ROSATOM

LMSU
MRC

PROGRAMME OF COMPLEX RESEARCH AND MONITORING OF SURFACE AND UNDERWATER ENVIRONMENTAL SAFETY OF THE NORTHERN SEA ROUTE

INTRODUCTION

Global natural processes and anthropogenic impact may significantly influence changes of the Arctic. The region implies a fragile and unique ecosystem that includes various species of plants, animals, fungi and microorganisms, many of them are presented in the Red Data Book of the Russian Federation and the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species.

At the same time, the Arctic is also a region of a huge development potential with population of almost 4 million people.

Human interest in the Arctic marine area as a transit corridor appeared in the XVI century. For five centuries, expeditions have been conducted, first to explore passages to Asia, and then to study natural resources of the region.

The successful expedition of Otto Schmidt on «Alexander Sibiryakov» icebreaker in 1932 led to possibility of paving of the Northern Sea Route (NSR). That period evidenced the beginning of the all-season study of the Arctic marine area that also considered study of logistics corridors in the northern seas.

Current global trends are transforming the NSR into a year-round transport and logistics route, which requires safe and sustainable shipping along the Arctic, while the establishment of a modern and efficient port infrastructure involves constant monitoring of the state of Arctic marine and terrestrial ecosystems adjacent to the NSR, in other words - ensuring the environmental safety of the Arctic. The latter is possible with the comprehensive application of regulatory support, management, navigation and technological solutions, as well as the effective interaction of authorities, nature resource users and the expert community.

Environmental monitoring implies one of the most effective mechanisms for obtaining the necessary information about the state of the environment in the Arctic. The monitoring is continuous, covers broadest possible study territory and includes application of modern technologies. Measures to identify, prevent and eliminate security threats, localize and neutralize their consequences, including remote methods of environmental research, also facilitate the monitoring process.

General conclusion of the previous marine area environmental studies results revealed gaps in information about the NSR territories. For instance, most of the data were obtained in summer period, while the biological processes seasonal dynamics on sea and land, as well as the annual cycle, have been studied rather poorly. The seas of the Western Arctic have been studied in the most detail, while studies, for instance, in the East Siberian Sea and the Laptev Sea are selective. In this regard, it is necessary to create a comprehensive program of systematic environmental studies that would ensure the regional environmental safety considering global environmental changes, as well as the growing intensity of navigation on the NSR.

Expedition of Otto Schmidt
on «Alexander Sibiryakov» icebreaker.
Archival photo

The first step on this path led to the joint Project of the Lomonosov Moscow State University Marine Research Center (LMSU MRC) and the Rosatom State Corporation started in 2021, involving foreign and Russian scientific organizations that later formed the International Expert Group (IEG).

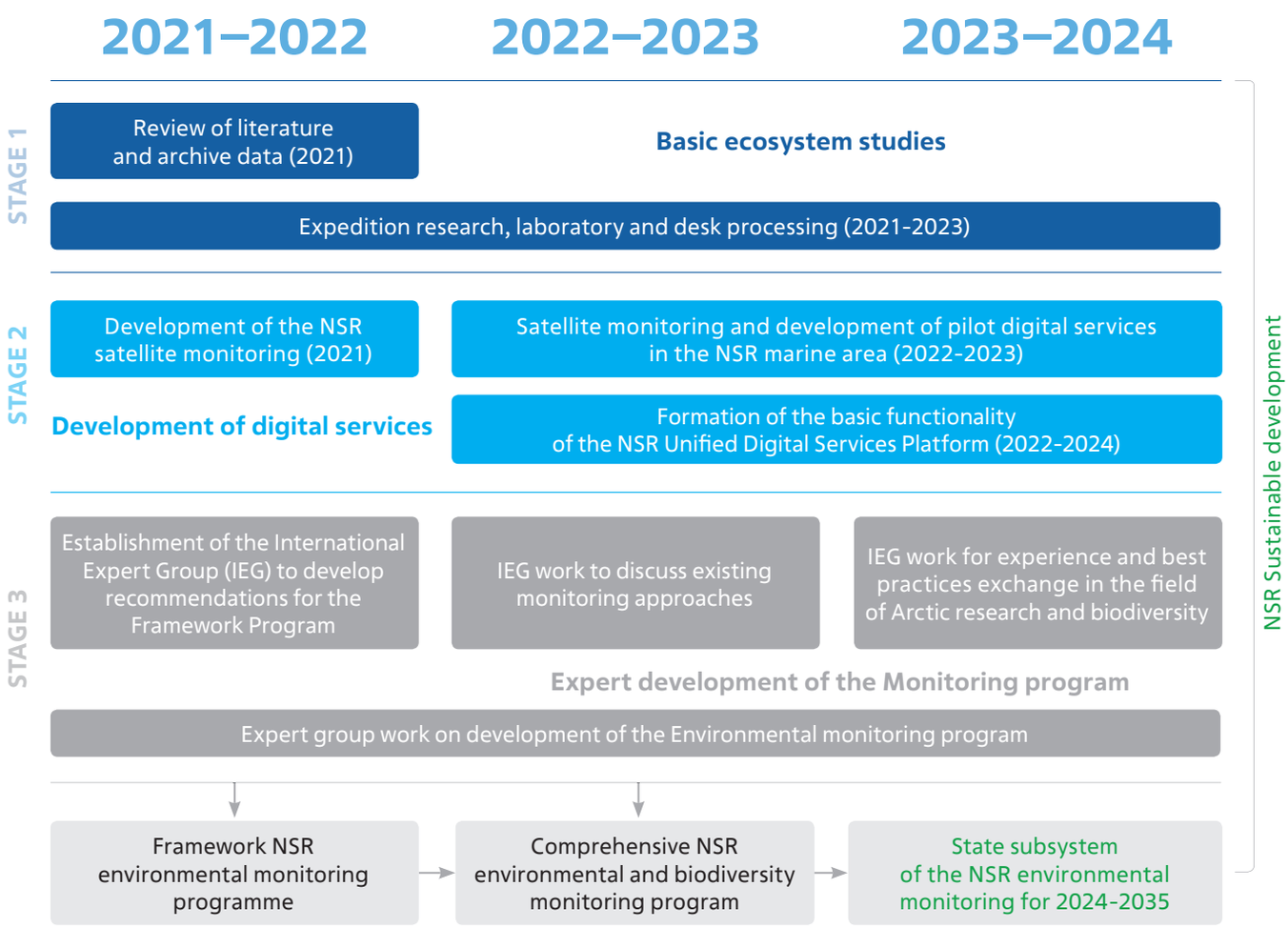
The Project was developed in accordance with the best Russian and international standards in the field of environmental protection and biodiversity, as well as the recommendations of the Arctic Council and its working groups regarding monitoring and assessment of the state of the environment in the Arctic (Arctic Monitoring and Assessment Program, Conservation of Arctic Flora and Fauna, Protection of the Arctic Marine Environment Working Groups).

