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Recent Ostracoda from the Laptev Sea (Arctic Siberia): species assemblages and some environmental relationships

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Abstract

Ostracod assemblages from coretop sediments collected at 26 localities at different depths of the Laptev Sea shelf and upper continental slope were investigated for assemblage studies. A total of 41 species belonging to 19 genera and 12 families have been identified. Three assemblages have been established that could be linked to environmental factors such as water depth, bottom salinities, water mass circulation and sea-ice transportation. The species-rich and abundant assemblages of the western and central Laptev Sea were related to the Atlantic waters occupying the upper continental slope. These include relatively deep-water forms that show clear affinities to North Atlantic and Arctic Ocean assemblages (*Cytheropteron biconvexa*, *C. testudo*, *C. simplex*, *C. nodosoalatum*, *C. inflatum*, *C. porterae*, *Krithe glacialis*, *K. minima*, *Pseudocythere caudata*, *Polycope punctata*, *P. orbicularis*). In the eastern middle shelf region, the assemblage is comprised of *Acanthocythereis dunelmensis* together with other normal marine species (*Semicytherura complanata*, *Elofsonella concinna*, *Cluthia cluthae*). This assemblage seems connected to the winter flaw polynya which is believed to be the main area of sediment entrainment into sea ice. The inner shelf assemblage of the southern Laptev Sea is dominated by shallow-water euryhaline species (*Paracyprideis pseudopunctillata* and *Heterocyprideis sorbyana*) with admixture of the brackish-water species *Roundstonia macchesneyi*. The unusual occurrence of a number of shallow-water ostracod species on the upper continental slope may be explained by ice-rafting which these ostracods are probably able to survive.

Keywords: Recent Ostracoda; Arctic shelves; Laptev Sea; Arctic Ocean

1. Introduction

Fossil Pleistocene shallow-water ostracods were studied at several localities on the Arctic coasts (Lev, 1970, 1972, 1983; Swain, 1963; Repenning et al., 1987; Brouwers et al., 1991), shelves (Kupriyanova, 1999; McDougall et al., 1986) and adjacent high-latitudinal areas of the North Atlantic and North Pacific (Cronin, 1977, 1981, 1989, 1991; Ingram, 1998; Penney, 1990; Brouwers, 1990, 1994; Brouwers et al., 2000). They were shown to be sensitive indicators of palaeoenvironmental changes in shallow shelf areas giving evi-

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dence of variations in water depth, temperature–salinity characteristics, river runoff and bottom hydrodynamics.

Although ostracods could also play an important role in palaeoenvironmental reconstructions of the shallow Siberian shelf seas, the data on Recent ostracods are limited, especially for the Laptev Sea. Only five publications mentioning Recent ostracod species from this area are available to date (Akatova, 1946; Gorbunov, 1946; Cronin et al., 1991; Bauch et al., 1995; Erlenkeuser and von Grafenstein, 1999). Akatova (1946) gives a taxonomic description of seven ostracod species found in the shallow waters around the New Siberian Islands (water depth range 14–68 m), while Gorbunov (1946) provides a total of 26 Ostracoda species. Neale and Howe (1975) used the data of Akatova (1946) in their review of the high-latitude ostracod fauna in order to assess the relationships between the Arctic ostracod faunas from different localities and the diverse fauna from the Russian Harbour (Novaya Zemlya, Barents Sea). In general, they regard the ostracod fauna of the Arctic shelf waters as a single circumpolar province with minor differences between the eastern and western subprovinces. However, in their review the authors deal with data from the western Arctic. Seven ostracod samples from different parts of the Laptev Sea, collected during the US Coast Guard *Northwind* cruise in 1963, are listed in the Modern Arctic Podocopid Database (MAPD; Cronin et al., 1991). The total number of identified species is nineteen. Three samples from the mid-depths, one from the western shelf and two from the submarine Lena valley exhibit a high taxonomic diversity (up to 15 species) with predominance of *Paracyprideis pseudopunctillata*, *Heterocyprideis fascis* and *Elofsonella neoconcinna*. In contrast, all samples from the eastern Laptev Sea are taxonomically rather poor, consisting of only three species, *Sarsicytheridea bradii*, *Heterocyprideis sorbyana* and *Paracyprideis pseudopunctillata*, the latter being the most abundant. Two other studies (Bauch et al., 1995; Erlenkeuser and von Grafenstein, 1999) present merely lists of ostracod species found in coretop samples collected during two expeditions in the early 1990s. Bauch et al. (1995) identified 17 ostracod species representing a typical inner shelf Arctic assemblage dominated by *Paracyprideis pseudopunctillata*, *Sarsicytheridea* spp., *Heterocyprideis sorbyana* and *Cluthia cluthae*. The authors conclude that a similar assemblage is also characteristic of the inner Alaskan and Canadian shelf (e.g. Cronin, 1989).

The present investigation was undertaken to provide a thorough assemblage study of the modern Ostracoda in the Laptev Sea. Using sediment samples from the shallow inner shelf region down to the upper continental slope, it is also attempted to relate the assemblages to water depth, water mass properties and prevailing circulation patterns. Finally, the modern ostracodal assemblages of the Laptev Sea are compared with the available data from other Arctic areas.

2. Environmental setting

The Laptev Sea is an open marginal sea of the Arctic Ocean occupying an area of 662×10^3 km^2 between 70°42’ to 81°16’N and 95°44’ to 143°30’E (Fig. 1). Its shelf has a vastly shallow topography, gently sloping northward down to water depths of 50–60 m, which is cut by several palaeoriver valleys. From October until mid-July the sea is covered with ice. A 1.5–2-m thick fast ice cover is characteristic of the shallow coastal zone. The northern boundary of the fast ice runs approximately along the 20–25 m isobath, where an up to 100-km wide polynya can form in winter, separating the fast ice from the region with drift ice.

Five large rivers empty into the sea, of which the annual discharge from the Lena River considerably affects the salinity in the eastern Laptev Sea. In the shelf zone, the upper, freshened, water layer is divided from the underlying saline water by a pycnocline, usually located in the depth range from 5–7 to 20–25 m (Dmitrenko et al., 1999).

The temperature of the bottom water layer is negative nearly all year round. At depths exceeding 80–100 m temperature rises up to 0.6–0.8°C due to the influence of the warm Atlantic waters. Recent oceanographic investigations (Dmitrenko et al., 2001a,b) have shown that at certain times

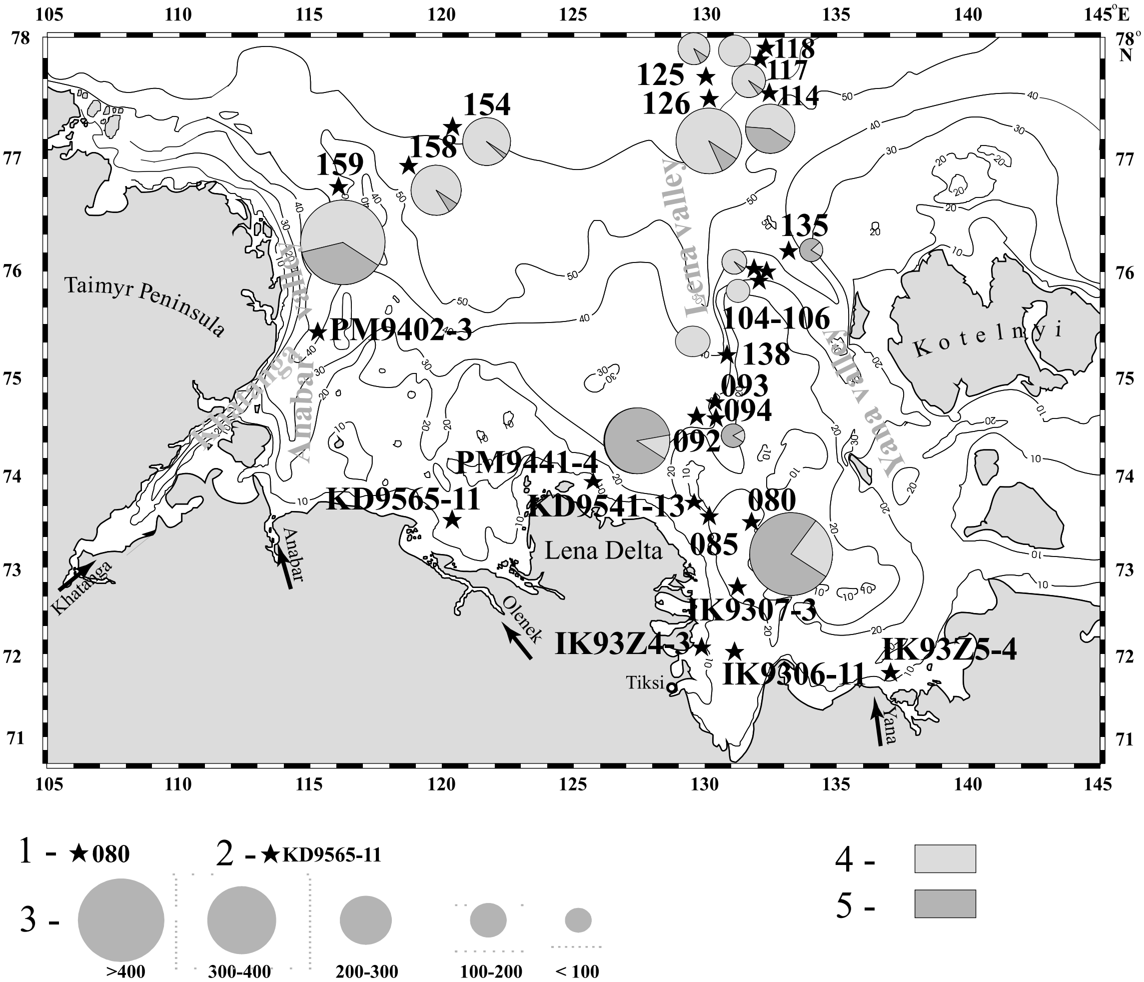


Fig. 1. Distribution of ostracods in the Laptev Sea surface sediments. Key: (1) location of stations of the TRANSDRIFT V expedition; (2) location of stations of the previous TRANSDRIFT expeditions (I-IK93, II-PM94, III-KD95); (3) abundance of ostracods in surface sediment samples (specimens per 100 g dry bulk sediment); (4) marine species; (5) euryhaline and brackish-water species. Isobaths in metres.

there exist strong wind-induced reversal bottom currents that can cause a southward advection of these relatively warm Atlantic waters along the palaeovalleys up to water depths of 20–40 m. Although the existing temperature variations are insignificant for the benthic organisms in the Laptev Sea, they appear to be good water mass indicators.

