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# From single species surveys towards monitoring of the Barents Sea ecosystem

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ABSTRACT

The Barents Sea, a large, high-latitude shelf sea, has been monitored and investigated for more than a century. More than 1800 occasional expeditions have been organized both by Norway and Russia, and since the1960s the collaboration between the Institute of Marine Research (IMR, Bergen) and the Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO, Murmansk) has been strengthened by developing and carrying out joint surveys. Monitoring changes in the Barents Sea fish stocks and collecting information needed for stock assessments and advice for fisheries management were the driving forces behind the increased effort spent on marine research. This triggered the development of sampling and observation methodology, the design of scientific research vessels for using various equipment and gear, and the development of new technologies for processing several types of samples. Increased data collection generated a need for the development of complex database systems and software that, could analyze larger data sets. Joint large-scale monitoring over the last 50 years, together with joint management of living marine resources during the last 20 years, resulted in high stock biomasses of commercially important fish stocks and thus the successful development of fisheries in the Barents Sea. Here, we describe the development of Barents Sea monitoring from single species (or fishery) surveys that were focused on target species/groups to integrated ecosystem surveys that aim to describe the status and main changes in the Barents Sea ecosystem.

## 1. Introduction

The Barents Sea is a high-latitude shelf ecosystem in the north-eastern Atlantic. It is a productive marine ecosystem with more than 200 species of fish, thousands of benthic invertebrate species and diverse communities of plankton, seabirds and marine mammals inhabiting or visiting the area (Jakobsen and Ozhigin, 2011). Only a limited number of species are of commercial interest. Nonetheless, these species provide the basis for some of the largest fisheries in the world, and in the 2000s, the total annual catches of capelin, polar cod, cod, haddock, redfish, Greenland halibut and shrimp were reported to be close to 1.1 million tonnes (averaged for the period of 2000–2014, Stiansen et al., 2008) and was the highest in 2002 and 2011 (1.5 million tonnes). Human activities such as shipping, tourism, and oil and gas exploration are also influencing the ecosystem.

The Barents Sea has been monitored and investigated for more than a century. Norway and Russia have carried out more than 1850 occasional expeditions during this period. Just after 1900, the countries built their first specially equipped research vessels, and thus, fishery expeditions became more regular (Alekseev et al., 2011). The oceanographic section “Kola meridian” has been observed annually (and in some periods several times per year) since 1903 and has the world’s longest continuous record of sea temperatures and salinity along a hydrographic section (Fig. 1). Research on the Barents Sea fish stocks was carried out during the first half of the 20th century; however, collaboration between Norway and Russia was limited from 1914 to 1954. Since then, collaboration between the Institute of Marine Research (IMR, Bergen) and the Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO, Murmansk) has been renewed and strengthened. Since 1965, these institutions have jointly planned and carried out annual fishery (or single species) surveys. Triggered by sharp declines in some of the major fisheries that were caused by overfishing and ecological events during the late 1960s to the mid-1980s, it became evident that a broader view of the ecosystems was necessary to avoid such devastating events in the future. From the beginning of the1980s’ multi-species and ecosystem considerations