Project goals

- Comprehensive assessment of the NSR marine area current environmental state;
- Study of the impact of Arctic shipping and infrastructure development on Arctic biodiversity;
- Development of the NSR environmental and biodiversity monitoring comprehensive program in accordance with world best practices to ensure sustainable and environmentally safe development of the region.

THE PROJECT FOCUSES on coastal and transit Arctic shipping, as well as the NSR port infrastructure at construction and operation stages

The Comprehensive environmental and biodiversity monitoring program 2021-2023 development plan



PROJECT IN DIGITS

more than 120 professionals and involved in the project

18 organizations participating in the project

22 months of satellite monitoring of the ships load and NSR pollution

147 comprehensive stations

5 vessels involved

1200 plankton samples and 600 benthos samples

100 atmospheric air samples, 400 sea water samples and about 130 sediment samples

«Alexey Maryshev» research vessel

ECOSYSTEM STUDIES BASED ON 147 COMPREHENSIVE STATIONS ALONG THE ENTIRE NSR

Field work within the NSR marine area was carried out in Summer-Autumn seasons of 2021 and 2022 from «Alexey Maryshev», «Ivan Kireev», «Professor Logachev», «Kartesh» research vessels and «Sevmorput» nuclear-powered LASH (lighter aboard ship). Field work of 2023 was carried out within the Amderma, Sabetta, Utrenny, Dikson, Dudinka, Khatanga, Tiksi and Pevek port areas. (Figure 1).

The network of comprehensive environmental monitoring stations was developed basing on the analysis of open access literature and stock research data from previous years. Location of stations considered the main shipping routes along the NSR and the areas of high ecological importance (i.e. areas of walrus rookeries, feeding, migration and wintering, molting, migration, breeding and feeding of birds, etc.).

Work at the stations included study of atmospheric air; sampling of sea waters, sediments, and microplastics; measurements of the water temperature and salinity; records of large debris. Study of the Arctic biota included sampling for the analysis of quantitative and qualitative indicators of planktonic and benthic communities, as well as for the study of biological invasions, important for the comprehensive understanding of the Arctic marine ecosystems state. Marine mammals and birds were being observed as well.

Walruses were most often encountered mammals during the surveys (more than 78%); 4 out of 5 species encountered are included in the bioindicators list* — polar bear, ringed seal, walrus and beluga (Fig. 2).

*Bioindicator species imply an important indicator of the ecosystem sustainability. In 2015, the Ministry of Natural Resources and Environment of the Russian Federation determined the list of species-indicators of the sustainable state of marine ecosystems of the Arctic zone of the Russian Federation (AZRF).

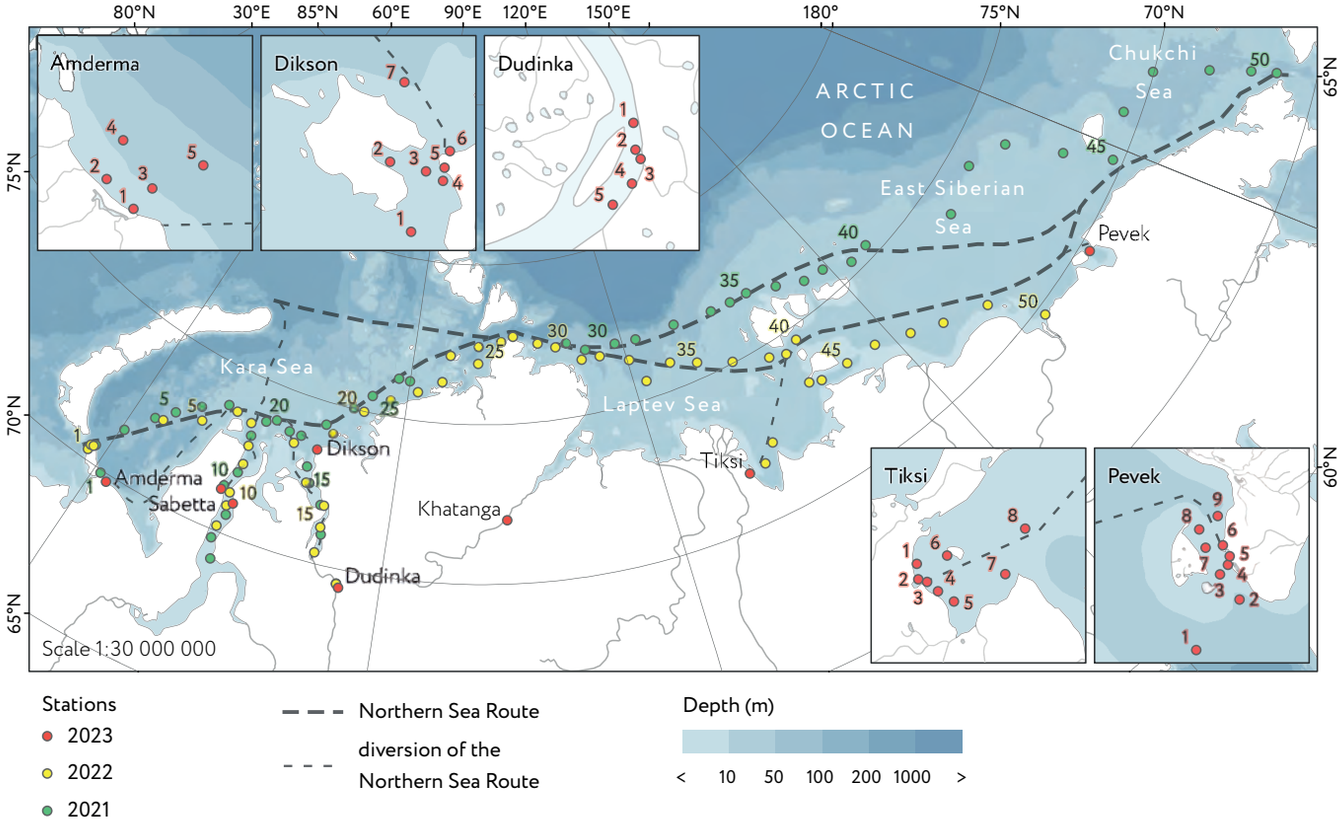


Fig. 1. Map of comprehensive environmental monitoring stations for basic ecosystem studies (complex stations numbered separately for each port)

Water sampling
in the Laptev Sea

Ichthyoplankton sampling
in the East Siberian Sea

During shipboard surveys of seabirds, ornithologists also recorded 6 of 10 species, such as common eider, glaucous gull, tarrock, black guillemot, slender-billed and thick-billed guillemot. The long-tailed duck, mutton-bird and tarrock were the most abundant species in all ornithological counts — these three species collectively constitute 73% of all birds counted (Fig. 3).

