Russia's Arctic is as an object of environmental monitoring

I Russkova1, N Dolgikh2, V Salkutsan1 and Y Logvinova1

1Peter the Great St.Petersburg Polytechnic University, St. Petersburg, Russia
2 ITMO University, St. Petersburg, Russia

russkova_ig@spbstu.ru

Abstract. Exploration of the Arctic Shelf is a strategic objective of the sustainable development of our country, taking into account the use of hydrocarbon potential of this territory. At the same time there is a real ecological threat to violate the integrity of biodiversity in the region without implementing the environmental policy of protection of the Arctic Shelf of the Russian Federation. The state strategy until 2025 formulated strategic policy objectives: preserving and restoring the natural environment, ensuring environmental quality, ensuring human well-being and using economic development, eliminating accumulated environmental damage as a result of intensifying economic and industrial activities. A complex solution of these tasks is, on the one hand, the creation of specially protected natural territories, and on the other, the development of an environmental monitoring system. The status of specially protected natural territories allows minimizing industrial activities in a given area, reducing the vulnerability of natural ecosystems to anthropogenic influences. The program of environmental monitoring is a real tool that allows for the collection and analysis of data on the study of environmental reactions to anthropogenic impact, followed by monitoring the state of the biosphere for a development policy for this region. The proposed system is considered on the example of the Russian Arctic National Park and can be extended to other specially protected natural territories of the Russian Federation.

1. Introduction
The negative influence of anthropogenic factors on the state of the biosphere as a whole, and on the Arctic systems in particular, is rapidly increasing from year to year. It affects not only terrestrial ecosystems, but also aquatic ecosystems. Taking into account the prospects for the development of these territories in the near future, the competent construction of an integrated environmental monitoring program plays a huge role. Environmental monitoring is not only a tool for tracking the dynamics of changes in key parameters of the state of the environment, but also an important source of information in making management decisions at various levels. [1].
The Russian Arctic accounts for almost a third of the entire Arctic zone, therefore it has an important role in maintaining the ecological balance of the North. In our territory, typical arctic landscapes have been preserved, as well as the overwhelming majority of representatives of the animal world (up to 80%) of this region. However, this delicate balance is in danger.

Of particular concern to scientists are serious concerns related to the development of the shelf areas of the Barents and Kara Seas by oil producing companies. These territories can be considered as natural reference objects in the high latitudes of the Arctic. Here remained intact the part of the territories with endemic representatives of flora and fauna, some of which are listed in the Red Book of Russia.

To protect such territories, specially protected natural areas have been created in the Russian Federation, which imply “the establishment of special regimes for the use of natural resources and the protection of the environment, including monitoring of its pollution” [2].

2. Characteristics of the national park "Russian Arctic"

Today, in the territory of the Russian Federation in the Arctic latitudes there are about 500 protected natural areas, which is almost 95 million hectares (about 16% of their total area) [3]. An example of such a territory is the project of the Russian Arctic National Park. The territory includes the archipelago of Franz Josef Land and the northern part of Novaya Zemlya created in 2011. Now "Russian Arctic" - a specially protected natural territory of Russia. The main activities are the study and preservation of the natural, historical and cultural heritage of the archipelago. The national park includes the Franz Josef Land Archipelago and the northern part of Novaya Zemlya.

![Figure 1. National Park "Russian Arctic"

The state natural reserve of federal significance "Franz Josef Land" is about 200 islands, which is almost 1600 thousand hectares of land and 2600 thousand hectares marine area. This is...
the most icy part of the territory of the Russian Arctic zone. About 85% of the area is under the ice. The entire territory of the archipelago belongs to the climatic zone of the Arctic deserts with an average January temperature of -25 degrees C, and July -1.5.

Winter temperatures reaching up to -50 degrees C are frequent. At the same time, 11 species of mammals live here. Among them: polar bears (about 2 thousand), Atlantic walruses (more than 1 thousand individuals), ringed seals, sea hares (bearded seals), bowhead whales, white whales, white-faced dolphins, narwhals (the rarest animal on the planet, the symbol of the “Russian Arctic”).