Due to considerable river runoff and ice formation in the Laptev Sea salinity is the most variable feature that affects the spatial distribution of benthic organisms. In general, both surface and bottom water salinity is lower in the eastern Laptev Sea (Dmitrenko et al., 2001a; Dmitrenko, unpubl. data). Following the distribution of the riverine waters, the average summer surface water salinity ranges from about 5 in the southeast to 10–15 in the east and up to 30 in the west (Fig. 2a). In winter, due to reduced river runoff and sea-ice formation, the average surface salinity is higher, varying from 10 to 12 in the southeast to 33 in the west (Fig. 2b). Bottom salinity is less dependent upon river runoff. Both in summer and in winter, it varies from 18–20 in the shallow

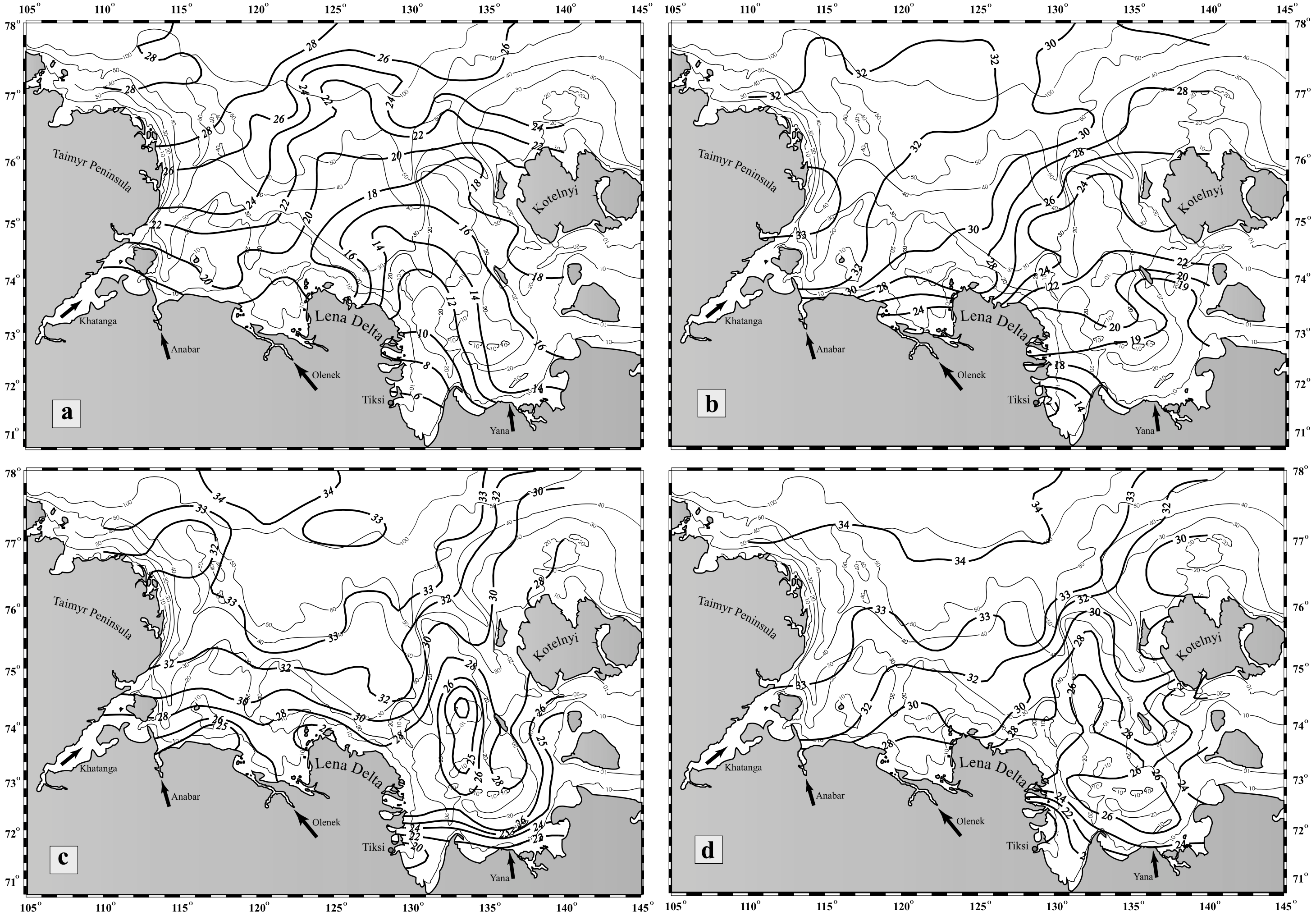


Fig. 2. (a) Average surface salinity in summer (Dmitrenko et al., 2001a). (b) Average surface salinity in winter (Dmitrenko et al., 2001a). (c) Average bottom salinity in summer (Dmitrenko, Kirillov, unpubl. data). (d) Average bottom salinity in winter (Dmitrenko, Kirillov, unpubl. data). Isobaths in metres.

Table 1
Location of stations, water depth, environmental data and percentage of live ostracod specimens

Station	Water depth (m)	Latitude	Longitude	Temperature (°C)	Salinity	Sediment	Live ostracod specimens (%)
PS-51/158-8 west	68	76°57,49N	118°35,37E	−1.481	33.488	sandy silt	96
PS-51/159-8 west	61.6	76°45,99N	116°01,86E	−1.617	33.687	clayey silt	95
PS-51/154-9 west	276.4	77°16,61N	120°36,03E	0.395	34.708	sandy silt	97
PM9402-3 west	47	75°29,44N	115°14,94E				
PS-51/118-1 centre	121	77°53,6N	132°12,57E	−0.7		sandy silt	80
PS-51/125-12 centre	127	77°36,09N	130°00,07E	−1.54		silty sand	95
PS-51/114-13 centre	66	77°35,52N	132°15,82E	−1.345	33.776	sandy–silty clay	99
PS-51/117-3 centre	76	77°49,8N	132°14,42E	−0.949	34.105	sandy silt	92
PS-51/126-2 centre	85	77°32,9N	130°07,9E	−1.54		silty sand	90
PS-51/135-2 east	51	76°09,93N	133°14,78E	−1.6		sandy silt	100
PS-51/104-14 east	34	75°57,83N	132°09,06E	−1.565	32.638	sandy silt	100
PS-51/106-1 east	33	75°56,97N	132°04,39E	−1.5		silty sand	90
PS-51/105-3 east	33	75°57,2N	132°06,13E	−1.590	32.821	sandy silt	94
PS-51/138-10 east	41	75°09,18N	130°49,75E	−1.648	33.219	sandy silt	100
PS-51/094-3 south	31	74°33,36N	130°27,2E	−1.592	32.673	silty sand	–
PS-51/093-1 south	33	74°56,74N	130°34,15E	−1.608	32.992	sandy silt	100
PS-51/092-11 south	34	74°35,5N	130°08,4E	−1.584	32.427	sandy–silty clay	100
PS-51/085-2 south	22	73°33,9N	131°16,3E	−1.086	27.896	sandy–silty clay	98
PS-51/080-11 south	21	73°27,83N	131°39,0E	−1.062	23.407	silty clay	85
IK9306-11 south	17.5	72°00,63N	130°59,23E			clay	
IK9307-3 south	20.7	72°32,97N	131°17,80E			mud	
IK93Z4-3 south	14	72°01,90N	130°07,55E			silty clay	
IK93Z5-4 south	11	71°41,41N	137°00,40E			mud	
PM9441-4 south	14	74°00,00N	125°59,29E				
KD9541-13 south	22	73°22,80N	129°56,57E			clayey silt	
KD9565-11 south	21	73°50,76N	120°19,00E			sandy silt	

southeastern region to 30–34 at depths exceeding 30 m (Fig. 2c,d).

A general cyclonic circulation pattern is characteristic of the surface and shelf bottom waters (Dobrovol'skii and Zalogin, 1982; Pavlov and Pavlov, 1999). The strong reversal currents (current velocity up to 59 cm/s) recently recorded in the submarine valleys make these troughs the main area of interaction between the Arctic Ocean water and the Laptev Sea shelf water (Dmitrenko et al., 2001a,b).

3. Materials and methods

Coretop sediment samples were collected from different parts of the Laptev Sea shelf and upper continental slope during the Russian–German TRANSDRIFT V expedition in August 1998 and from eight nearshore localities (water depths down to 11 m) collected during the TRANSDRIFT I, II and III expeditions in 1993, 1994 and 1995 (Table 1; Fig. 1). All samples from the TRANSDRIFT V expedition were obtained using a giant box-corer. A total of 36 (two samples per station) undisturbed surface samples (approximately the uppermost centimetre) were taken at 18 stations covering a water depth from 21 to 276 m (Table 1). Coretop samples from the other TRANSDRIFT expeditions were taken from both box and kasten cores.

Both sets of samples were treated differently. The first set (~400 cm^2) was stained with Rose Bengal, washed over a 63-μm mesh-size sieve onboard, and later used for estimating the percentage of ostracod species collected alive (Table 1). We considered both strongly and slightly Rose Bengal coloured valves as living ones. Many of the strongly coloured carapaces had their chitinous soft body parts preserved. The number of less brightly Rose Bengal coloured valves and carapaces was by far lower than that of strongly coloured ones. Thus, we combined all these specimens into the group of live ostracods, although certain problems exist in distinguishing dead from living specimens using this method (see discussion in Brouwers et al., 2000). The second set of sediment samples (100 cm^2) was freeze-dried, weighed and also washed over a 63-μm mesh-size sieve. After sieving, ostracods were picked, identified and counted. Ostracod abundance was calculated per 100 grams of dry bulk sediment. Percentages of different ecological groups, i.e. marine and euryhaline together with brackish-water species, were calculated for this set of samples (Fig. 1). Although all ostracods are well preserved, there does exist a certain difference between the two sets of samples. The samples that were first freeze-dried and then washed contained mainly single valves, whereas those that were stained and washed already onboard during the expedition had considerable numbers of complete carapaces.

