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Regional differences of mesozooplankton communities in the Kara Sea

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ABSTRACT

The Kara Sea is a little studied high Arctic region located between the Barents Sea, the Arctic Ocean and the Laptev Sea. The aim of this study was to reveal the spatial distribution of mesozooplankton community in relation to hydrographic conditions. Our survey was the first study covering most of the sea, excluding the eastern part. Zooplankton samples were collected at 47 stations using a Juday net (168 μm, 0.1 m^2) in August 2012. Copepods dominated the total mesozooplankton abundance and biomass, with *Calanus* spp. being the most numerous in the western part and *Pseudocalanus* spp. in the eastern area. Cluster analyses revealed four groups of stations differing in terms of composition, abundance, biomass, species richness and diversity. The regional distribution of mesozooplankton communities was clearly associated with hydrographic habitats defined by their physical (temperature, salinity and main currents) and biological characteristics (food conditions). The domination of copepod populations by young copepodite stages and nauplii suggests early summer-like conditions in the mesozooplankton community although a high abundance of meroplankton suggests spring-like conditions in the mesozooplankton. Principal components analysis showed that temperature determined variations in the biomass of major taxa in the west, while the salinity was the main factor in the east. Phytoplankton concentrations also have measurable effect on the mesozooplankton community. The total mesozooplankton average biomass (6 ± 1 g dry mass m^{-2}) was higher than in adjacent waters, suggesting a high reproductive potential of zooplankton populations in the summer season.

1. Introduction

The shelf regions of the Barents and Kara seas represent a link between the Atlantic Ocean and the Arctic Ocean (Hirche et al., 2006; Wassmann et al., 2006). The hydrography is characterized by frontal structures, and transformation and mixing processes, resulting from the flow of warm and saline North Atlantic Water from western boundary, cold and less saline Arctic Water from the north, and abundant river runoff from east (Kulakov et al., 2006). The Kara Sea can be considered as a true Arctic sea with permanent ice cover existing from October to May (Borkin, 2008). More than 40% of the sea has a depth less than 50 m (Volkov et al., 2002). The greatest depths are found in the St. Anna Trough (> 500 m) in the north and in the Novaya Zemlya Trough (433 m). The estuaries of the Ob and Yenisei and the adjacent southern and eastern coastal zone are very shallow (Hirche et al., 2006).

Recent studies have shown clear climatic variations in the Arctic region (Sakshaug et al., 2009; Drinkwater, 2011). Year-to-year changes in climatic conditions are strongly connected to the intensity of the inflow of Atlantic water (Sakshaug et al., 2009). The Kara Sea is affected by this inflow to a lesser degree than the Barents Sea (Hirche et al., 2006) that may be detected as low abundances of true Atlantic species (e.g. *Calanus finmarchicus*, *Oithona atlantica*) in south-western Kara Sea compared to adjacent waters of the Barents Sea. Therefore, the impact of this factor is weaker than in the Barents Sea. Zooplankton communities, in general, are affected by climate conditions and they may be used as indicators for global changes in the Arctic seas (Hays et al., 2005; Dvoretsky and Dvoretsky, 2013). Studying of zooplankton community in the Kara Sea is an important task to evaluate future possible climatic effects on the pelagic ecosystem in this region.

Hirche et al. (2006) have delineated four large geographical regions in the Kara Sea: (1) a southern area strongly affected by freshwater input; (2) a south-western area strongly influenced by waters from the Pechora Sea; (3) a central area shaped by the Barents Sea waters entering north of Novaya Zemlya and by Arctic water; (4) the northern troughs and slope influenced by the advection from the west of transformed Atlantic waters and Arctic waters from the Arctic Ocean and the Barents Sea. Zooplankton communities of these regions differ from each other in terms of composition, structure, abundance and biomass (Chislenko, 1972a, 1972b; Vinogradov, et al., 1994a, 1994b; Hirche et al., 2006). However, it should be noted that such a delimitation is based on the data collected mostly in the southern Kara Sea (Fetzer et al., 2002) and on some data from the Russian literature (see review

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Hirche et al., 2006) collected during different years and seasons.

Previous studies did not cover all of the sea. They were focused on different regions – southern (Fetzer et al., 2002; Flint et al., 2010), south-eastern (Chislenko 1972a, 1972b; Vinogradov et al., 1994a), south-western (Fomin, 1989; Vinogradov et al., 1994b; Nesterova and Orlova 2008), and north-western (Nesterova and Orlova, 2008). The western area (Novaya Zemlya Trough area) has not been studied at all. To reveal features of spatial distribution a survey covering most of the sea is needed. Such an investigation may be useful in the detection of the possible impacts of climatic changes in the Kara Sea. MMBI conducted such an expedition in the summer of 2012.

The aims of the present article were (1) to describe mesozooplankton communities in the Kara Sea so that comparisons may be made with previous and future investigations, (2) to study population structure of common copepod species and (3) to examine the influence of environmental conditions on the mesozooplankton community.

