Oceanologia (2016) 58, 249—263

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.journals.elsevier.com/oceanologia/

ORIGINAL RESEARCH ARTICLE

Satellite observations of seasonal and regional variability of particulate organic carbon concentration in the Barents Sea

Malgorzata Stramska[a,b,*], Jagoda Bialogrodzka[b]

[a] Institute of Oceanology, Polish Academy of Sciences, Sopot, Poland
[b] Department of Earth Sciences, Szczecin University, Szczecin, Poland

Received 20 November 2015; accepted 13 April 2016
Available online 4 May 2016

KEYWORDS
Barents Sea;
Satellite remote sensing;
Ocean color;
Particulate organic carbon

Summary The Nordic and Barents Seas are of special interest for research on climate change, since they are located on the main pathway of the heat transported from low to high latitudes. The Barents Sea is characterized by supreme phytoplankton blooms and large amount of carbon is sequestered here due to biological processes. It is important to monitor the biological variability in this region in order to derive in depth understanding whether the size of carbon reservoirs and fluxes may vary as a result of climate change. In this paper we analyze the 17 years (1998—2014) of particulate organic carbon (POC) concentration derived from remotely sensed ocean color. POC concentrations in the Barents Sea are among the highest observed in the global ocean with monthly mean concentrations in May exceeding 300 mg m^{-3}. The seasonal amplitude of POC concentration in this region is larger when compared to other regions in the global ocean. Our results indicate that the seasonal increase in POC concentration is observed earlier in the year and higher concentrations are reached in the southeastern part of the Barents Sea in comparison to the southwestern part. Satellite data indicate that POC concentrations in the southern part of the Barents Sea tend to decrease in recent years, but longer time series of data are needed to confirm this observation.

* Corresponding author at: Institute of Oceanology, Polish Academy of Sciences, Powstańców Warszawy 55, Sopot 81-712, Poland. Tel.: +48 58 73 11 600; fax: +48 58 55 12 130.
E-mail address: mstramska@wp.pl (M. Stramska).
Peer review under the responsibility of Institute of Oceanology of the Polish Academy of Sciences.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.oceano.2016.04.004

1. Introduction

The Barents Sea (BS) is an Arctic shelf sea. It is an important region for monitoring climate change and interactions between the atmosphere, the sea ice, and the ocean. This sea with its area of about 10% of the Arctic Ocean and an average depth of about 230 m is in large part free of sea ice even during the winter season and has a great influence on the Arctic. This is because BS is located on the main pathway of the heat transported by the ocean from low to high latitudes (e.g., Ådlandsvik and Loeng, 1991; Beszczynska-Möller et al., 2012; Smedsrud et al., 2013). The heat is transported with the relatively warm Atlantic Water (Fig. 1a) by the Norwegian Atlantic Current (NAC). Near Tromsøflaket, a bank located at the entrance to the Barents Sea, the NAC splits into two branches. One branch flows eastwards into the Barents Sea, and the other one flows northwards to Spitsbergen and Fram Strait (e.g., Furevik, 2001). The inflow of AW into the BS takes place through the Barents Sea Opening (BSO, Fig. 1a). The AW is exposed in the BS to the cold air. It becomes chilled and vertically mixed (Maslowski et al., 2004; Rudels et al., 2004; Schauer et al., 2002, 2008). In addition, there is the Norwegian Coastal Water (NCW) flowing along the Norwegian coast and over the continental shelf as the Norwegian Coastal Current (NCC). The vertical and horizontal extent of the NCC varies seasonally, and the front between the NCW and AW is characterized by eddies and meanders.

