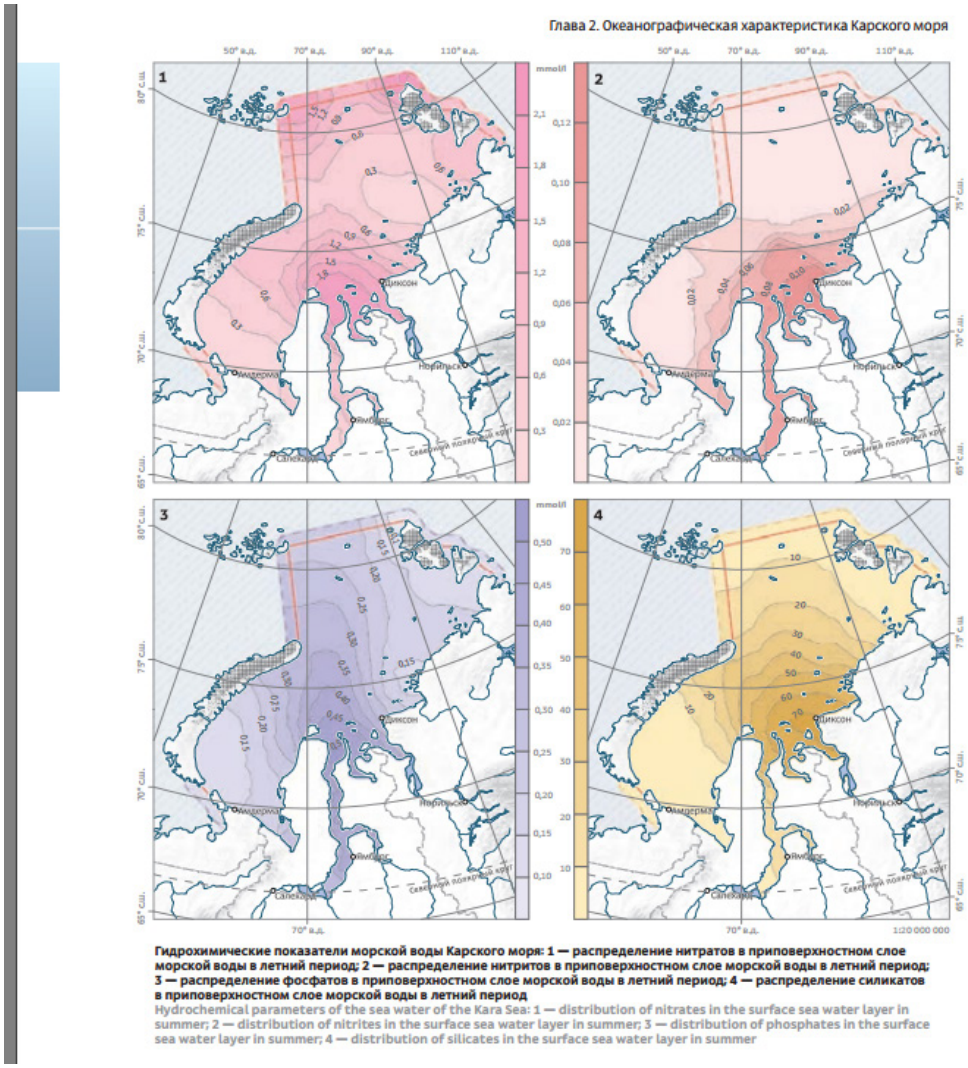

Fig. 3 Example of the four maps block

INFORMATION VISUALIZATION FEATURES OF THE RUSSIAN SEAS ECOLOGICAL ATLASES MAPS

Everincreasing information volume casts a difficult problem to map-makers – to visualize several properties of the same item. The main principle of the atlases maps appearance is the data representation clarity and cartographic image readability.

For information visualization were used almost all methods of cartographic representation, from simple signs and isolines with layer-based coloring (Fig 4. a) b)) to complex methods for several features representation at the same map or integrated features. The environmental coastal sensitivity maps and biodiversity maps are examples of such complex methods of cartographic image creation.