Ecological characteristics of the species found in our samples are based on both our own data and published evidence on their occurrences in other Arctic and high-latitudinal seas (e.g. Cronin, 1977, 1981; Cronin et al., 1991, 1994; McDougall et al., 1986; Brouwers, 1990, 1994; Brouwers et al., 2000; Jones et al., 1998; Lev, 1983; Nikolaeva, 1989; Neale and Howe, 1975; Reimnitz et al., 1992). In order to demonstrate some possible environmental preferences of the ostracods, average frequencies of the more abundant species were plotted vs. water depth and average summer surface salinity (Fig. 3a,b). In terms of water depth, four groups were distinguished, i.e. ostracods preferring the shallow inner shelf (11–30 m), the middle-outer shelf (30–60 m), the upper continental slope (60–100 m) environments, and depths exceeding 100 m (in our case 100–276 m) (Fig. 3a). We used the average summer surface salinity as a factor to approximate the riverine influence on the ostracod community (Fig. 3b), following the method applied by Polyak et al. (in press) who distinguish between benthic foraminiferal species in the Kara Sea on the basis of three environmental categories: river-proximal (< 15), river-intermediate (15–25), and river-distal (> 25).

By applying cluster analysis, the studied ostracod samples were grouped in relation to their geographical location and, hence, environmental conditions (water depth, salinity variations). The percentage data of 39 taxa from 20 samples (samples containing 1–2 species were excluded) were entered into the Statistica 4.3 software package. We used the 1-Pearson r coefficient and average linkage cluster analysis to attain the cluster dendrogram (Fig. 4).

4. Results

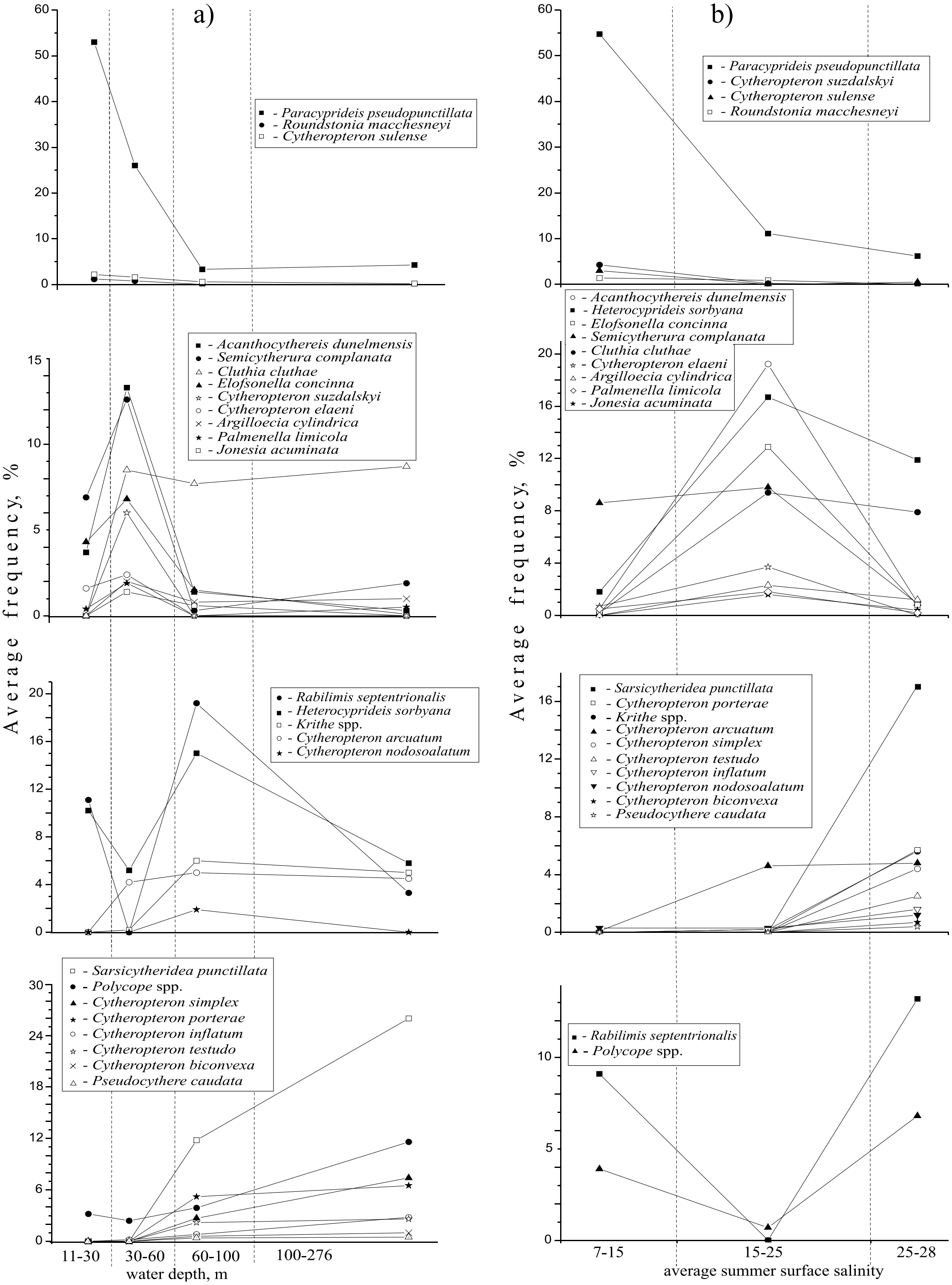
4.1. The Laptev Sea Ostracoda fauna

A total of 1122 valves and 595 carapaces were collected from the entire set of 36 samples. In all, 35 species were identified to species level belonging to 19 genera and 12 families. Four species were identified to generic level and two species remained unidentified (species A, B). For identification we followed the taxonomy provided by Nikolaeva (1989), with additions from Athersuch et al. (1989) and Brouwers (1990). The complete list of taxa with numbers of plates and figures in this paper together with corresponding references from the literature is given in Table 2 (see Plates I–IV). The entire collection is stored at Moscow State University, Geological Faculty, Chair of Palaeontology (No. 292/1-196).

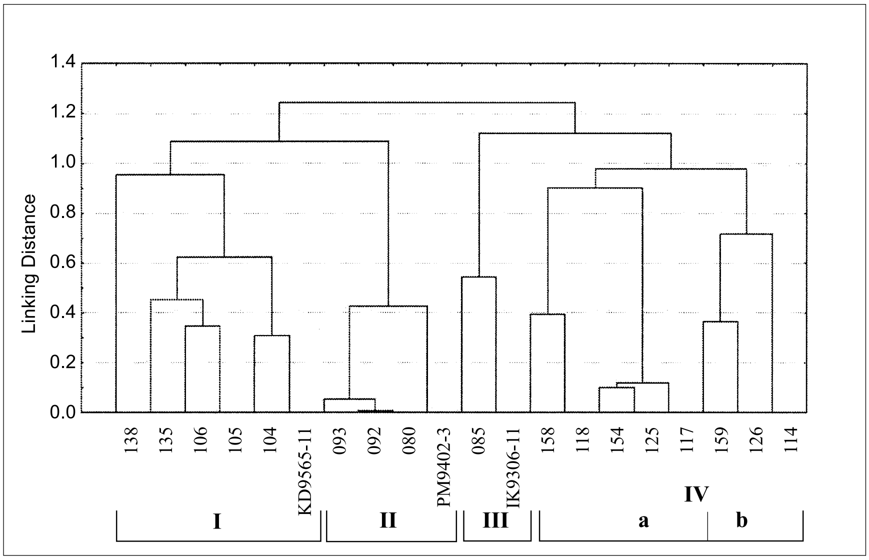
4.2. Composition and abundance of ostracods in surface samples

In general, ostracod abundance is high in the southern nearshore zone and in the Khatanga

Fig. 3. (a) Average frequencies of ostracod species vs. water depth in discrete increments. (b) Average frequencies of ostracod species vs. average summer surface salinity in discrete increments.


a)
b)
Average frequency, %
- Paracyprideis pseudopunctillata
- Roundstonia macchesneyi
- Cytheropteron sulense
- Acanthocythereis dunelmensis
- Semicytherura complanata
- Cluthia cluthae
- Elofsonella concinna
- Cytheropteron suzdalskyi
- Cytheropteron elaeni
- Argilloecia cylindrica
- Palmenella limicola
- Jonesia acuminata
- Rabilimis septentrionalis
- Heterocyprideis sorbyana
- Krithe spp.
- Cytheropteron arcuatum
- Cytheropteron nodosoalatum
- Sarsicytheridea punctillata
- Polycope spp.
- Cytheropteron simplex
- Cytheropteron porterae
- Cytheropteron inflatum
- Cytheropteron testudo
- Cytheropteron biconvexa
- Pseudocythere caudata
11-30
30-60
60-100
100-276
water depth, m
- Paracyprideis pseudopunctillata
- Cytheropteron suzdalskyi
- Cytheropteron sulense
- Roundstonia macchesneyi
- Acanthocythereis dunelmensis
- Heterocyprideis sorbyana
- Elofsonella concinna
- Semicytherura complanata
- Cluthia cluthae
- Cytheropteron elaeni
- Argilloecia cylindrica
- Palmenella limicola
- Jonesia acuminata
- Sarsicytheridea punctillata
- Cytheropteron porterae
- Krithe spp.
- Cytheropteron arcuatum
- Cytheropteron simplex
- Cytheropteron testudo
- Cytheropteron inflatum
- Cytheropteron nodosoalatum
- Cytheropteron biconvexa
- Pseudocythere caudata
- Rabilimis septentrionalis
- Polycope spp.
7-15
15-25
25-28
average summer surface salinity

a)



b)