The uniqueness of this place is due to the fact that it is the second largest for feeding of polar bears, lying in dens and the birth of offspring, as well as the most important habitat of the Spitzbergen population of the bowhead whale, on the verge of extinction. For cetaceans and pinnipeds, this is a gathering place for food and rookeries. 18 species of birds nest on the islands of the archipelago, and a total of 50 species of birds and 60 bird markets are recorded. This is the only nesting site in Russia of such subspecies as the Atlantic black goose, the Greenlandic subspecies of the common eider. The flora of Franz Josef are mainly mosses (over 150 species), lichens (167 species), fungi (94 species), vascular plants (almost 50 species). The most common plants of the cruciferous, kamnelomkovy and clove families.

The peculiarity of this area is the preservation of the natural landscape and wild nature, almost untouched by human; this is the most isolated archipelago on the territory of the Russian Arctic. The Novaya Zemlya archipelago consists of 2 large islands with a total area of more than 80 thousand km2 and a total length of just less than 1000 km.

It is inhabited by the Novaya Zemlya reindeer Rangifer tarandus pearssoni, an endemic native subspecies listed in the Red Book of the Russian Federation.

On the islands of the archipelago there are four metrological stations, including the oldest polar station on the archipelago Tikhaya Bay on Hooker Island, opened in 1929.

The development of these territories in the second half of the last century was closely associated with the placement of defense facilities, as well as the creation of the necessary infrastructure for conducting scientific research, including hydrometeorological (observatory named after E. T. Krenkel). During “the perestroika” military facilities were closed. Only the Nagurskoye frontier post functions. When closing these facilities, due to the need to attract significant financial costs, the necessary environmental requirements were not taken into account. Abandoned buildings, equipment and materials remained at decommissioned facilities. This caused not only changes in the natural landscape of the archipelago, but also led to the emergence of a threat of environmental pollution.

According to various estimates, by the beginning of 2000, a significant number of barrels and tanks with thousands of tons of oil and oil products had accumulated in these territories. As a result of corrosion, there was a threat of petroleum products entering the soil. Despite the fact that the majority of this waste was removed from the archipelago by 2016, the oil content in the soil in certain territories can reach 200 times the maximum permissible concentration (MPC). Land reclamation carried out in these territories does not allow us to speak with confidence about their full ecological safety. For a more accurate assessment of the human impact, it is necessary to conduct a comprehensive study within the framework of the proposed system of environmental monitoring.

Today, no less dangerous for the ecology of the Arctic zone is the activity of companies in the extraction of hydrocarbon fuels at 60 onshore oil and gas fields, where production is actively carried out. For example, several sites of Rosneft PJSC and Gazprom Neft PJSC that are adjacent to the park borders (a total of 91 offshore development licenses are granted a license) may pose a potential threat to the nature of the Russian Arctic National Park. Objects of exploration and production of the oil and gas complex are platforms, a network of technological and transport pipelines, temporary storage facilities, receiving and transshipment coastal
terminals, main transport oil and gas pipelines, their operation in the future may pose a potential environmental threat.

All this makes the development of a monitoring system in the Arctic zone extremely relevant. So far, there has not been a uniform and centralized action plan for the implementation of integrated environmental monitoring of these lands. The bulk of scientific research and observations belong to the middle of the last century, while the data are scattered and do not have a unified concept.

