

Structure and function of contemporary food webs on Arctic shelves: A panarctic comparison The pelagic system of the Kara Sea – Communities and components of carbon flow

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Abstract

After a short introduction to the physical setting and the history of biological research the pelagic ecosystem of the Kara Sea is described. Main emphasis is on regional aspects of the plankton communities and their seasonal dynamics using mostly data collected between 1996 and 2001. In the zooplankton, for which most data were available, four regional aggregations were separated: (1) the rivers and estuaries of the Southern Kara Sea, (2) the south-western and (3) the central Kara Sea, and (4) the northern troughs and slope. The phytoplankton communities had a similar distribution. To provide components for detailed carbon budgets the regional dynamics of bacterial, phytoplankton and zooplankton biomass and production are described and carbon requirements of bacteria and zooplankton are estimated. For completeness a short literature review on higher trophic levels is included. Finally, recent observations of the pelago-benthic coupling are considered. Estimates of the carbon requirements from the plankton and benthos reveal a large underestimation of primary production, which to date, together with seasonal aspects, shows the largest gap in our knowledge.

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1. Introduction

The Russian arctic seas can be subdivided into two groups; the Barents and Chuckchi Seas undergo much more influence from the comparatively warm waters of the Atlantic and Pacific Oceans than do the Kara,

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Table 1
Zooplankton nets used for vertical zooplankton tows during cruises of RV *Dalnye Selentsye*, RV *Polarstern*, and RV *Boris Petrov*

Platform	Net type	Area (m ²)	Mesh (μm)	Time
RV <i>Dalnye Selentsye</i> ^a	Juday net	0.1	180	October 2000
RV <i>Polarstern</i>	Multi net	0.25	155	September 1995/September 1996
RV <i>Boris Petrov</i> ^b	Nansen net	0.44	155	August/September 1997, 1999, 2000, 2001

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^b In the text referred to as “SIRRO” Cruises.

Laptev and East Siberian Seas, for which more river runoff determines characteristic features of the carbon cycle (Vetrov and Romankevich, 2004). Recent interest in the fate of anthropogenic pollution, the exploration of natural resources, together with indications for increased river discharge due to climate change (Peterson et al., 2002) has directed increased attention to the Kara Sea (Stein et al., 2003). Klages et al. (2003) have recently presented a first assessment of organic carbon consumption by the macrozoobenthos. However, except for the work of Vetrov and Romankevich (2004), which represents more a generalizing attempt to characterize the carbon cycle, the pelagic ecosystem and role in biogeochemical cycles has not been much considered. Here we describe the physical setting, but restrict ourselves to aspects that are directly relevant for ecology. Our main emphasis is on regional aspects of phytoplankton and zooplankton communities and their seasonal dynamics. In addition we provide a short review of the long history of Russian pelagic ecosystem research in the Kara Sea. To provide input for detailed future assessments of carbon budgets we describe the regional dynamics of phytoplankton, zooplankton and bacterial biomass, estimate bacterial and zooplankton production and their food requirements. Finally, we report on recent observations from sediment trap moorings. Due to the lack of quantitative assessments we include only a short review of the populations of fish, birds and mammals. Most of the presented data originate from four SIRRO (Siberian River Runoff, a German–Russian cooperative Project, Fütterer and Galimov, 2003) cruises, two expeditions with RV *Polarstern* and one RV *Dalnye Selentsye* cruise (Table 1). This represents the largest consistent regional data set of recent origin, applying similar mesh sizes for plankton nets, methods of analysis, and taxonomic criteria. Other data were used when appropriate and their origin is mentioned.

2. Geography and physics

The environmental factors with the strongest impact on the arctic marine ecosystem are sea ice, riverine freshwater inflow and stratification, temperature, and advection. Detailed descriptions and reviews of the hydrography and sea ice of the Kara Sea have been published recently, e.g. Volkov et al. (2002), Stein et al. (2003). Therefore we include here only the aspects relevant for the marine pelagic ecosystems.

2.1. Geography and topography

The Kara Sea is the second largest arctic shelf sea (883,000 km²). According to the officially adopted boundaries (Fig. 1; Boundaries of the Oceans and the Sea, 1960), the Kara Shelf area comprises 99.4% of the sea area with the shelf water volume comprising 96.5% of the sea volume. More than 40% of the sea area has a depth less than 50 m, yet the average sea depth is 111 m (Volkov et al., 2002). Greatest depths are found in the St. Anna Trough (>500 m) in the north and in the Novaya Semlya Trough (433 m). The estuaries of Ob and Yenisei and adjacent southern and eastern coastal zone are very shallow.

2.2. Ice cover

The Kara Sea is covered by ice for about 9 months per year (Blanchet et al., 1995). Sea ice thickness for first year ice ranges from 1.2 m in the southwest to 2 m in the northeast (Barnett, 1991). Ice formation starts in the end of September or beginning of October. Land-fast ice forms along the coasts along the 10–15 m isobath in the south-western region and along the 20–25 m isobath in the north-eastern region (Volkov et al., 2002),

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