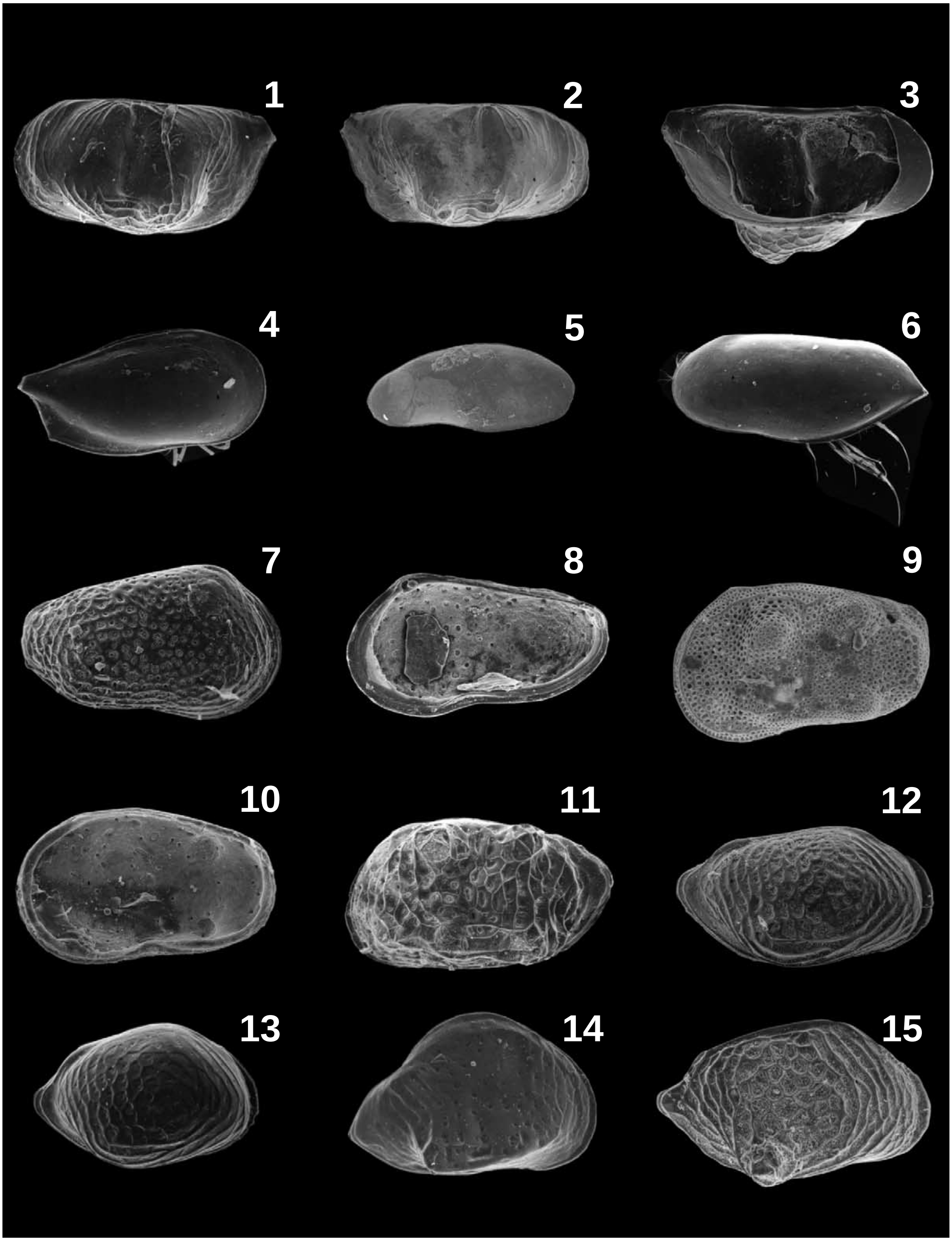
cluster	region	water depth range, m	dominant ostracod species	characteristic species, comments
I	Eastern (+ one sample KD9565 from southern region)	21-51	*Acanthocythereis dunelmensis*	*Semicytherura complanata, Elofsonella concinna, Cluthia cluthae*
II	Southern (+ one sample PM9402 from western region)	21-47	*Paracyprideis pseudopunctillata*	*Heterocyprideis sorbyana, Cytheropteron elaeni, Cytheropteron sulense*
III	Southern	17.5-22	-	085-*Semicytherura complanata, Polycope bireticulata, Polycope orbicularis, Polycope punctata* IK9306-11- *Paracyprideis pseudopunctillata*
IV a	Western-Central	68-276	*Sarsicytheridea punctillata, Cytheropteron arcuatum, Cytheropteron porterae*	*Cluthia cluthae, Cytheropteron simplex, Krithe glacialis, Polycope bireticulata, Polycope orbicularis, Polycope punctata*
IV b	Western-Central	62-85	*Rabilimis septentrionalis, Heterocyprideis sorbyana*	predominance of shallow-water species as a result of ice-rafting?

Fig. 4. (a) Cluster analysis dendrogram of 20 Laptev Sea samples based on the relative abundance of 39 ostracod taxa. (b) Description of the obtained assemblages (clusters).

palaeovalley, ranging from about 300 to 600 specimens per 100 g dry bulk sediment (Fig. 1). The abundance is also relatively high on the continental slope (160–350 specimens). Although samples from the eastern middle shelf contain considerably less valves (27–113 specimens), they have the highest abundance of living ostracods (up to 100%; Table 1). These stations are restricted to those parts of the submarine river valleys where the strongest bottom currents have been observed (I. Dmitrenko and J.A. Hölemann, pers. commun.). Thus, it is probable that dead valves are being constantly removed from these sites. Such a situation is quite common for hydrodynamically active environments (Frenzel and Boomer, in press). Also, possibly due to the same reasons,

Table 2
List of ostracod species identified from the Laptev Sea

Species	Reference	Figs. this paper
Bythocythere constricta Sars, 1926	Neale and Howe, 1975, pl. 4, fig. 4	Plate I, figs. 1–3
Pseudocythere caudata Sars, 1865	Athersuch et al., 1989, p. 255, fig. 108	Plate I, fig. 4
Sclerochilus contortus (Norman, 1862)	Athersuch et al., 1989, p. 260, fig. 110.	Plate I, fig. 5
Jonesia acuminata (Sars, 1866)	Athersuch et al., 1989, p. 252, fig. 107.	Plate I, fig. 6
Roundstonia macchesneyi (Brady and Crosskey, 1871)	Brouwers et al., 2000, p. 136, fig. 7, 8	Plate I, figs. 7 and 8
Cluthia cluthae (Brady, Crosskey and Robertson, 1874)	Whatley et al., 1996, pl. 3, figs. 17 and 18	Plate I, figs. 9 and 10
Cytheropteron arcuatum (Brady, Crosskey and Robertson, 1874)	Cronin, 1981, p. 402, pl. 7, fig. 1, 1	Plate II, figs. 13 and 14
Cytheropteron biconvexa Whatley and Masson, 1979	Whatley and Masson, 1979, p. 229, pl. 3, figs. 5, 10, 14–16, 18–20	Plate II, figs. 7 and 8
Cytheropteron champlainum Cronin, 1981	Cronin, 1981, p. 404, pl. 8, figs. 7 and 8	Plate II, fig. 2
Cytheropteron elaeni Cronin, 1989	Brouwers, 1994, p. 23, pl. 22, figs. 11–13	Plate I, fig. 14
Cytheropteron inflatum (Brady, Crosskey and Robertson, 1874)	Whatley et al., 1998, pl. 1, figs. 20 and 21	Plate II, fig. 1
Cytheropteron inornatum Brady and Robertson, 1872	Whatley and Masson, 1979, p. 238, pl. 3, figs. 1–3, 5–7	Plate II, Fig. 9
Cytheropteron montrosiense (Brady, Crosskey and Robertson, 1874)	Cronin, 1989, pl. V, fig. 2	Plate II, fig. 15
Cytheropteron nodosoalatum Neale and Howe, 1975	Neale and Howe, 1975, pl. 6, figs. 8 and 10, pl. 7, fig. 2, 4, 10, 11	Plate II, figs. 3 and 4
Cytheropteron cf. *nodosum* Brady, 1868		
Cytheropteron porterae Whatley and Coles, 1987	Whatley et al., 1996, pl. 2, figs. 7 and 9	Plate II, figs. 10 and 11
Cytheropteron simplex Whatley and Masson, 1979	Whatley and Masson, 1979, p. 252, pl. 2, figs. 11, 12, 19–21	Plate II, fig. 12
Cytheropteron sulense Lev, 1972	Lev, 1983, pl. XVI, figs. 12 and 13	Plate I, figs. 12 and 13
Cytheropteron suzdalskyi Lev, 1972	Lev, 1983, pl. XV, figs. 13 and 14	Plate I, fig. 11
Cytheropteron testudo Sars, 1869	Whatley et al., 1996, pl. 3, figs. 2 and 3	Plate II, figs. 5 and 6
Semicytherura complanata (Brady, Crosskey and Robertson, 1874)	Cronin, 1989, pl. III, figs. 7–9	Plate II, fig. 15; Plate III, fig. 1
Palmenella limicola (Norman, 1865)	Athersuch et al., 1989, p. 82, fig. 28	Plate III, figs. 2 and 3
Acanthocythereis dunelmensis (Norman, 1865)	Athersuch et al., 1989, p. 133, fig. 52	Plate III, figs. 4 and 5
Rabilimis septentrionalis (Brady, 1866)	Kupriyanova, 1999, pl. 1, fig. 1	Plate III, fig. 6
Heterocyprideis sorbyana (Jones, 1857)	Kupriyanova, 1999, pl. 1, fig. 3	Plate III, figs. 7 and 8
Heterocyprideis fascis (Brady and Norman, 1889)	Hazel, 1968, text-fig. 2	
Sarsicytheridea bradii (Norman, 1864)	Athersuch et al., 1989, p. 116, fig. 45	Plate III, fig. 14
Sarsicytheridea punctillata (Brady, 1864)	Athersuch et al., 1989, p. 118, fig. 46	Plate III, figs. 11–13
Eucythere cf. *argus* (Sars, 1866)		
Paracyprideis pseudopunctillata (Swain, 1963)	Swain, 1963, p. 812, pl. 95, figs. 9 and 13, pl. 96, fig. 12, pl. 97, figs. 14 and 17, pl. 98, fig. 4a–e, text-fig. 7a	Plate IV, figs. 5–7
Krithe glacialis (Brady, Crosskey and Robertson, 1874)	Whatley et al., 1998, pl. 3, figs. 5 and 6	Plate IV, figs. 3 and 4
Krithe minima Coles, Whatley and Moguilevsky, 1994	Didié et al., 1999, pl. I, figs. 9 and 10	Plate IV, figs. 1 and 2
Krithe sp.		Plate III, fig. 15
Argilloecia cylindrica Sars, 1923	Whatley et al., 1998, pl. 1, figs. 2 and 3	Plate IV, fig. 8
Argilloecia sp.		Plate IV, figs. 9 and 10
Elofsonella concinna (Jones, 1857)	Cronin, 1991, fig. 14 (4)	Plate IV, figs. 11 and 12
Elofsonella aff. *concinna* (Jones, 1857)		Plate IV, fig. 13
Polycope bireticulata Joy and Clark, 1977	Joy and Clark, 1977, p. 144, pl. 1, figs. 21 and 22	Plate IV, figs. 14 and 15
Polycope orbicularis Sars, 1866	Whatley et al., 1998, pl. 3, fig. 24	Plate IV, fig. 16
Polycope punctata Sars, 1866	Whatley et al., 1996, pl. 4, fig. 14	
Polycope sp.		Plate IV, fig. 17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no juvenile valves were found in the samples from shallow areas and only few juveniles were recognised in the deeper western and central regions (Tables 3 and 4). Surface sediments in the Laptev Sea are mainly represented by olive-brown sandy silt (Table 1). The highest abundance of ostracods is usually recorded in the more clayey sediments, as found in the submarine valleys (stations 80, 159; Fig. 1), while the coarser sandy sediments occur in the hydrodynamically more active zones and show lower ostracod abundances (stations from the eastern middle shelf).