The polar bear *(Ursus maritimus)* — is the world's largest land carnivore. 4 out of 19 currently identified Polar bear's subpopulations inhabit the territory of the Russian Arctic

The ringed seal *(Pusa hispida)* — is one of the smallest seals species. It is one of the main feeding objects of the polar bear, so the numbers of both species are closely related

The walrus *(Odobenus rosmarus)* — is a herd animal that forms large rookeries on beaches and ice. Females also have fangs in the upper jaw, they are thinner and shorter than male species

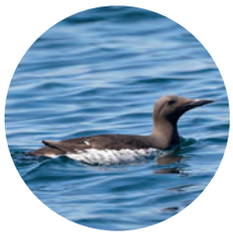
The beluga whale *(Delphinapterus leucas)* — is a social marine mammal with light skin color and no dorsal fin. Chasing the fish, it can go deep river into bays and estuaries

The common eider *(Somateria mollissima)* — is a large seabird species that go ashore only during the nesting period, moving no further than 500 meters inland

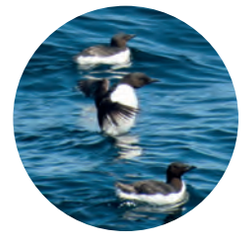
The glaucous gull *(Larus hyperboreus)* — is the second largest light grey gull. This gulls roam along the north coasts and seas until the late autumn and pre-winter

The Black-legged kittiwake *(Rissa tridactyla)* — is a marine species of gulls that commonly nest in colonies on rocky islands and coasts. Partly migratory, partly nomadic

The BLack guillemot *(Cepphus grylle)* — is a pigeon-sized seabird that nests commonly in shelters on the islands. Swims and dives well, does not do long-distance migrations



The common murre *(Uria aalge)* — is a nomadic seabird species whose two subspecies nest in the Barents and Chukchi Seas. They look clumsy on land, but perfectly adapted to life in the water



The thick-billed murre *(Uria lomvia)* — is one of the deepest diving flying birds, inhabit the coasts of the Arctic and subarctic seas

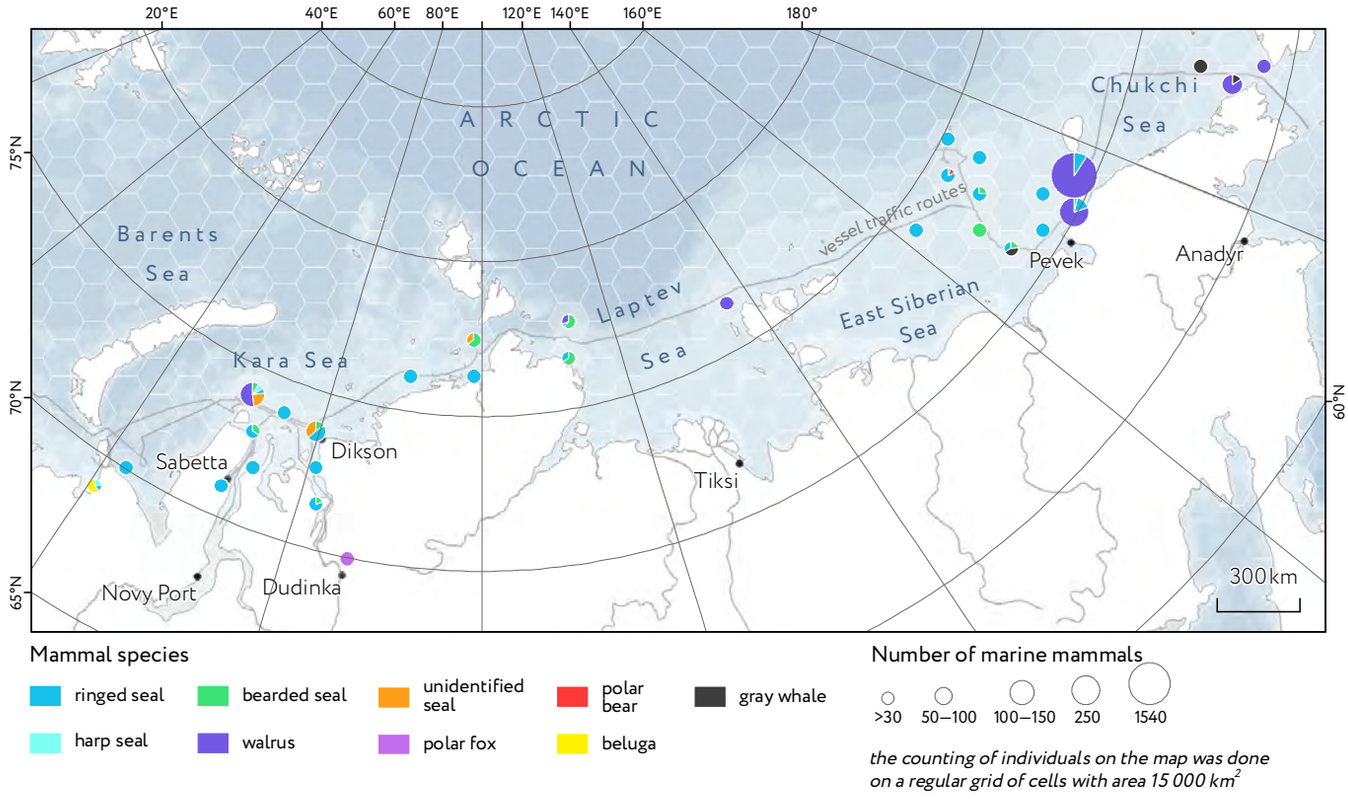


Fig. 2. Distribution of marine mammals encountered within the NSR based on data of on-route studies in 2021