3. Environmental monitoring. System and program.

The main directions in the study of these areas were: research in the field of cartography (conducting topogeodesic surveys); determination of radioactive contamination of territories; pollution levels with polychlorinated biphenyls). The chronology of the main ecological expeditions, for example, to Franz Josef Land is given in Table.

| Year | Who carried out the expedition | Basic goals |
|------|--------------------------------|-------------|
| 1994 | International Complex Scientific Expedition, organized by the Murmansk Marine Biological Institute | Research in the field of biology, geodesy, geology, glaciology, topography. The aim of the study was to test the functioning of geodetic and meteorological equipment in arctic conditions. |
| 1995 | Research Institute of the Arctic and Antarctic together with St. Petersburg branch of Sevmorgeo | Topographic and geodetic studies in the central part of the archipelago and assessment of the stability of reference points. |
| 2001 | Northern Territorial Fund of Geological Information. | Determination of radioactive gamma background and the level of radioactive contamination of the archipelago. |
| 2004 | Arctic Monitoring and Assessment Program (AMAP) | Studies of the level of contamination with polychlorinated biphenyls (PCBs) |
| 2008 | Northern UGMS | Works to provide polar stations and research on the program of the International Polar Year |
| 2012 | FSBI National Park "Russian Arctic" and the World Wildlife Fund (WWF) | Complex scientific expedition |
| 2013 | Russian Arctic sea expedition of the national geographic society of the USA and the Russian Arctic national park to the Franz-Josef Land | Evaluation of biodiversity of various groups of animals, plants and microorganisms of terrestrial and marine ecosystems of the reserve Franz Josef Land; - Assessment of modern ecosystems of Franz Josef Land; - assessment of changes in the landscape, topography and biotic components of natural systems that occurred during the period of the historical study of the Franz Josef Land archipelago; |
Currently, comprehensive environmental monitoring is not being carried out on the Russian Arctic shelf. In recent years, there have been significant changes in the climatic conditions in the Kara Sea region, and its role in the conservation of Arctic biodiversity has increased. The Barents Sea as a habitat for many representatives of the fauna has become less suitable due to global warming and the associated changes in the sea’s ecosystems. Assessment of the state of these ecosystems, accounting for the migration of certain species of fauna and the preservation of individual populations are impossible without environmental monitoring.

The urgency of creating such an observing system is also dictated by the need to fulfill Russia's international obligations under the UN Convention on the Law of the Sea (1982), as well as the Convention on Biological Diversity (1992), the Ramsar Convention (1971), and a number of other international agreements.

The main recommendations on the organization of a global environmental monitoring system were set out in the UN Environment Program (UNEP) at the UN Stockholm Conference in 1972. The main objectives of global monitoring are formulated in this Program:

- the establishment of emission levels of pollutants in a particular environment, their emissions in space and time;
- assessment of the rates and magnitudes of the flows of the emitted pollutants and harmful products of their transformations;
- providing a comparison of the practice of sampling and analysis between countries, the exchange of experience of monitoring organizations;
- exchange of information on a global and regional scale for management decisions in the fight against polluters.

The territory of the Arctic shelf of Russia in view of a number of geographical features requires a special approach to building a system for its monitoring [4]

When creating it, you should take into account a number of such features:
1. Remoteness from civilization
2. Lack of satellite coverage
3. The peculiarity of alternating polar day and night

| Year | Event                                                                 | Description                                                                                           |
|------|------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| 2015 | AVIA-KARA-2015: AVIATION EXPEDITION TO THE ISLANDS OF THE KARA SEA     | Assessment of the state of spring habitats of polar bears, marine mammals and birds.                 |
|      | Scientific Expeditionary Center of the Association “Maritime Heritage”| (NEC AMN)                                                                                             |
| 2016 | Maritime Heritage Association:                                         | Collection and updating of information on the state of specially protected natural areas to support   |
|      | We Explore and Save.                                                  | the implementation of a set of measures aimed at preserving biological diversity in the development   |
|      | Implemented under the grant of the United Nations Development Project  | of the oil and gas resources of the north-east of the Barents Sea.                                   |
|      | in Russia                                                              |                                                                                                        |
4. Constancy of extremely low temperatures and strong winds.
5. The presence or absence of permanent or temporary ice cover.