Taxonomic diversity was found to decrease in eastward direction, from on average 15–16 species in the west to 5–7 species in the east and south (Tables 5 and 6). The lowest diversity (1–2 species) was recorded in the nearshore zone close to the Lena delta and Yana estuary (Table 5) and in the samples obtained in the Sannikov Strait near New Siberian Islands and in the Yana valley (MAPD; Cronin et al., 1991).

As the studied samples were obtained from geographically different localities, they could be divided into three groups: a western–central group, a southern and an eastern group (Fig. 1; Tables 3–6). This geographical grouping is also supported by cluster analysis (Fig. 4). The obtained dendrogram clearly defines two major groupings mainly corresponding to the western–central and southern–eastern regions. Most stations in the western and central Laptev Sea are located on the upper continental slope (62–276 m water depth). The southern and eastern stations are restricted to the shallow shelf areas (11–51 m). Samples from the western–central region represent a single assemblage (cluster IV; Fig. 4), with two subdivisions according to their water depths. The difference between assemblages from the eastern (cluster I) and southern (clusters II, III) regions is well pronounced (Fig. 4).

4.2.1. *Western–central Laptev Sea*

The ostracod assemblage from the western–central Laptev Sea exhibits the highest taxonomic diversity among the studied samples (Tables 3 and 4). It is distinguished from the other assemblages by the presence of relatively deep-living species (Fig. 3b) such as *Pseudocythere caudata*, *Krithe glacialis*, *K. minima*, *Cytheropteron inflatum*, *C. biconvexa*, *C. nodosoalatum*, *C. simplex*, *C. porterae*, *C. testudo*, *Polycope punctata*, *P. orbicularis* and *P. bireticulata*, all of which are typical of the Arctic seas and the North Atlantic (Whatley et al., 1998; Cronin, 1989, 1996; Cronin et al., 1994, 1995; Joy and Clark, 1977; Jones et al., 1998, 1999; Didié, 2001). However, their

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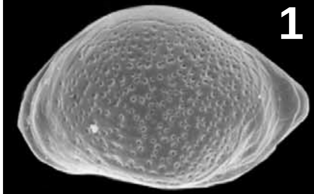
Plate I.

1–3.	*Bythocythere constricta* Sars, 1926; (1) MSU292/185, sample PS51/118-1, left valve, external view, ×61; (2) MSU292/169, sample PS51/117-3, right valve, external view, ×74; (3) MSU292/189, sample PS51/158-8, left valve, internal view, ×61.
4.	*Pseudocythere caudata* Sars, 1866; MSU292/177, sample PS51/154-9, carapace, ×83.
5.	*Sclerochilus contortus* (Norman, 1862); MSU292/188, sample PS51/158-8, left valve, external view, ×62.
6.	*Jonesia acuminata* (Sars, 1866); MSU292/163, sample PS51/105-3, carapace, ×38
7, 8.	*Roundstonia macchesneyi* (Brady and Crosskey, 1871); sample PS51/138-12, core section, 355–358 cm; (7) MSU292/191, right valve, external view, ×100; (8) MSU292/192, right valve, internal view, ×103
9, 10.	*Cluthia cluthae* (Brady, Crosskey and Robertson, 1874); sample 118-1; (9) MSU292/184, left valve, external view, ×125; (10) MSU292/74, right valve, internal view, ×100.
11.	*Cytheropteron suzdalskyi* Lev, 1972; MSU292/140, sample PS51/135-4, core section, 390–393 cm, left valve, external view, ×79.
12, 13.	*Cytheropteron sulense* Lev, 1972; (12) MSU292/179, sample PS51/085-2, right valve, external view, ×65; (13) MSU292/135, sample PS51/135-4, core section, 490–493 cm, right valve, external view, ×85
14.	*Cytheropteron elaeni* Cronin, 1989; MSU292/144, sample PS51/135-4, core section, 390–393 cm, right valve, external view, ×102
15.	*Cytheropteron montrosiense* (Brady, Crosskey and Robertson, 1874); MSU292/180, sample PS51/085-2, right valve, external view, ×94.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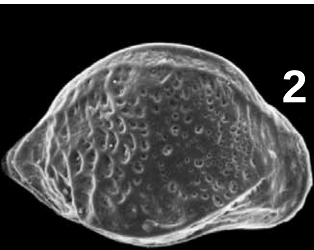
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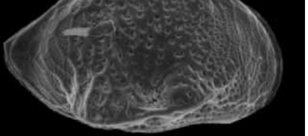
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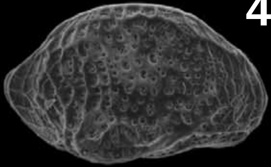
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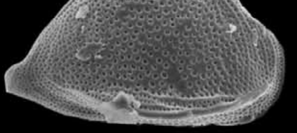
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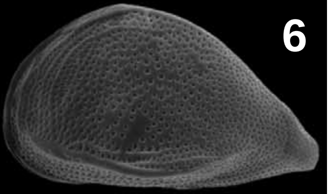
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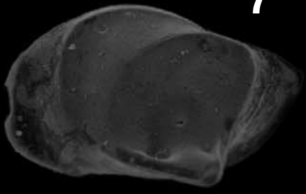
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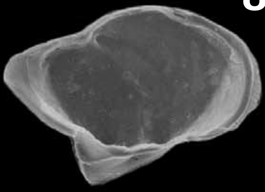
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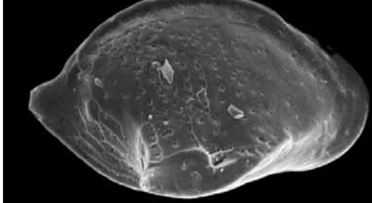
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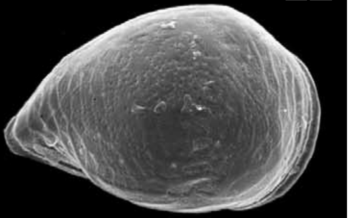
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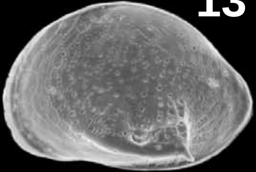
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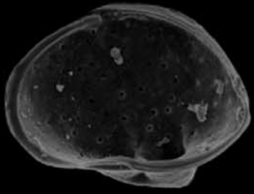
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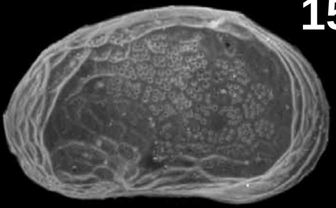
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relative abundance in the samples as well as the total species composition change with depth (Fig. 4). Most samples combined into cluster IVa are dominated by *C. porterae, Cytheropteron arcuatum* and, with increasing depth, by *Sarsicytheridea punctillata* and *Polycope* spp. (*P. punctata*, *P. orbicularis*, *P. bireticulata* and *Polycope* sp.). Three samples, comprising cluster IVb, are dominated by shallow-water species *Rabilimis septentrionalis* and *Heterocyprideis sorbyana*, but also include many of the above-mentioned deep-living forms. Increased abundance of shallow-water species that were found alive in these samples could result from ice-rafting that is a well-known factor affecting the distribution of ostracods in the Arctic (Jones et al., 1998, 1999; Cronin et al., 1994). As seen in Fig. 3a, *R. septentrionalis* and *H. sorbyana* have in fact two abundance maxima – in the shallow inner shelf zone and on the upper continental slope within the water depth range of 60 to 100 m. Many specimens of these species are represented by juvenile valves and carapaces (Tables 3 and 4). This all might point to the importance of ice-rafting in distributing shallow-water species across the Laptev Sea shelf.

4.2.2. Eastern Laptev Sea

Samples from the eastern part of the Laptev Sea (33–51 m) form a single, well-defined assemblage (cluster I; Fig. 4) which is dominated by four normal marine middle and outer neritic species (Table 5; Fig. 3a,b). Primarily, these are *Acanthocythereis dunelmensis* together with *Semicytherura complanata*, *Elofsonella concinna* and *Cluthia cluthae*. A single sample from the southern Laptev Sea (KD9565) is included into the same cluster, probably because it was obtained from the shallow region to the west off the Lena delta where there is considerably less river runoff than in the area to the east and north off it. Therefore, the taxonomic composition of sample KD9565 also differs from all other southern samples.