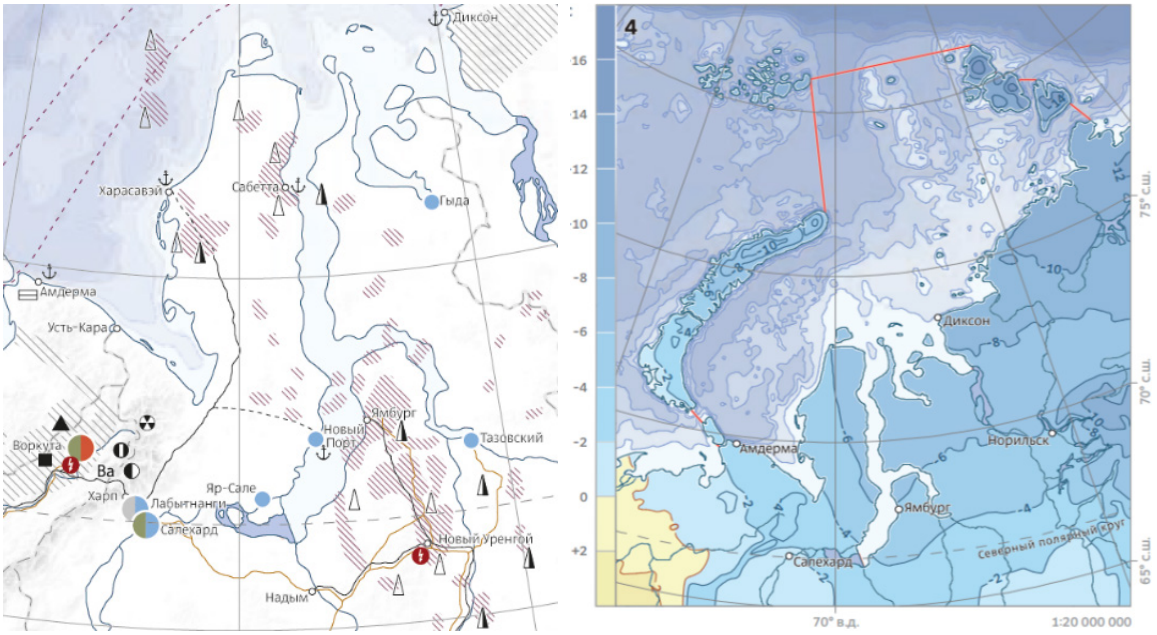

Figure 4 a) Area Economic Development map snippet, b) Average Long-term Maximal Atmospheric Temperature map

For complete representation of the coastal oil spill sensitivity it was necessary to show the coast categorization under ESI and describe the morphodynamical coast types. This properties was shown by two parallel lines. The first one is completely matches the coast line, and the other one goes in parallel with the first one (Fig. 5).

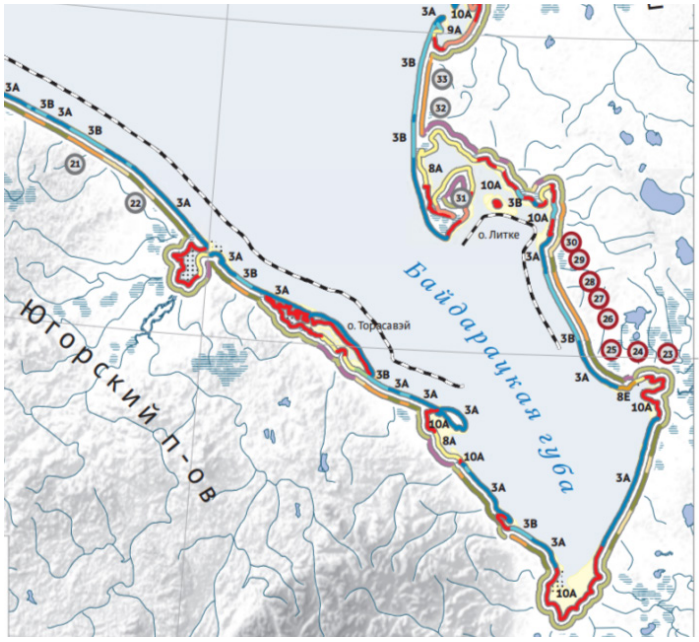

Figure 5 Coastal Sensitivity map snippet.