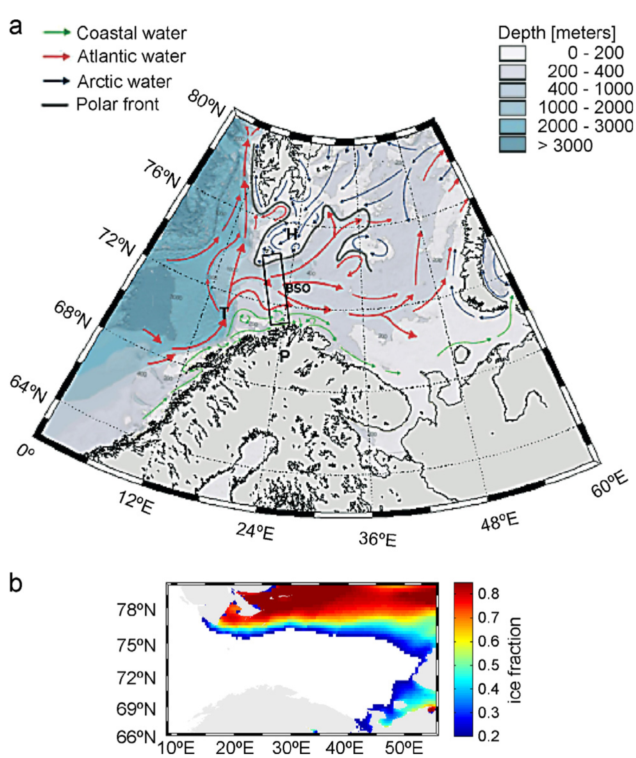

Figure 1 (a) Surface currents and bathymetry in the Barents Sea. Approximate position of the Barents Sea Opening (BSO) is indicated by a box, and letters T, H, and P indicate the location of Tromsoflaket, Hopen Island, and Porsangerfiorden. (b) The 33-year averaged (1982—2014) ice fraction in the study region in the month of May.

Tides are strong in the Barents Sea (the strongest in the Arctic apart from region near the Canadian Arctic Archipelago, Padman and Erofeeva, 2004) and they have substantial role affecting circulation and sea ice formation. Tidal mixing plays also a significant role for abyssal stratification and in controlling the water column structure on continental shelf. Interactions between tides and topography can stimulate topographic waves along the continental slope off the Northern Norway (Kowalik and Proshutinsky, 1995). This is an effective mechanism for cross slope exchange between the open sea and the shelf.

The atmospheric circulation over the BS is strongly influenced by cyclones advected from the North Atlantic. The strongest atmospheric pressure gradients are present in winter months, when southwesterly and westerly winds dominate in the southern part of the BS and southeasterly and easterly winds are frequently observed in the north (Terziev et al., 1990). The river runoff is small (163 km^3 $year^{-1}$) compared to other marginal seas of the Arctic Ocean. The Pechora River contributes most of the runoff (130 km^3 $year^{-1}$) (Lebedev et al., 2011).

Seasonal water mass transformations are driven by an intense vertical mixing due to cooling of the water masses over the entire Barents Sea in winter. In the Atlantic Water, the water column may become homogeneous down to 300 m due to vertical convection. Water mass transformations also include brine rejection processes caused by sea-ice formation in the northern and coastal BS (Schauer et al., 2002). In the spring, the water column stability in the Barents Sea is influenced by two mechanisms, ice melt and seasonal warming of the surface layer. Ice starts to melt in late April or early May, and a thin layer of melt water is progressively formed. This layer is usually more pronounced north of the Polar Front. Its thickness increases to 15—20 m during the summer and early autumn. The melt water surface layer is well-mixed and homogenous. In the Atlantic Water that is not covered by ice in winter, the stratification starts to develop when the sun begins to warm the surface layer. The stratification progresses very slowly. During summers a vertically homogeneous surface layer with about 10 m thickness is formed and some warming of the water can be observed down to 50—60 m. The Coastal Water along the Norwegian coast is, unlike the other main water masses in the Barents Sea, vertically stratified during the entire year. It preserves a weak vertical stability throughout the winter. In the spring and summer, the stratification increases because of the supply of fresh water and increased surface temperature.

It has been estimated that more than 50% of the Arctic Ocean winter heat loss occurs in the BS (Serreze et al., 2007). The oceanographic processes within the Barents Sea have a documented influence on the entire Arctic region and contribute significantly to the overall overturning in the Atlantic Ocean (Guemas and Salas-Melia, 2008; Semeneov et al., 2009). It has been shown that the Nordic and the Barents Seas are a significant sink for atmospheric carbon dioxide throughout the year (about 20—85 g C m^{-2} $year^{-1}$), while the export production due to biological productivity is in the range of 15—75 g C m^{-2} $year^{-1}$ (Skjelvan et al., 2005; Wassmann et al., 2006). Because there is a significant production of the dense (cold and salty) waters, the carbon contained in these waters can be sequestered for hundreds of years when the waters flow into the neighboring deep basins