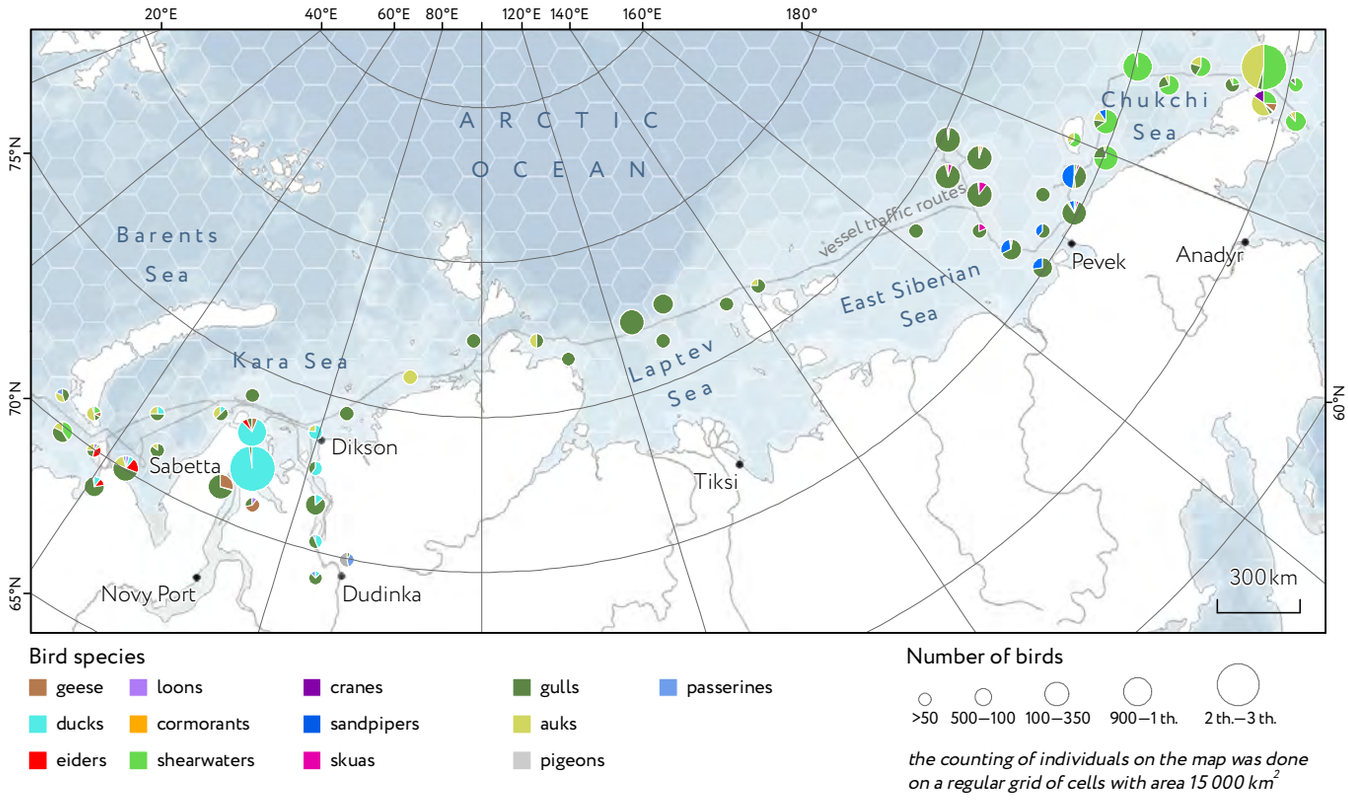


Fig. 3. Distribution of birds groups by species within the NSR based on data of on-route studies in 2021

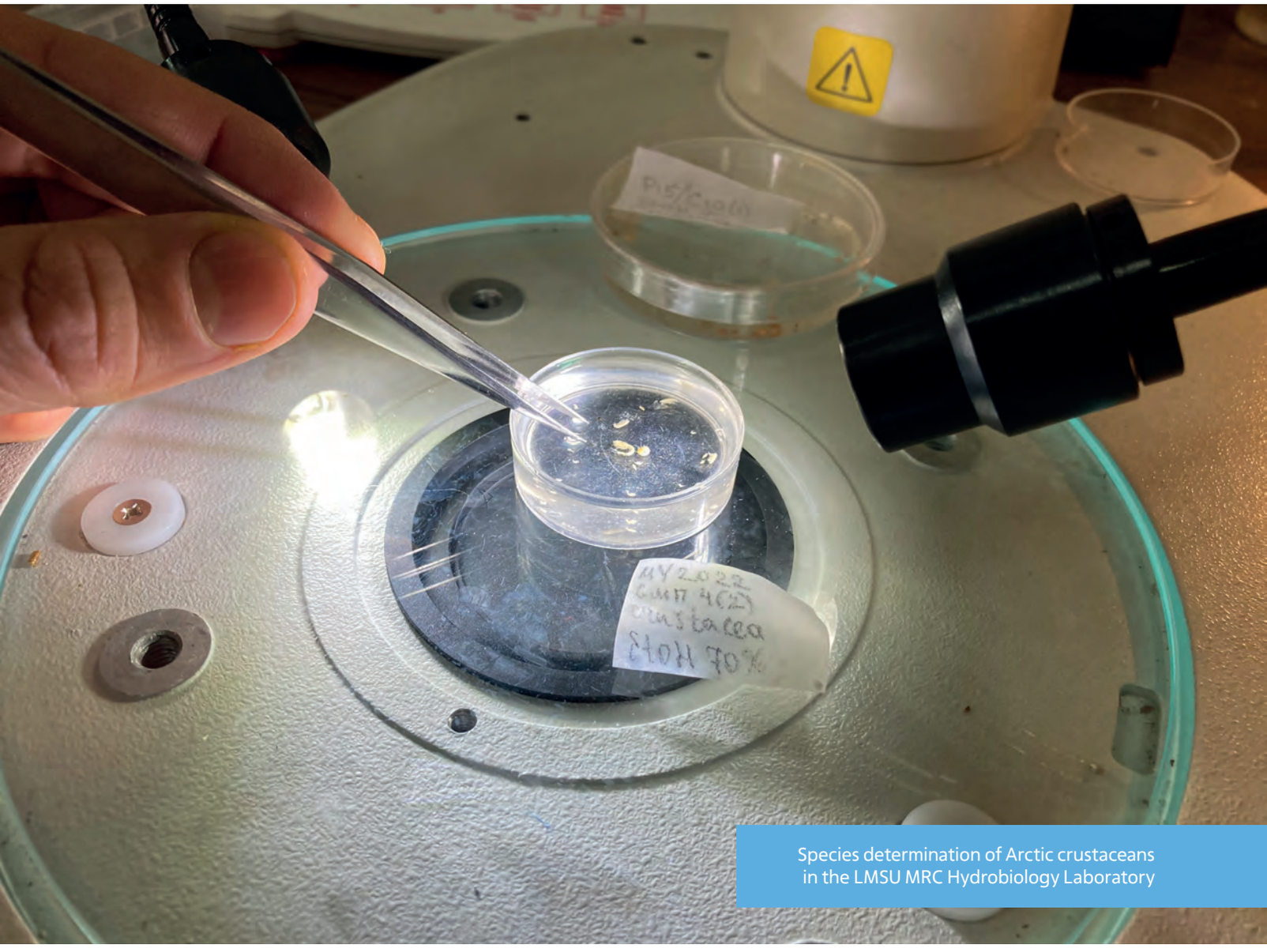
DESK STUDY

In the period from October to December in 2021, 2022 and 2023, sample processing and further desk study of materials obtained during field work was implemented in specialized laboratories of Moscow and St. Petersburg.

In total, within 3 years, experts analyzed 100 samples of atmospheric air, 300 samples of sea water for more than 35 parameters and about 130 samples of sediments for more than 30 parameters (Fig. 42). Hydrobiologists processed more than 1,200 samples of plankton, including bacterioplankton, phytoplankton, zooplankton and ichthyoplankton, as well as about 600 samples of benthos, including macrobenthos, meiobenthos, microphytobenthos.

Studies have shown that in the Summer-Autumn periods the estimated parameters for most indicators had values specific for the seasons and regions of observation.

The continuation of year-round studies will allow to compare the results of future expeditions with the values obtained, observe the changes and adjust monitoring programs based on conclusions about the state of marine ecosystems.