In biodiversity map it was necessary to show the much information about species of Russian seas and their structure. The limited atlas volume make it impossible to create a separate map per species. That's why it was used the regular hexagonal grid to unify the information, where cell-color indicates the species count. The species structure is shown in inset-diagrams with the same hexagonal grid, but with bigger cells (Fig. 6).

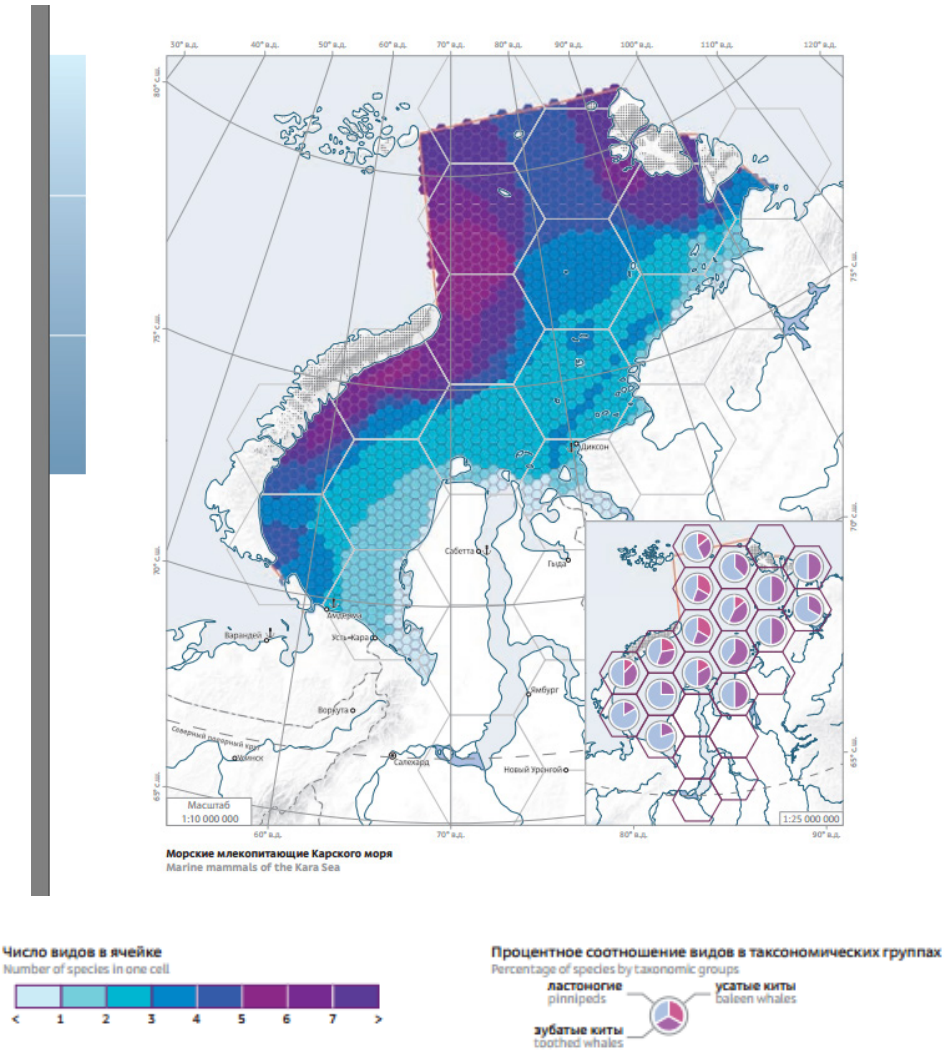

Figure 6 The Kara Sea Marine Mammals map

RESULTS

The works of the Russian Seas ecological atlases series development have resulted in establishing of the basic information management and arrangement principles and definition of the entire atlas and maps basic content. There was approached the methods of big data array integration into one map. Both created atlases are reference materials, where unless readable maps the big volume of general geographical and special information about seas is represented. These atlases contains the whole state-of-the-art in the water area research. It is intended both as a reference book and as a tool for water areas study factor analysis and assessment.

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