PAST, MODERN, AND FUTURE STATE OF THE PECHORA SEA

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Abstract

The Pechora Sea is quite unique among Arctic seas as it is a region directly influenced by both Atlantic and Polar waters as well as river waters (Fig. 1). This area has important economic value due to the existence of extensive oil and gas fields, but it is also home to traditional fishing and reindeer breeding. Because exploitation of the natural resources will start in the nearest future, an establishment of regional sustainable development strategies seems necessary. Since the Pechora Sea will soon be increasingly influenced by these anthropogenic factors, such strategies should be based on a detailed analysis of the ongoing situation, but even more so, should consider those environmental changes which occurred in this area during the past. Hence, there is a need to investigate the pre-anthropogenic phase in order to better understand any possible future environmental changes. Such investigations were carried out by various groups from Russia, Germany and Norway between the years 2000 and 2002, in a project which was financially supported by INTAS (No. 1489-99).

Introduction

Large oilfields recently explored in the Pechora Sea are now ready for exploitation. Therefore, this region will undergo considerable changes due to man-induced technogenic impact. Unlike the Barents Sea, the semi-enclosed and rather small Pechora Sea is much shallower and ice-covered for a considerable time of the year. Moreover, its coasts are being actively eroded. Altogether, this allows the assumption that the Pechora Sea basin could undergo major environmental change due to climate warming and sea-level rise. Because of the increasing economic interest in the Pechora region there is a demand to develope a strategy for widespread territorial exploration, for instance, for suitable construction sites.

An example, which points to the necessity of ecologically substantiated approach for industrial exploitation of the new coastal areas, is the Varandei area. Active industrial exploitation of the Varandei area started in the seventies. Varandei Island experienced maximum technogenic impact, because here the main industrial objects together with Novyi Varandei settlement are located. There is ample evidence from this region that, for instance, enhanced coastal abrasion observed more recently resulted from improper exploitation of the area without understanding the characteristics of the coastal relief and its dynamics.

Because the Arctic environment is known for its sensitivity, it is especially important to minimize negative anthropogenic impacts. However, to do this properly requires profound knowledge of the present and past geoecological state of this territory as basis for a better forecast of possible future environmental changes.

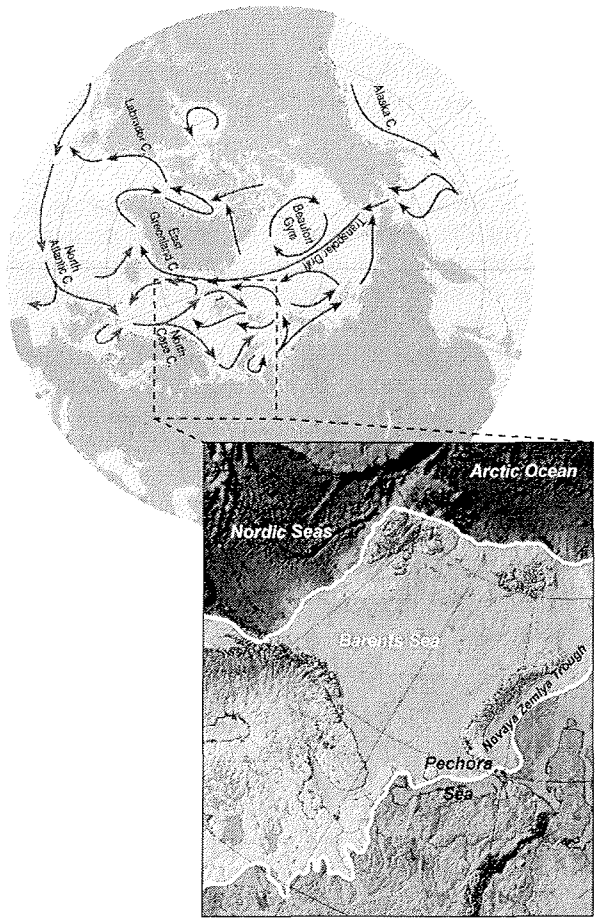

Fig. 1 Main surface ocean circulation in the Arctic Ocean, its shelf seas and neighbouring ocean basins (top). Inset below shows Barents Sea region with the Pechora Sea. The white line marks the outer limit of glacial ice extent during the last glacial maximum according to the most recent reconstruction (adopted from Svendsen et al., 2004). The reconstruction for the Pechora Sea and Novaya Zemlya Trough region is thereby based on Polyak et al. (2000) and Gataullin et al. (2001)

So far, a number of questions concerning the Quaternary history of the Pechora Sea region still remain unanswered (Fig. 1). These relate to the stratigraphic subdivision and facial characteristics of the seafloor sediment sequences, the shelf geomorphology, the lack of information of the sediment sequence in the southern Novaya Zemlya trough, and the uncertainty of the impact of glaciological activity on this particular shelf during the last glaciation.