Species determination of Arctic crustaceans in the LMSU MRC Hydrobiology Laboratory

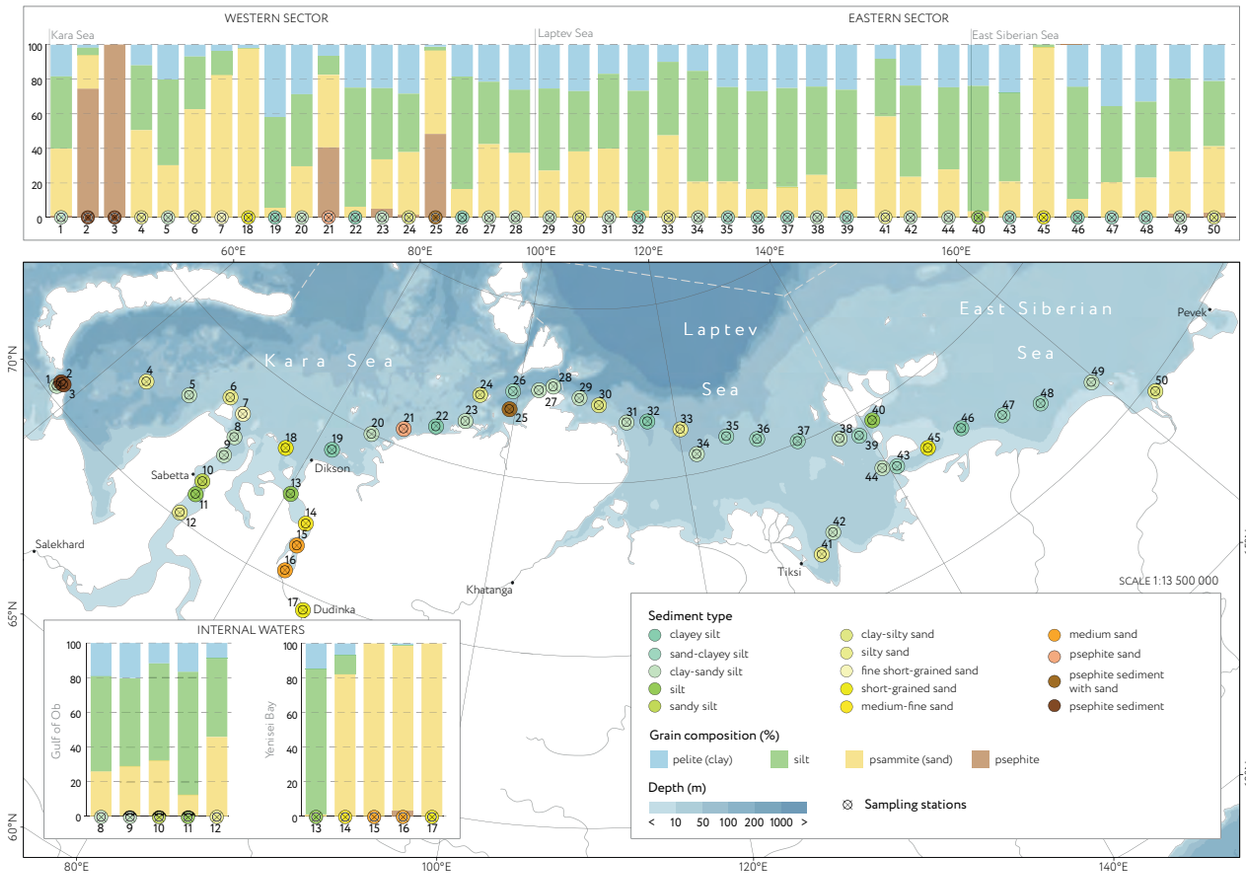


Fig. 4. Distribution of bottom sediments on stations in 2022

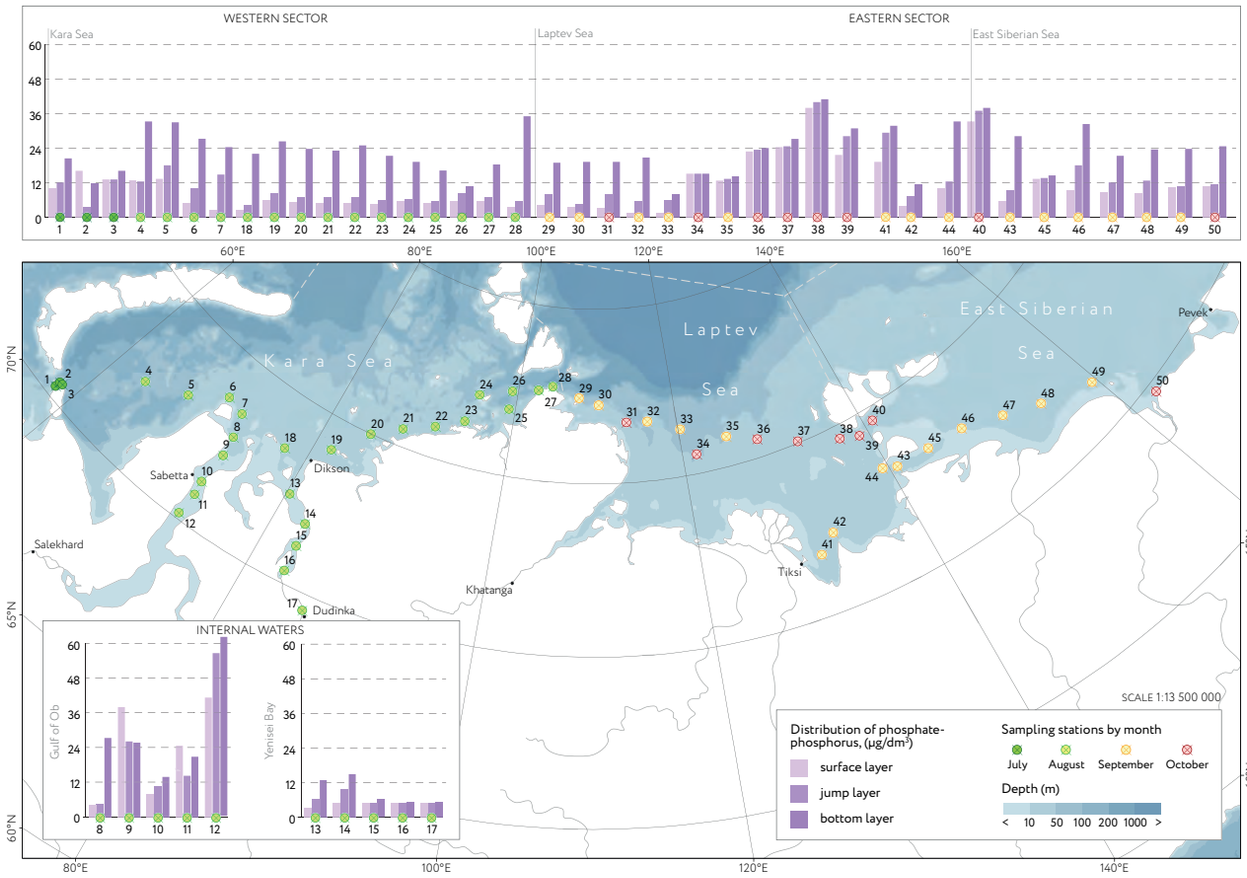


Fig. 5. Phosphate fosfor distribution on stations in 2022

DIGITAL SERVICES AND SATELLITE MONITORING OF THE NSR

The main goal of the development of the Northern Sea Route and its infrastructure is the implementation of responsible, efficient and safe navigation in the Arctic. With this aim in 2021-2023, a project of digital service for satellite environmental monitoring of the NSR marine area ship load and pollution was implemented. The increase in the activity of ship traffic is associated not only with an increase in the volume of cargo transportation, but also with an increase in the frequency of the Arctic seas' exploration.