Modern monitoring system for the main indicators of the environment is carried out with the involvement of high-tech observation tools of various bases (earth, atmosphere, space). The requirement of today is integration with existing and newly created international environmental monitoring systems. The main task is the detection, analysis and construction of a predictive model of the impact on natural ecosystems of the Arctic zone of the Russian Federation. [5]

Based on the analysis of the existing characteristics of specially protected natural areas of the Arctic zone of the Russian Federation, as well as possible prospects for the emergence of anthropogenic risks, a program was proposed for conducting environmental monitoring of this segment of the territory. As an example, the selected national park "Russian Arctic".

The proposed environmental monitoring program on the territory of the Russian Arctic National Park includes:

- continuous monitoring of the state of ecosystems;
- study of natural as well as anthropogenic impacts in high arctic regions in order to predict the regional effects of global changes;
- monitoring populations of endemic animal and plant species;
- data exchange in the framework of international cooperation.

The creation of such a program will help in solving a number of tasks that are set for the specially protected natural territories of Russia.

- provide protection to the ecosystems of the Arctic from human impact;
- contribute to the restoration of environmental quality;
- implement sustainable use of natural resources;
- organize monitoring of the state of the Arctic ecosystems;
- to detect and eliminate pollution of the natural habitat.

Ecological monitoring of ecosystems should have a systematic approach. When creating environmental monitoring in the Arctic regions, it is necessary to take into account the reduced ability of natural systems to recover, therefore, it is necessary to exclude the occurrence of anthropogenic accidents in the studied areas.

The general structure and principles of creating a system include:

- identification of the main threats and hazards, designation of the area with increased danger;
- selection of monitored parameters, with justification and analysis of the obtained values;
- definition of methods, tools and techniques for field measurements of individual parameters;
- selection of the necessary equipment for equipping mobile or stationary laboratories;
- analysis of the values obtained as a result of monitoring;
- prognostic evaluation of results;
- creation of databases of obtained values of monitored parameters
- data processing and analysis;
- evaluation of results.

The above principles of environmental monitoring provide an opportunity not only to assess the current state of controlled objects, but also to extrapolate the trends of its change. This will make it possible to work out a number of constructive measures to minimize the possible damage to ecosystems, to create a basis for taking protective measures to prevent such situations. With the help of monitoring, you can monitor the effectiveness of the measures taken, make adjustments on its basis and develop a strategic plan for making competent management decisions.

To carry out field measurements on the main indicators of pollution of the controlled environment, it is necessary:

- use the guest equipment;
- apply methodologies in accordance with international practice to facilitate data exchange with interested organizations on a global scale.

The developed monitoring scheme includes several blocks: expeditionary, remote, stationary and background observation. Depending on the tasks being solved, an optimal combination of blocks is possible, which are regulated by state standards. [6]

When implementing a project to create an environmental monitoring program, it is necessary to maximize the use of already existing elements of the system, and also to take into account the experience in organizing certain types of observations in a given area. We are talking about the creation (or use) of stationary observation posts, which include carrying out chemical analyzes of all types of samples, as well as organizing an analytical center for carrying out continuous monitoring in the automatic mode of a number of parameters: meteorological, atmospheric air, soil, ice, biota, radiation background. All collected information should be transferred to the data processing center, for example, Roshydromet structural units.

— the E. Krenkel meteorological station and the geophysical observatory on Hays Island, as well as field expeditions. These strongholds can transmit the received and processed data to various units of the Northern UGMS under the auspices of Roshydromet.

In the organization of such a structural and organizational monitoring scheme, already existing observation points can play a significant role.