Because of the various abovementioned issues, scientific interest in the Pechora Sea region became more eminent and, eventually, led to the initiation of an INTAS-funded project (No 1489-99) entitled *The Pechora Sea – Late Pleistocene paleogeography, present state of the shelf and coastal zone and forecast for the 21st century.*

The various articles compiled in this report deal with the main goals of the Pechora Sea project. These may be summarized as follows:

- to reconstruct the paleoenvironmental evolution of the Pechora Sea during the Late Pleistocene and Holocene on the basis of geological evidence (e.g., seismic, lithological, geochemical, and micropaleontological data) in order to link the past and recent environmental changes with possible future development of this region;
- to study the morphology and sedimentary dynamics of the Pechora Sea coastal and shelf zones and to outline patterns of change as expected due to future climate warming and associated sea-level rise;
- to analyze natural sedimentological processes in the shelf and coastal zones as well as the anthropogenic impact upon natural environment caused by the existing sources of pollution and those that will appear due to intensified oil/gas exploitation;
- to forecast possible evolution of the Pechora Sea shelf and coastal zones according to the following scenarios: stable climate and sea-level conditions; climate warming and sea-level rise in the 21st century.

To tackle these problems, several scientific teams and respective team leaders from various countries and research institutes were formed. These included

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To successfully meet the stated objectives, several research tasks were conducted by either one or both partners. These activities included the following:

Task 1: Establishment of a Late Pleistocene - Holocene stratigraphical scheme for the Pechora Sea on the basis of geochronological, seismostratigraphical, lithostratigraphical, biostratigraphical, and ecostratigraphical data.

Task 2: Reconstruction of the paleoenvironmental conditions of the Pechora region during specific time intervals of the Late Pleistocene and Holocene.

Task 3: Analysis of the modern and past sedimentological processes and its application to the present and possible future pollution, its sources and sinks.

Task 4: Determination of the coastal evolution and development of coastal processes over various time scales.

Task 5: Forecast of the Pechora Sea shelf and coast evolution in the 21st century.

Summary of Results

The scientific teams of the project developed new concepts of shelf and coastal evolution of the Pechora Sea during Late Pleistocene and Holocene times by linking together past and recent environmental change in order to deduce possible future developments of this region as they are related to both natural and anthropogenic factors.

A subdivison of Upper Quaternary sediments was carried out using facial analysis and high-resolution acoustic profiles. A further stratigraphical refinement of the late Pleistocene to Holocene deposits was constructed on the basis of geochronological, seismostratigraphical, lithostratigraphical, and biostratigraphical approaches. By studying micrfossils in surface and downcore sediments the main biostratigraphical events were determined and correlated with the seismostratigraphical units. The distribution of modern benthic organisms and sediments was also used to reconstruct different aspects of paleoenviornmental conditions (e.g., paleocurrents, paleosalinity, paleoproductivity). Paleogeographical models of the Pechora Sea for three different time slices were then developed.

Various maps were compiled that demonstrate the schematic geomorphological nature of the Pechora Sea bottom and the principal character of dominant coastal features. The main factors of coastal development and directions of alongshore sediment movement were identified and their intensity evaluated. Ten morphodynamic regions with specific dynamic and morphological characteristics were distinguished and mapped. The main stages of barrier beach formation were established for the southern Pechora Sea.

By evaluating the various morphological and sedimentological features, past and modern dynamics of coasts and shelf regions were interpreted. Assuming a further increase in climate warming, sea-level rise and anthropogenic activity, different scenarios were developed. It is found that in the economically most developed and developing areas, namely those of oil and gas prospection, extraction, storage and transportation, intensity of the anthropogenic impact during the present century will reach a crucial level. Using semi-quantitative models of coastal evolution, which were elaborated in form of maps for various types of coasts, it is further concluded that barrier coasts and icy-rich coastal escarpments will suffer much from the future

changes. Applying these models to several coastal segments, the shoreline retreat by the end of the present century was estimated.

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