Pollution monitoring

The project led to detection of a number of local pollutants in the Yenisei Bay, the Laptev Sea, the East Siberian and Kara Seas. Specialists from the Ocean Optics Laboratory of the Institute of Oceanology of the Russian Academy of Sciences after additional examination of the monitoring results determined the superficial impact and the pollutants short life period, which did not require measures to eliminate them.

Vessel traffic density

The analysis of the vessels traffic density during the monitoring period was based on the Automatic identification system (AIS) data. Project results revealed the southwestern part of the Kara Sea as the most intensive shipping area throughout the entire period with the maximum intensity in the Gulf of Ob, where river transport makes the main contribution. In December, following the appearance of a stable ice cover, the ship activity significantly decreases both in the waters of the Kara Sea and the NSR area as a whole. (Fig. 6)

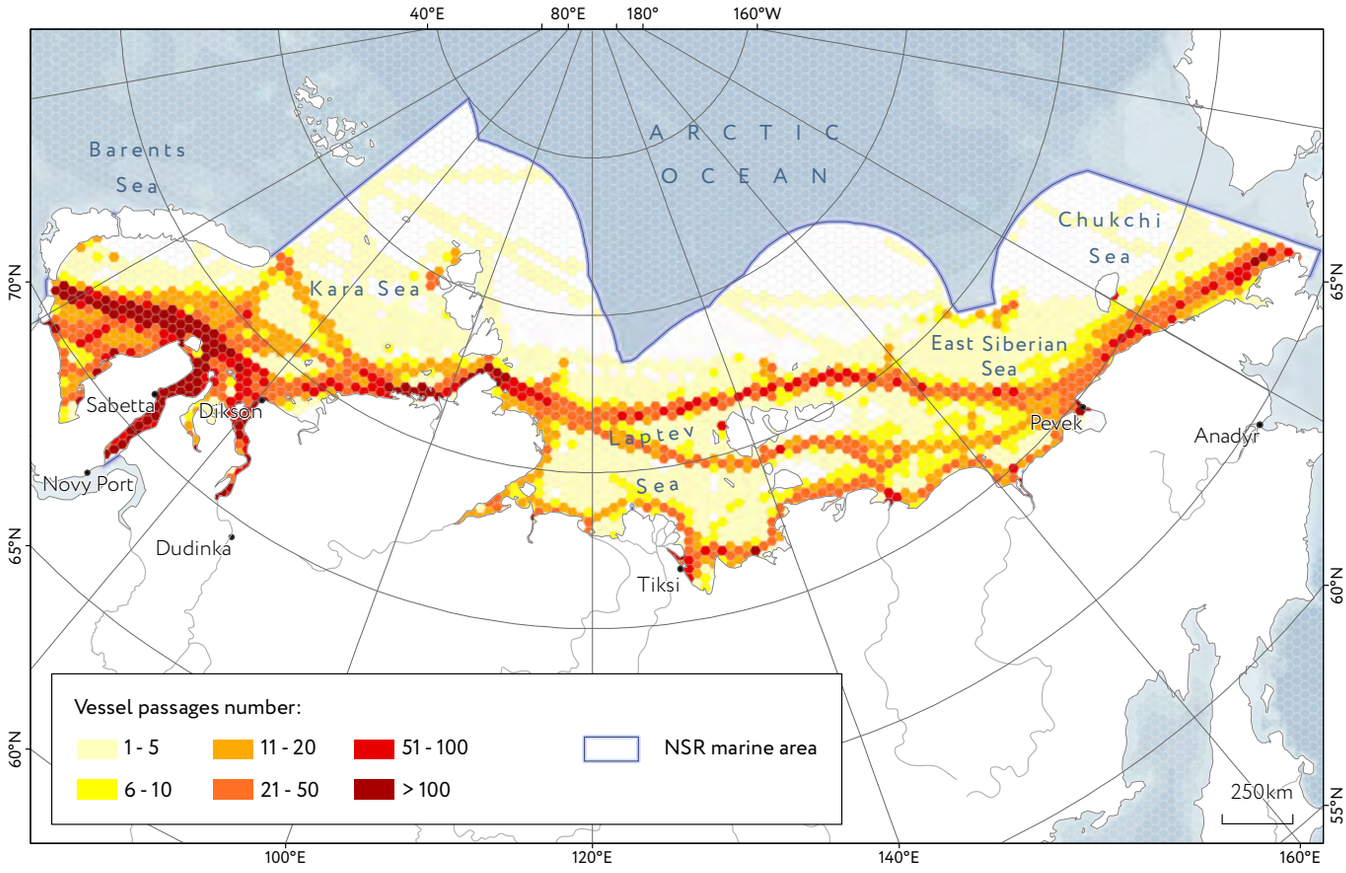


Fig. 6. Integral vessel load along the NSR in the IV quarter of 2021

Additional information

The NSR Unified Digital Services Platform

For the subsequent regular collection, aggregation, storage and analytical processing of monitoring data in 2024-2025, it is planned to introduce the subsystem «Environmental monitoring of the NSR» of the Unified Digital Services Platform (UDSP). The results of environmental monitoring will be presented in the subsystem in the form of two services:

- *Digital service «Environmental monitoring information and analytical portal»;*
- *Digital service «Environmental monitoring of the NSR».*

The NSR UDSP with an integrated environmental monitoring program in the service will become a unified digital platform allowing to effectively monitor the state of the Russian Arctic marine area environment and reduce the risks of negative impacts. The platform will also provide opportunities to minimize anthropogenic impact and build forecasts for rapid management decisions in the field of environmental protection and possible environmental threats prevention.

The «50 Let Pobedy» nuclear icebreaker escorts of the «Polar King» cargo vessel

INTERNATIONAL EXPERT GROUP

The NSR sustainable development of navigation essentially depends on its compliance with Russian and, what is most important, international environmental standards and best environmental practices. In this regard, one of the priorities of the NSR environmental monitoring project is the interaction with the international expert community in order to exchange experience and provide coordination of the monitoring program with existing platforms for collecting environmental data in the Arctic.