4.2.3. Southern Laptev Sea

Ostracod samples from the shallow southern Laptev Sea are quite different from most other samples, being dominated by inner shelf euryhaline species (Table 6; Fig. 3a,b). Taxonomic diversity sharply decreases, down to 1–2 species per sample in the most shallow nearshore zone (stations IK9307, IK93Z5, KD9541). The highest abundance of valves was recorded in the nearshore area (600 specimens/100 g at station 80), whereas numbers sharply decrease northward (down to 27 at station 94). Samples from the

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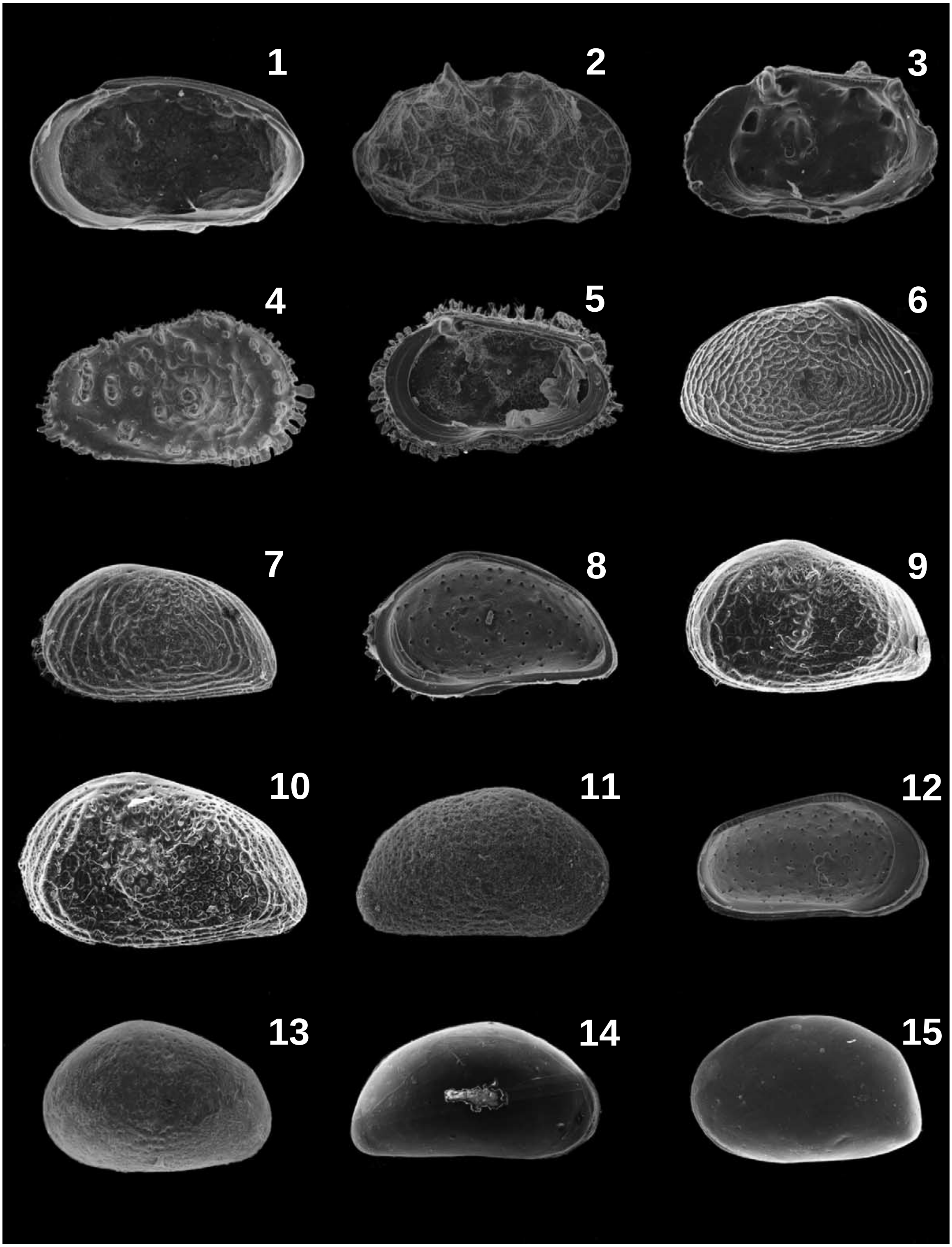
Plate II.

1.	*Cytheropteron inflatum* (Brady, Crosskey and Robertson, 1874); MSU292/71, sample PS51/118-1, left valve, external view, ×70.
2.	*Cytheropteron champlainum* Cronin, 1981; MSU292/59, sample PS51/117-3, right valve, external view, ×86.
3, 4.	*Cytheropteron nodosoalatum* Neale and Howe, 1973; (3) MSU292/81, sample PS51/158-8, left valve, external view, ×87; (4) MSU292/39, sample PS51/138-12, core section, 151–154 cm, left valve, external view, ×85.
5, 6.	*Cytheropteron testudo* Sars, 1869; sample PS51/118-1; (5) MSU292/69, right valve, external view, ×96; (6) MSU292/71, left valve, external view, ×120.
7, 8.	*Cytheropteron biconvexa* Whatley and Masson, 1979; (7) MSU292/76, sample PS51/118-1, left valve, external view, ×115; (8) MSU292/85, sample PS51/158-8, left valve, internal view, ×100.
9.	*Cytheropteron inornatum* Brady and Robertson, 1872; MSU292/84, sample PS51/158-8, right valve, external view, ×97.
10, 11.	*Cytheropteron porterae* Whatley and Coles, 1987; (10) MSU292/61, sample PS51/117-3, right valve, external view, ×80; (11) MSU292/89, sample PS51/158-8, left valve, external view, ×90.
12.	*Cytheropteron simplex* Whatley and Masson, 1979; MSU292/60, sample PS51/117-3, right valve, external view, ×96.
13, 14.	*Cytheropteron arcuatum* (Brady, Crosskey and Robertson, 1874); sample PS51/118-1; (13) MSU292/78, left valve, external view, ×97; (14) MSU292/79, right valve, internal view, ×115.
15.	*Semicytherura complanata* (Brady, Crosskey and Robertson, 1874); MSU292/194, sample PS51/135-2, right valve, external view, ×70.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southern region comprised of more than two species were arranged into clusters II and III (Fig. 4). Unlike the other regions, clustering of the taxonomically poor ostracod samples from this area with the most changeable environmental conditions gave rather controversial results. Cluster III (stations 85 and IK9306) was included into the major group of the western–central assemblage. This is only because these two samples contain species of the *Polycope* genus (*P. punctata*, *P. orbicularis*, *P. bireticulata* and *Polycope* sp.) and *Bythocythere constricta*, which are absent in the remaining samples from the shallow eastern Laptev Sea (Table 6). Also, cluster II includes one sample (PM9402) from the western Laptev Sea (47 m water depth) which is dominated by the shallow-water euryhaline species *Paracyprideis pseudopunctillata* and *Heterocyprideis sorbyana*. *Paracyprideis pseudopunctillata* predominates in the majority of samples from the southern region (Fig. 3a,b). *H. sorbyana* and *Semicytherura complanata* are subdominant species. All three species are known to inhabit shallow inner shelf environments (Nikolaeva, 1989; McDougall et al., 1986; Reimnitz et al., 1993; Brouwers et al., 1991; Brouwers et al., 2000). Two of them, except *S. complanata*, are known to tolerate salinities as low as 5–10 (Cronin, 1977; Neale and Howe, 1975; Lev, 1983). Several valves of the brackish-water species *Roundstonia macchesneyi* were also identified.

5. Discussion

5.1. Distribution of recent ostracods in relation to environmental parameters

The data presented above show that there is significant variability in the distribution of ostracod species over the Laptev Sea shelf and upper slope area, reflecting varying environmental conditions (Fig. 3a,b). In terms of water depth, the most pronounced differences are found between the western–central assemblage (upper continental slope, water depths > 60 m) and assemblages from the southern and eastern shelf regions (water depths less than 60 m). A comparison of the assemblages on the basis of the Jaccard index (Jaccard, 1912) shows that there is a strong similarity between the eastern and southern assemblages (60%). On the contrary, the values of the Jaccard index for the western–central assemblage, on the one hand, and the eastern–southern assemblages, on the other hand, are less than 50%. This implies that the taxonomic composition of these two regions is significantly different. The relatively deep-living species occurring here are also known from

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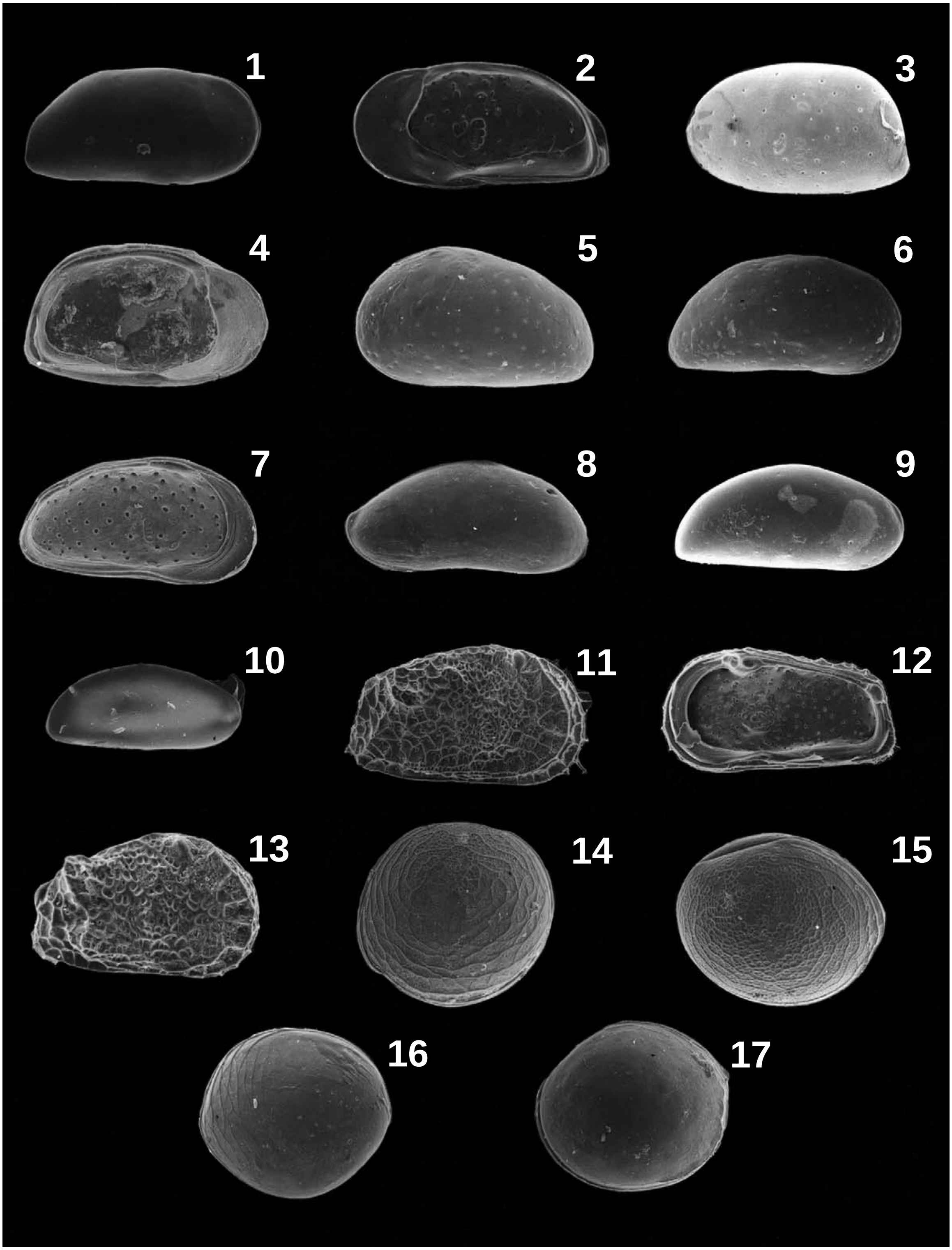
Plate III.