2. Material and methods

2.1. Sampling

Our survey was conducted from the RV *Dalnie Zelentsy* at 47 stations in the Kara Sea in August 2012 (Table 1, Fig. 1). At each station, vertical profiles of water temperature and salinity were recorded using a SBE 19 plus SEACAT CTD profiler. Zooplankton was sampled using a Juday net (mouth size, 0.1 m^2; mesh size, 168 μm) towed vertically from 3–5 m above the bottom to the surface with a towing speed in the range 0.8–1 m/s. The volume of filtered water was determined by multiplying the length of cable released by the area of the mouth net (Harris et al., 2000). All samples were preserved immediately upon retrieval of the net using a 4% borax–buffered sea water–formaldehyde solution. The same method was used in previous studies conducted by Murmansk Marine Biological Institute in the Barents and Kara seas (e.g. Fomin, 1978, 1989; Timofeev, 2000; Dvoretsky and Dvoretsky,

Table 1
Summary of sampling locations in the Kara Sea in August 2012.

#	Date	Time	Latitude	Longitude	Depth, m	Rope length, m	Region*	Community**
1	09-Aug-12	0:30	71.87	59.25	152	150	SW	WKC
2	10-Aug-12	10:30	72.33	59.19	135	145	SW	WKC
3	10-Aug-12	20:30	72.82	59.13	315	315	SW	NZTC
4	11-Aug-12	7:20	73.31	59.06	379	390	SW	NZTC
5	11-Aug-12	21:50	73.75	60.84	141	145	SW	WKC
6	12-Aug-12	7:10	73.16	60.84	112	105	SW	WKC
7	12-Aug-12	16:30	72.54	60.84	120	120	SW	WKC
8	13-Aug-12	2:00	71.87	60.84	129	125	SW	WKC
9	13-Aug-12	6:20	71.87	61.83	146	145	SW	WKC
10	13-Aug-12	12:00	72.30	62.29	94	95	SW	WKC
11	13-Aug-12	17:40	72.73	62.75	79	80	SW	WKC
12	14-Aug-12	5:50	73.21	63.30	86	90	SW	WKC
13	14-Aug-12	16:38	73.90	62.76	135	140	SW	WKC
14	15-Aug-12	0:10	74.40	62.76	281	285	SW	NZTC
15	15-Aug-12	8:43	74.92	62.76	350	370	W	NZTC
16	15-Aug-12	23:20	75.28	64.43	304	350	W	NZTC
17	16-Aug-12	13:00	74.79	64.43	51	50	W	YC
18	17-Aug-12	1:35	74.06	64.43	109	115	W	WKC
19	17-Aug-12	6:43	73.75	64.49	158	170	SW	YC
20	17-Aug-12	19:03	74.06	66.09	119	120	SW	WKC
21	17-Aug-12	1:05	74.50	66.21	186	180	W	NZTC
22	18-Aug-12	10:15	74.96	66.21	180	180	W	NZTC
23	18-Aug-12	18:30	75.39	66.21	296	300	W	NZTC
24	19-Aug-12	2:20	75.72	66.47	294	285	W	NZTC
25	19-Aug-12	11:28	75.74	68.14	294	285	W	WKC
26	19-Aug-12	21:50	75.12	67.93	192	185	W	WKC
27	20-Aug-12	5:13	74.50	67.66	117	110	W	WKC
28	20-Aug-12	14:00	73.75	67.66	39	35	C	YC
29	21-Aug-12	1:24	74.45	69.30	30	25	C	YC
30	21-Aug-12	8:34	75.12	69.30	85	80	W	WKC
31	21-Aug-12	16:16	75.74	69.30	273	270	W	WKC
32	21-Aug-12	23:50	75.74	70.38	145	150	W	WKC
33	22-Aug-12	7:25	75.12	70.54	42	35	C	YC
34	22-Aug-12	14:31	74.45	70.54	18	18	O-Y	OYC
35	22-Aug-12	19:17	74.06	70.54	16	15	O-Y	OYC
36	23-Aug-12	2:25	73.75	71.85	17	18	O-Y	OYC
37	23-Aug-12	6:38	74.11	71.85	20	18	O-Y	OYC
38	23-Aug-12	13:45	74.81	71.85	26	30	C	YC
39	23-Aug-12	21:53	75.48	71.85	85	120	W	WKC
40	24-Aug-12	2:15	75.26	71.09	34	35	C	YC
41	24-Aug-12	5:45	75.12	73.88	31	30	C	YC
42	24-Aug-12	14:32	74.45	73.09	23	28	C	OYC
43	24-Aug-12	20:25	73.95	73.09	30	30	O-Y	OYC
44	25-Aug-12	2:11	73.75	74.52	13	10		OYC
45	25-Aug-12	7:10	73.65	73.09	26	30	C	OYC
46	25-Aug-12	18:50	73.47	69.17	18	19	O-Y	OYC
47	26-Aug-12	4:30	73.54	66.08	91	95	SW	WKC

* Regions delineated by cluster analysis based on the hydrological conditions and phytoplankton features: SW – south-western, W – western, C – central, O–Y – Ob–Yenisei Shallow.

** Communities delineated by cluster analysis based on the biomass of major zooplankton taxa: WKC – Western Kara Sea community, NZTC – Novaya Zemlya Trough community, YC – Yamal community, OYC – Ob–Yenisei community.

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