In September 2021, the Lomonosov Moscow State University Marine Research Center established the International Expert Group of NSR environmental monitoring project (IGE) as an international forum for discussing concept and implementation of the project.

THE IEG AIMS to evaluate the Comprehensive NSR environmental monitoring program and develop recommendations for its further improvement

The IEG members imply experts on ornithology, zoo- and phyto-plankton, marine mammals, fish, etc., from more than 18 leading Russian and foreign research institutes, associations and public organizations in the field of environmental protection and biological diversity conservation, i.e. Shirshov Institute of Oceanology of the Russian Academy of Sciences, Institute of Ecology and Evolution Problems of the Russian Academy of Sciences, Arctic and Antarctic Research Institute, Murmansk Marine Biological Institute of the Kola Scientific Center of the Russian Academy of Sciences, etc. Within three years, the Project has evidenced participation of representatives from foreign scientific institutions of (China, India, Egypt, Malaysia, Turkey, as well as Norway, Finland, France, Iceland, UK.

Within 2021-2023, the IGE members participated in scientific, analytical and expert work on environmental monitoring as reviewers of the Comprehensive Environmental Monitoring Program, provided reports, and held discussions on the areas of work within the Project.

One of the most important IEG areas has been the impact assessment of coastal and transit Arctic shipping, as well as the NSR port infrastructure on biodiversity and the state of the Russian Arctic seas, including:

- Selection of monitoring objects (indicators) based on the results of the ranking procedure;
- Assessment of the biodiversity objects vulnerability and possibility to apply them for the shipping impacts monitoring;
- Development of a program for each selected monitoring object (a group of close objects/species) — monitoring parameters, spatial and temporal coverage and methods applied.

To broaden the interaction with the international expert community, the Project has been repeatedly presented at such international events as Arctic Frontiers, World Conference on Marine Biodiversity, ATOMEXPO, Eastern Economic Forum, St. Petersburg International Economic Forum, etc.

NORTHERN SEA ROUTE
I.E.G.

THE COMPREHENSIVE NSR ENVIRONMENTAL AND BIODIVERSITY MONITORING PROGRAM

The Program is developed jointly with the expert community based on:

- Collection and analysis of stock data from previous years;
- Environmental monitoring at 100 comprehensive stations along the entire NSR in 2021-2022;
- Joint scientific and research work with the expert group to develop monitoring programs for NSR marine ecosystems.

Development of the Comprehensive environmental and biodiversity monitoring program provides:

- integration of recommendations on transforming the NSR environmental monitoring into a single program of the NSR environment and biodiversity comprehensive monitoring;

- development of a measurement system to monitor the NSR environment with regard to Russian state, business, scientific and non-profit organizations and the foreign expert community;

- environmental monitoring programs with defined set of mandatory monitoring objects, parameters, methods, observations frequency and polygons. Programs are developed for abiotic (atmospheric air, sea waters, sea ice, bottom sediments) and biological objects (bacterio-, phyto-, zooplankton, macrozoo-, microphytobenthos, ichthyofauna, avifauna, marine mammals);

- identification of 80 monitoring polygons, including port zones, meridional sections through the NSR impact and background areas, stationary bird and marine mammal observation polygons; and development of monitoring programs related (Fig. 7).

Main question to be provided by biodiversity monitoring within the comprehensive NSR environmental monitoring - what is the response of ecosystems to the impacts from various economic activities on the NSR, including Arctic shipping:

- Does the state of marine and coastal ecosystem components change?
- What particular negative processes appear?
- What impact factors act?
- Do these changes relate to the NSR operation?

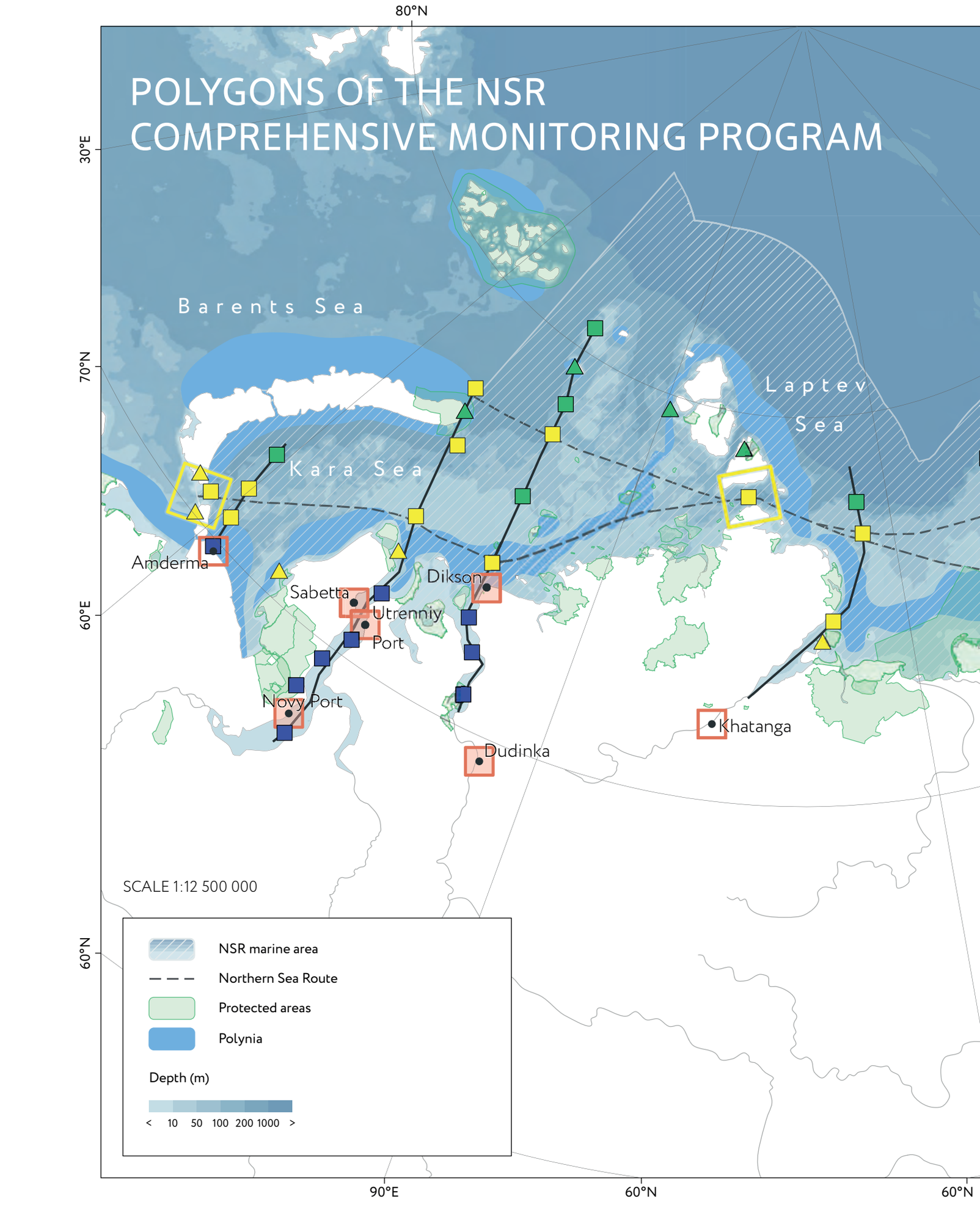
Monitoring polygons and stations are divided with regard to the current level of anthropogenic load into following groups:

- background (no direct impact from activities on the NSR);
- potentially impacted (located in the zone of constant impact, but no significant effects from the activities on the NSR revealed yet);
- impact (areas with intense anthropogenic impact identified);
- port areas and large bays with intensive shipping (Ob Bay and Yenisei Bay);
- areas of bird colonies and marine mammals.