1.	*Semicytherura complanata* (Brady, Crosskey and Robertson, 1874); MSU292/44, sample PS51/138-12, core section, 151–154 cm, right valve, internal view, ×68.
2, 3.	*Palmenella limicola* (Norman, 1865); sample PS51/135-2; (2) MSU292/153, right valve, external view, ×100; (3) MSU292/193, right valve, internal view, ×84.
4, 5.	*Acanthocythereis dunelmensis* (Norman, 1865); (4) MSU292/148, sample PS51/135-4, core section, 390–393 cm, right valve, external view, ×53; (5) MSU292/149, sample PS51/114-13, right valve, internal view, ×43.
6.	*Rabilimis septentrionalis* (Brady, 1868); MSU292/95, sample PS51/159-8, right valve, external view, ×57.
7, 8.	*Heterocyprideis sorbyana* (Jones, 1857); sample PS51/114-13; (7) MSU292/173, left valve, external view, ×47; (8) MSU292/174, right valve, internal view, ×61.
9, 10.	*Heterocyprideis fascis* (Brady and Norman, 1889); sample PM942-3, left valves, external view; (9) MSU292/205, ×65; (10) MSU292/206, ×55.
11–13.	*Sarsicytheridea punctillata* (Brady, 1864); (11) MSU292/171, sample PS51/114-13, right valve, external view, ×63; (12) MSU292/170, sample PS51/114-13, left valve, internal view, ×56; (13) MSU292/101, sample PS51/154-9, left juvenile valve, external view, ×75.
14.	*Sarsicytheridea bradii* (Norman, 1864); MSU292/96, sample PS51/159-8, right valve, external view, ×57.
15.	*Krithe* sp.; MSU292/62, sample PS51/117-3, left valve, external view, ×75.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the North Atlantic and the Arctic Ocean. This is not too surprising because the western–central Laptev Sea region is influenced by Atlantic waters penetrating the upper continental slope and outer shelf (Dobrovol'skii and Zalogin, 1982).

Salinity also seems to have an important impact on the distribution of ostracods in the eastern Laptev Sea, especially, where there is a strong effect of river runoff. The average bottom water salinity ranges from 26 to 32 (Fig. 2), and the bottom salinity measured in this area during the expedition in 1998 varied from 23–27 at 21 m water depth to 32 at 40–50 m water depth (Table 1). It is known that taxonomic diversity usually decreases in lower salinities, while total abundance of ostracod valves is often greater (Frenzel and Boomer, in press). Compared to the assemblage from the western–central region with normal marine salinity, the total number of species found in the eastern and southern assemblages is considerably lower (20 vs. 33–34 species). However, the highest abundance of ostracod valves was recorded in the nearshore part of the Lena valley (600 specimens/100 g). The ostracod assemblage (Table 6) of the southern inner shelf zone (11–33 m) with highly variable environmental conditions is enriched in euryhaline species *Paracyprideis pseudopunctillata* and *Heterocyprideis sorbyana*. The brackish-water species *Roundstonia macchesneyi* found in this assemblage tolerates a low and fluctuating salinity and at times has been found together with freshwater species (Schoning and Wastegård, 1999). This is the only assemblage where the share of brackish-water and euryhaline species reaches 76–88%, thus exceeding that of marine species (Fig. 1).

With increasing water depth and salinity, shallow normal-marine species become dominant (Fig. 3b). These include mainly *Acanthocythereis dunelmensis* but also *Semicytherura complanata*, *Cluthia cluthae* and *Elofsonella concinna* which together sometimes comprise 100% of the assemblage (Fig. 1). This assemblage is also characteristic of the area where the flaw polynya forms during wintertime. A similar assemblage was found in sea-ice sediments sampled from an ice floe in the Beaufort Sea (Reimnitz et al., 1993). As shown by Reimnitz et al. (1992, 1993), the inner and middle shelf (10 to 30–40 m water depth) is the main area where benthic organisms can be easily entrained into ice, mainly through the mechanism of anchor ice formation. Some shallow-water species (*Heterocyprideis sorbyana*, *S. complanata*, *C. cluthae*, *Roundstonia macchesneyi*) have been reported even from central Arctic Ocean surface sediments as part of the 'ice-rafted assemblage' (Jones et al., 1998, 1999; Cronin et al., 1994). Therefore, it may be concluded that

Plate IV.

1, 2. *Krithe minima* Coles, Whatley and Moguilevsky, 1994; sample PS51/158-8; (1) MSU292/82, right valve, external view, ×57; (2) MSU292/83, right valve, internal view, ×62.

3, 4 *Krithe glacialis* (Brady, Crosskey and Robertson, 1874); sample PS51/118-1; (3) MSU292/65, left valve, external view, ×57; (4) MSU292/66, left valve, internal view, ×62.

5–7. *Paracyprideis pseudopunctillata* (Swain, 1963); (5) MSU292/118, sample PS51/092-11, left valve, external view, ×55; (6) MSU292/116, sample PS51/092-11, right valve, external view, ×52; (7) MSU292/8, sample PS51/138-12, core section, 481–484 cm, left valve, internal view, ×52.

8. *Argilloecia cylindrica* Sars, 1923; MSU292/100, sample PS51/126-2, right valve, external view, ×94.

9, 10. *Argilloecia* sp.; (9) MSU292/93, sample PS51/114-6, right valve, external view, ×96; (10) MSU292/64, sample PS51/117-3, carapace, ×72.

11, 12. *Elofsonella concinna* (Jones, 1857); sample PS51/114-6; (11) MSU292/90, right valve, external view, ×49; (12) MSU292/91, right valve, internal view, ×47.

13. *Elofsonella* aff. *concinna* (Jones, 1857); MSU292/94, sample PS51/159-8, right valve, external view, ×92.

14, 15. *Polycope bireticulata* Joy and Clark, 1977; (14) MSU292/166, sample PS51/117-3, carapace, ×75; (15) MSU292/195, sample PS51/080-11, carapace, ×90.

16. *Polycope orbicularis* Sars, 1866; MSU292/165, sample PS51/117-3, carapace, ×92.

17. *Polycope* sp.; MSU292/175, sample PS51/125-12, carapace, ×56.

Table 3
Occurrence of ostracods in coretop samples from the western Laptev Sea

Species	Station 158-8		Station 159-8		Station 154-9		Station PM9402-3
	stained	unstained	stained	unstained	stained	unstained	
Bythocythere constricta	4v3c						
Pseudocythere caudata	2c				2c		
Sclerochilus contortus	1v8c						
Jonesia acuminata	4v2c						
Cluthia cluthae	1v8c	3v	1v	9v	6c	10v	
Cytheropteron sulense	2c	2v					
C. arcuatum	2v6c	1v	1v	3v	1v2c		
C. porterae	2v6c	15v	4v2c		4v1c	3v	
C. testudo	2c	1v					
C. simplex	3v5c			6v	5v13c		
C. inornatum		2v					
C. biconvexa		2v					
C. inflatum		4v1jc		1v			1v
C. nodosoalatum	1v1c	4v					
C. cf. *nodosum*							1v
Semicytherura complanata			2c			5v	
Palmenella limicola						4v	
Acanthocythereis dunelmensis			2v			2v	
Rabilimis septentrionalis	1v8c	5v2j	34v13c	1v	2v1c	11v7j	
Heterocyprideis sorbyana	2c	3v	16v4c	2v	8v	7v	10v
H. fascis							16v
Heterocyprideis sp. juv.							4j
Sarsicytheridea bradii				3v		6v	
S. punctillata	2v	2v		18v1c14j	58v16c		
Paracyprideis pseudopunctillata	1c	1v	23v25c			22v	15v
Krithe minima	1c	2v			2v		
K. glacialis	8v1c	9v	1v		1c		
Krithe sp.							1v
Argilloecia cylindrica	1c				1v2c		
Elofsonella concinna			3v				3v
Elofsonella aff. *concinna*			1v			1v	10v
Eucythere cf. *argus*		1v					
Polycope punctata		1c	1c				
Polycope spp.	2c				1v9c		
Undetermined, species A		1v					

Rose Bengal used for staining. Abbreviations: v, single valves; c, carapaces; j, juvenile valves; jc, juvenile carapaces.

many of the shallow-water species found in our samples from the upper continental slope (*Rabilimis septentrionalis*, *H. sorbyana*, *Paracyprideis pseudopunctillata*) were also ice-rafted. It is interesting in this respect that most ostracods (90–95%) in our samples from the TRANSDRIFT V expedition were found stained. It is unknown whether ostracods can survive ice-rafting. However, it has been observed that some other crustaceans (4th and 5th copepodite stages of cyclops) remained alive after being frozen into riverine and lacustrine ice in the Lena River deltaic zone (E. Abramova, pers. commun.). A survival of macroepibenthic organisms that were frozen into fast ice is reported from the Gulf of St. Lawrence (Medcof and Thomas, 1974). Therefore, it seems conceivable that some shallow-water species are able to settle onto the seafloor after having been ice-rafted.