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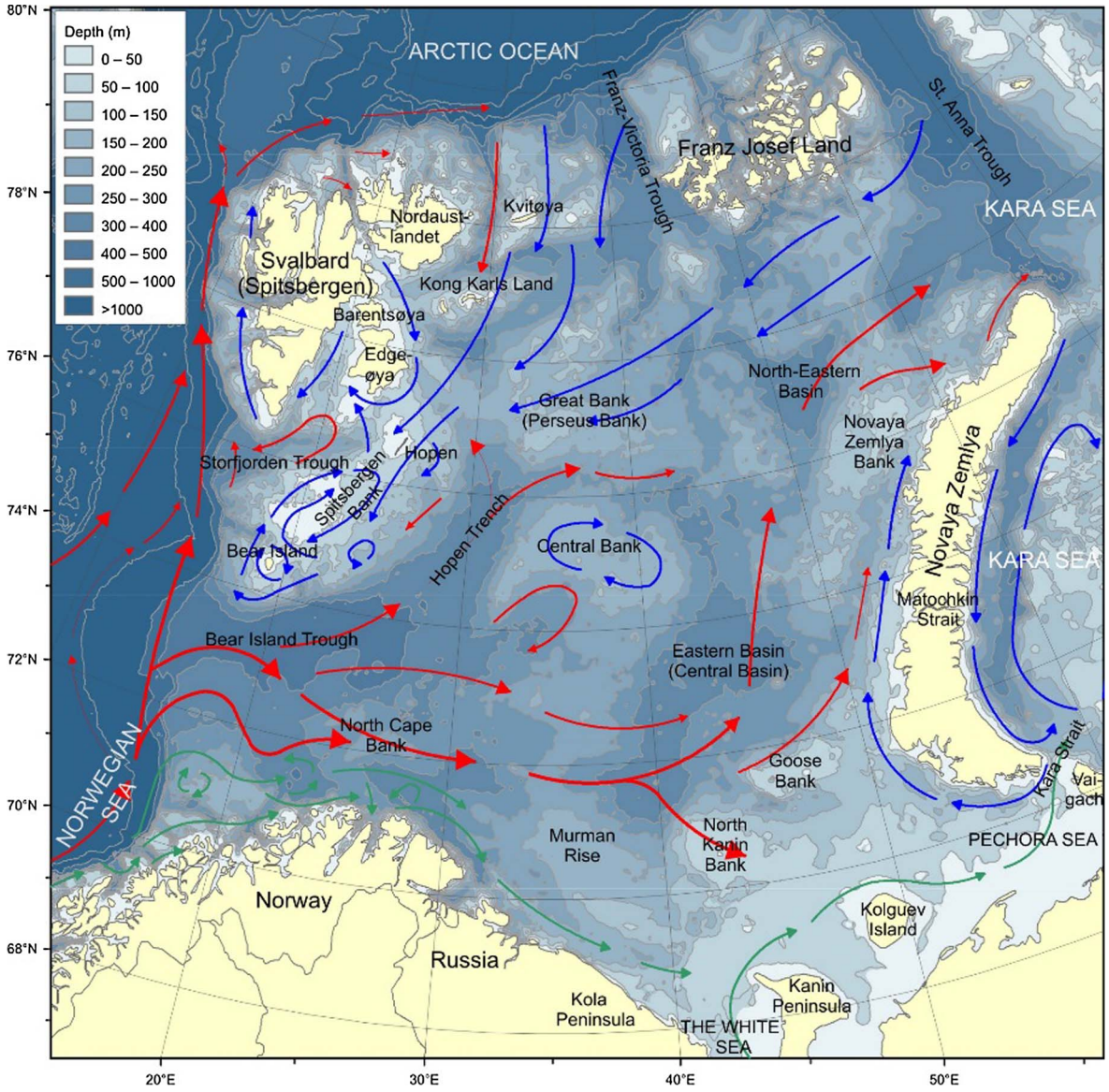


**Fig. 1.** The Barents Sea. Red arrows show Atlantic water currents, blue arrows Arctic currents and green arrows currents of coastal waters. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

have been gradually added to the aim of various surveys to increase our knowledge about the ecology of the commercial species and later, the ecosystem structure and dynamics. Thus, more than 50 years of a collaborative effort between Norway and Russia has provided an extensive knowledge base for this marine ecosystem (Røttingen et al., 2007; Sakshaug et al., 2009; Jakobsen and Ozhigin, 2011; Hammer and Hoel, 2012). Monitoring of the ecosystem is vital for operative, up-to-date fishery science to support the principles and criteria for the precautionary, ecosystem-based and bio-economically viable management approaches laid down by the Joint Norwegian-Russian Fishery Commission (Alekseev et al., 2011). The successful fisheries management of the Barents Sea is based on comprehensive monitoring (Røttingen et al., 2007; Hammer and Hoel, 2012).

Right from the beginning, the expeditions to map and monitor the large commercial fish stocks in the Barents Sea were based on the need to maximize the output from the fisheries. An increasing demand for healthy seafood as well as a need for a stable outcome for the high number of fishers inhabiting northern Norway and Russia led to this monitoring becoming high priority. Monitoring changes in the stocks and the collection of information needed for stock assessments for fisheries management advice were the driving forces behind the increased effort spent on marine research. The monitoring surveys were rather specialized, predominantly considering only one target species at a time, and they were devoted to the most abundant fish species. The main reason for that was that neither the research vessels at that time nor the fishing vessels occasionally used for research purposes could operate several types of trawls, seines, nets, or other equipment on a day-to-day basis. Alongside this surveying, much effort was spent on developing sampling methods and gear to match the data demands for these important fish stocks. Analytical stock assessments require data on the status and biological parameters of a stock (abundance indices, length and age composition of catches, mean weights at age of stock and catches, and proportion of mature individuals at age).

In recent years, there has been an increasing focus on the effects of human activities other than fisheries on the ecosystem. This research has been driven both by legislation, such as the protection of biodiversity, and global challenges, such as climate change and ocean acidification. The need to investigate additional ecosystem components (water quality and pollution, biodiversity and abundance of phyto- and zooplankton, pelagic and demersal fish, benthos, marine mammals and seabirds) and processes led to the use of a range of methods and gear to simultaneously observe various ecosystem components, such as several