The proposed environmental monitoring program is a complete list of ongoing activities aimed at studying and analyzing the current state of ecosystems on the territory of the Russian Arctic National Park. Basic research should be conducted on the following components [3]:

- chemical analysis of soil (chemical analysis for the determination of quality indicators, analysis for heavy metals (7 elements), analysis for petroleum products, analysis for the content of PCBs);
- the total chemical composition of water, the content of oil products, heavy metals (72 indicators), nitrogen compounds (nitrate ions, nitrite ions, ammonium ions), PCBs, organochlorine pesticides, polyaromatic hydrocarbons, etc
- main climatic parameters (air temperature, repeatability of hazardous hydrometeorological phenomena, measurement of precipitation, wind direction, etc.);
- observations of the atmosphere (the optical thickness of the atmosphere in different wavelength ranges, the mass concentration of aerosol, the chemical composition, and the scattering and absorption coefficients of solar radiation);
- collection of information on biological diversity (observation of populations of endemic species of animals and plants).

As priority activities when creating stations it is necessary to:
1. To carry out activities for the development of infrastructure at the facilities;
2. To equip the stations with equipment for cloud and radiation studies complying with the standards of the international network of base stations for the study of radiation processes (BSRN) and the US Atmospheric Radiation Measurement Program (ARM);
3. To organize the regularity of observation;
4. To organize the conduct of complex observations of the aerosol and chemical components of the polar atmosphere under the international program GAW.

Year-round maintenance of the station should be provided on a rotational basis. The minimum required number of staff is 6 people.

4. Conclusion
Thus, on the basis of the analysis of existing environmental threats and ongoing activities to monitor the state of the environment in the Arctic latitudes, it was proved that there is an urgent need to organize a range of environmental monitoring programs in specially protected natural territories. These programs should take into account the geographical location of the territories.
and the resulting climatic characteristics. In organizing such programs, an important factor in the success of their implementation is the combination of remote sensing and field research methods. The key role in the selection of stationary observation points is due not only to the representativeness of the data collected, but also to the physical ability of the staff to be present at the territory of such stations, taking into account the geographical features of the location.

A promising direction is the creation of a unified network of environmental monitoring of specially protected natural areas to effectively monitor the implementation of environmental protection measures, the dynamics of pollution processes and the state of ecosystems, and to respond to potential negative scenarios for the development of the situation for individual components of the biosphere.

References
[1] Russkova I G 2016 Environmental protection and environmental management. Teaching manual. The text of the lectures., FP SPbPU
[2] President of the Russian Federation 2008 Fundamentals of the state policy of the Russian Federation in the Arctic for the period up to 2020 and further perspective
[3] Dolgikh N Y 2017 The program of environmental monitoring for a specially protected natural area National Park "Russian Arctic" Peter the Great St. Petersburg Polytechnic University
[4] Stishov M S 2013 Specially Protected Natural Territories of the Russian Arctic: Current State and Development Prospects The color speed of WWF Russia
[5] ISO / TC 67 / SC 8 / WG 3 Oil and gas industry - Arctic operations. Environmental monitoring.
[6] President of the Russian Federation 2008 Strategy for the development of the Arctic zone of the Russian Federation and national security for the period up to 2020
[7] Russkova I G and Dolgikh N Yu 2017 Environmental monitoring of specially protected natural areas of the Arctic zone of Russia Comprehensive study of the Arctic. Arctic Complex Research. Collection of scientific papers of the International Symposium 122s.
[8] Didenko N et al O 2017 Modeling the changes in global temperature due to pollution International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85041943534&doi=10.22616%2frrd.23.2017.067&partnerID=40&md5=30749500ce730c6e5b424159c5c7b53 [Accessed 20th March 2018]
[9] Efremova I et al 2017 Disparities in rural development of the Russian Arctic zone regions Research for Rural Development Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85013230972&doi=10.1134%2fs1075700717010105&partnerID=40&md5=dba57cc36ff14694f8e72dcd55805c1a [Accessed 20th March 2018]
[10] Romashkina G F et al 2017 Socioeconomic modernization of Russia and its Arctic regions Studies on Russian Economic Development Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85032381128&doi=10.5593%2fsgem2017%2f153%2fS21.070&partnerID=40&md5=ea8f2716988e54925e7cc983ac41b436 [Accessed 20th March 2018]