The Comprehensive program contains solutions for data, geoinformation systems (GIS) and software products processing. In particular, the Program provides methodology for using open databases, as well as a specific list of resources with thematic databases with which integration is necessary. For the analysis and interpretation of the data obtained, a number of solutions have already been formed with a detailed description of their work.

The program also provides further steps of the NSR environmental monitoring system development:

- integration of the environmental monitoring results into continuous monitoring systems digital services, seeding databases and analysis systems related;
- coordination with existing national and regional data collection and analysis systems;
- regulatory support for monitoring programs in accordance with international and Russian legislation;
- constant consultations and open interaction with the expert community during the development and operation of the environmental monitoring system in terms of analysis and quality evaluation of the information received.


POLYGONS OF THE NSR
COMPREHENSIVE MONITORING PROGRAM
80°N
30°E
70°N
60°E
60°N
90°E
60°N
60°N
Barents Sea
Kara Sea
Laptev Sea
Amderma
Sabetta
Utrenniy Port
Novy Port
Dikson
Dudinka
Khatanga
SCALE 1:12 500 000
NSR marine area
Northern Sea Route
Protected areas
Polynia
Depth (m)
< 10 50 100 200 1000 >

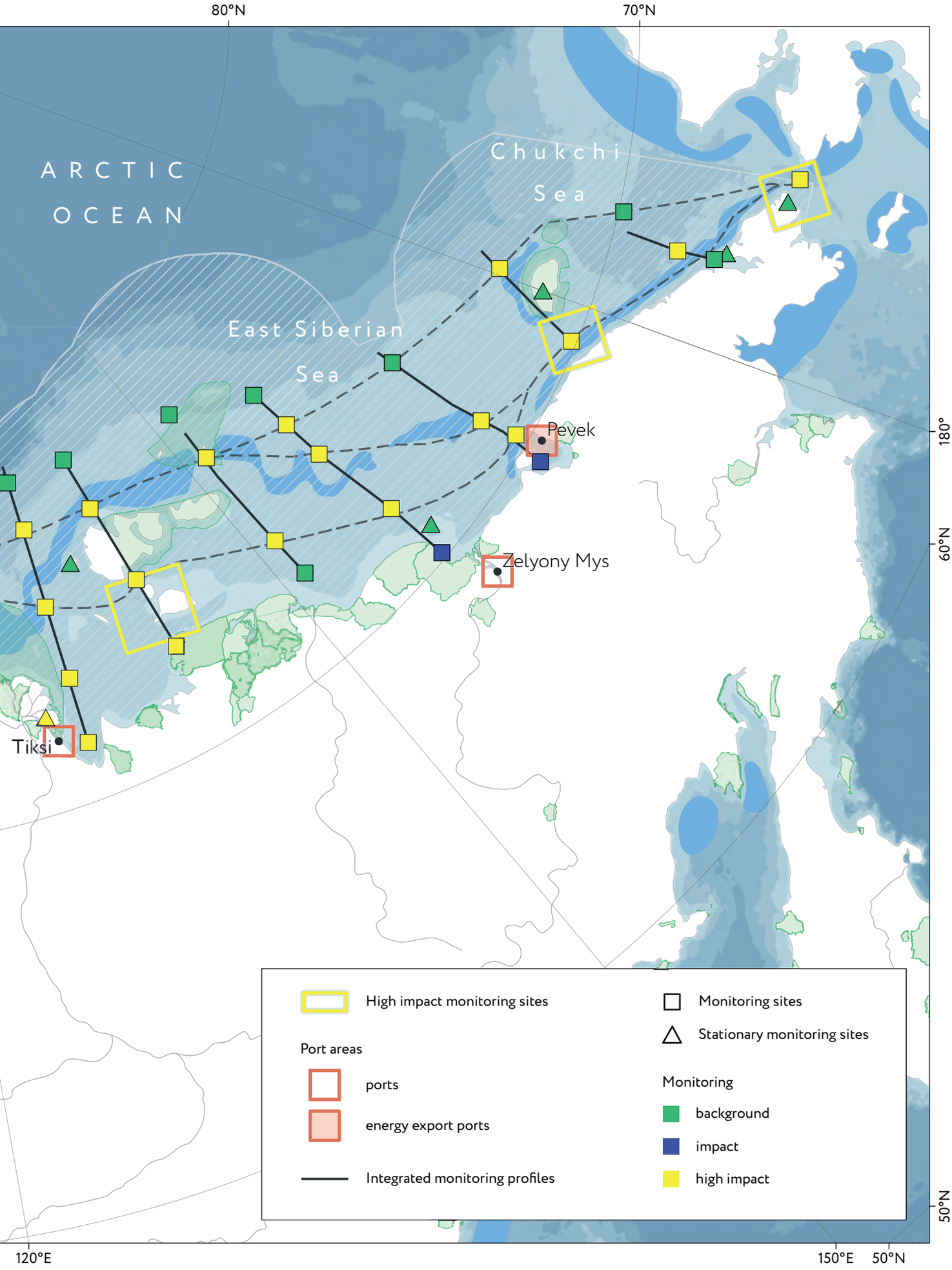


Fig. 7. Polygons of the NSR Comprehensive monitoring program

CONCLUSION

Basic studies of 2021-2022 imply the first comprehensive full-scale environmental project implemented along the entire NSR marine area focusing on the effects of shipping on the NSR marine ecosystems. Research results confirm the current absence of maximum permissible concentrations exceedance in atmospheric air, sea waters, bottom sediments and general deviations, which could indicate a detrimental impact of economic activity on the NSR.

In 2023, project continues with finalizing of the methodology for each NSR monitoring area together with the expert community, field works to survey the NSR port areas, development and testing of new digital environmental services in the NSR marine area.

In accordance with the Plan for Development of the Northern Sea Route, starting from 2024 it is planned to create a system of state environmental monitoring of the NSR to ensure constant monitoring of the state of the marine environment.

The project remains relevant and will require to expand in the coming years due to increased economic activity in the northern seas and climate change in the Arctic. In this regard, the continuation of environmental monitoring and introduction of environmental management measures will contribute to the NSR sustainable development in the long term.

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