5.2. *Comparisons with other Arctic areas*

One of the first attempts to review Arctic shallow-water ostracod faunas was undertaken by

Table 4
Occurrence of ostracods in coretop samples from the central Laptev Sea

Species	Station 118-1		Station 125-12		Station 114-3		Station 117-3		Station 126-2	
	stained	unstained	stained	unstained	stained	unstained	stained	unstained	stained	unstained
Bythocythere constricta	1v2c						1v1c			
Cluthia cluthae	8c		1c	4v		5v	12c	4v	5c	4v
Cytheropteron sulense			1v							
C. arcuatum	9v	4v	1c				6c	2v	2v2c	12v
C. porterae	7v1c	5v		5v1c	1v		2v2c	5v	3v	2v
C. testudo	3v	4v	1v1c				1v3c	3v	4c	
C. simplex	7v1c		2v1c				2v1c	1v	2v1c	
C. biconvexa	2c								2c	1v
C. nodosoalatum										1v
C. champlainum							1v	2v		
C. inflatum		7v		4v						1v
Semicytherura complanata	2v	2v		1v						
Acanthocythereis dunelmensis					5v2c		4c	1v		
Rabilimis septentrionalis			2v1c		9v16c	17vlj	1v1c	1v	3v5c	8v50j
Heterocyprideis sorbyana	5v		5v2c	3v	26v47c	25v1c	2v1c	4v		5v1c
Sarsicytheridea punctillata	6v1c	2v	19v5c	18v3c	4v1c	2v	8v3c	11v1c28j	4v	5v1c
S. bradii				14v		1v		uv		
Paracyprideis pseudopunctillata			3v	3v	8v	1v	3v2c	1v		
Krithe minima	4v								2v1c	2v
K. glacialis	3v1c	6v	2v		5v4c	6v	1v	1v	8v4c	3v
Argilloecia cylindrica	1c						3c		2v	1v
Argilloecia sp.						2v				
Elofsonella concinna					3v2c	6v				
E. aff. *concinna*					1c					
Eucythere cf. *argus*				4v						
Polycope spp.	10c		4v6c				3v13c		1c	
Undetermined, species A		1v				1v				

Rose Bengal used for staining. Abbreviation: v, single valves; c, carapaces; j, juvenile valves.

Table 5
Occurrence of ostracods in coretop samples from the eastern Laptev Sea

Species	Station 104-14		Station 105-3		Station 106-1		Station 135-2		Station 138-10	
	stained	unstained	stained	unstained	stained	unstained	stained	unstained	stained	unstained
Jonesia acuminata	1c		2v3c		1v					
Roundstonia macchesneyi					1v				1c	
Cluthia cluthae		2v	4v14c	3v	6c		10c			
Cytheropteron arcuatum			2c		4v7c					
C. elaeni						2v	3v7c	1v		
C. suzdalskyi					1v				1v5c	3v1c
C. nodosoalatum			1v	1v						1v
Semicytherura complanata		9v	4c	4v	5c		3v11c		2c	6v1c
Palmenella limicola		1c					4v5c			
Acanthocythereis dunelmensis	1v15c	14v	4v8c	6v	4v4c	3v	1v7c	2v		
Sarsicytheridea bradii				3v						
Paracyprideis pseudopunctillata			2c	1c	4v2c		1v3c	11v	1v1c	
Argilloecia cylindrica	1v5c		1v				1v			
Elofsonella concinna	1v2c	4v	4v4c		1v					
Elofsonella aff. *concinna*			4c	1v	2c					
Polycope spp.	2v1c									

Rose Bengal used for staining. Abbreviations: v, single valves; c, carapaces.

Table 6

Occurrence of ostracods in coretop samples from the southern Laptev Sea

Species	Station 085-2		Station 092-11		Station 093-1		Station 080-11		Station IK93 06-11	Station IK93 07-3	Station IK93 Z4-3	Station IK93 Z5-4	Station PM94 41-4	Station KD95 41-13	Station KD95 65-11
	stained	unstained	stained	unstained	stained	unstained	stained	unstained							
Bythocythere constricta	1c														
Roundstonia macchesneyi		1v							1f		3v				
Cluthia cluthae					1c	1v									
Cytheropteron sulense	2v3c	1v	1c		3v	7v			1v						
C. arcuatum					1c										
C. montrosiense	1v3c	1v			2c	2v									
C. elaeni				1v			1c								1v
C. suzdalskyi															
Semicytherura complanata	10c			1v	2c					1v					1v
Palmenella limicola	2c			1v											
Rabilimis septentrionalis												22v1c			
Acanthocythereis dunelmensis							1c								3v
Heterocyprideis sorbyana			1c		9v2c	5v		1v					6v1c		
Paracyprideis pseudopunctillata			3v3c	21v	17v17c	27v	6v1c	2v1c	23v	3v1c	41v10c			2v	2v
P. cf *pseudopunctillata*													1v		
Elofsonella concinna															1v1c
E. aff. *concinna*								1v							1v
Polycope spp.	7c				2v9c				1v						
Undetermined, species B													1v		

Rose Bengal used for staining. Abbreviations: v, single valves; c, carapaces; f, fragments.

Table 7
Laptev Sea Ostracoda compared with published materials from other Arctic regions

Laptev Sea Ostracoda (own data)[a]	White Sea[b]	Barents Sea[c,d]						Kara Sea[d]	East Siberian Sea[d]	Chukchi Sea[d]	Greenland Sea and Scoresby Sund[e]	Western Greenland coast and eastern Canadian Arctic[c,d]	Beaufort Sea[c,d,f]
		Russian Harbour	Matochkin Shar	Franz Joseph Land	Spitzbergen fjords	Easten–Central Barents Sea	Norwegian–Barents Sea						
Bythocythere constricta		+			+		+	+			+		+
Pseudocythere caudata				+			+	+			+	+	
Sclerochilus contortus	+	+		+			+	+		+		+	+
Jonesia acuminata												+	
Roundstonia macchesneyi		+						+					+
Cluthia cluthae			+	+	+						+	+	+
Cytheropteron arcuatum								+	+		+	+	+
C. biconvexa													+
C. champlainum													+
C. elaeni							+	+		+		+	+
C. inflatum								+			+	+	+
C. inornatum													
C. montrosiense					+				+		+		+
C. nodosoalatum		+		+			+	+		+			+
C. porterae											+		
C. simplex								+			+		+
C. sulense													+
C. suzdalskyi													+
C. testudo							+				+		
Semicytherura complanata										+			+
Palmenella limicola		+	+	+				+		+		+	+
Acanthocythereis dunelmensis	+	+	+	+	+			+	+	+		+	+
Rabilimis septentrionalis	+	+	+	+				+				+	+
Heterocyprideis sorbyana	+	+		+	+		+	+	+	+		+	+
H. fascis							+						+
Sarsicytheridea bradii	+	+	+	+		+	+	+		+		+	+
S. punctillata	+	+	+	+	+	+	+	+				+	+
Paracyprideis pseudopunctillata									+				+
Krithe glacialis											+		+
K. minima											+		
Argilloecia cylindrica											+		
Elofsonella concinna					+		+					+	+
Eucythere argus													+
Polycope bireticulata											+		
P. orbicularis				+							+		
P. punctata											+		
Robertsonites tuberculatus[a]		+	+	+	+	+							+
Roundstonia globulifera[a]		+			+			+					+
Elofsonella neoconcinna[a]										+			+
Semicytherura affinis[a]		+					+	+					+

Table 7 (*Continued*).

Laptev Sea Ostracoda (own data)[a]	White Sea[b]	Barents Sea[c,d]						Kara Sea[d]	East Siberian Sea[d]	Chukchi Sea[d]	Greenland Sea and Scoresby Sund[e]	Western Greenland coast and eastern Canadian Arctic[c,d]	Beaufort Sea[c,d,f]
		Russian Harbour	Matochkin Shar	Franz Joseph Land	Spitzbergen fjords	Easten–Central Barents Sea	Norwegian–Barents Sea						
S. concentrica[a]		+			+			+					+
Cytheropteron pseudomontrosiense[a]									+				
Total number of species	24	45	9	31	46	6	59	45	10	24	61	46	~90
Number of species in common with the Laptev Sea	6	14	7	12	10	3	12	18	6	9	15	14	31
Percentage of species in common with the Laptev Sea	25	31	78	39	22	50	20	40	60	38	25	30	34
Ranges in water depths (m)	0–45	15	18–28	3–55	0–1000	100–200	192–264	223–500	21–37	41–55	274–3355	2–3065	1–1000

[a] Species not found in our samples but reported from the Laptev Sea by Cronin et al. (1991).

[b] Akatova (1957); Rudyakov (1962).

[c] Neale and Howe (1975).

[d] Cronin et al. (1991).

[e] Whatley et al. (1996, 1998).

[f] Reimnitz et al. (1993).

Neale and Howe (1975). Their investigation has shown that, in general, the shallow-water fauna forms a circumpolar province, although with certain peculiarities between the eastern and western subprovinces. Comparison of our data from the Laptev Sea with the published materials from other Arctic regions reveals similar features in the distribution of ostracods. Table 7displays the total species list of the Laptev Sea Ostracoda (our data with additions from Cronin et al., 1991) and the occurrence of these species in other Arctic (White Sea, Barents Sea, Kara Sea, East Siberian Sea, Chukchi Sea, Beaufort Sea, eastern Canadian Arctic) and high-latitude seas (Greenland Sea).

From the 24 species described from the White Sea (Akatova, 1957; Rudyakov, 1962) only six species were also found in the Laptev Sea (Table 7). While in the White Sea they were reported from the shallow nearshore area with an average bottom water salinity of 20–26 (Doronin, 1986), these ostracods are abundant all over the Laptev Sea and are typical representatives of the shallow inner shelf environments. However, they reach their maximum quantitative abundance in the deep-sea assemblage of the western–central Laptev Sea (salinity 33–34).

Recent ostracod assemblages from Novaya Zemlya in the Barents Sea were described in detail by Neale and Howe (1975). These authors also summarised the data from Matochkin Shar (Novaya Zemlya), near Franz Joseph Land, Spitzbergen, the eastern–central Barents Sea and the Norwegian–Barents Sea area. Additional data are available from the MAPD (Cronin et al., 1991). The number of Barents Sea species in common with the Laptev Sea ranges between 4 and 15 (Table 7). In the Laptev Sea most of them occur in shallow-water assemblages. As a whole, the Barents Sea ostracod fauna is considerably more diverse than the Laptev Sea one. This may result from more favourable environmental conditions in the Barents Sea due to a stronger influence of Atlantic water.

Only scattered data on the Kara Sea ostracods are available (Cronin et al., 1991). All the studied samples originate from the relatively deep areas of this sea (> 223 m). This is the reason why among species in common with the Laptev Sea most belong to the group of relatively deep-living species found in the western–central Laptev Sea (Table 7).

Just as for the Kara Sea, the data on the East Siberian Sea ostracods are given by Cronin et al. (1991). The data on ostracods are non-representative, because most of the samples contain only one to three valves, and only two samples out of a total of nine included more than 30 valves.

From five samples recovered from the Chukchi Sea Cronin et al. (1991) identified 24 species of which nine are also found in the Laptev Sea (Table 7). Most of them are typical representatives of the ostracod assemblages from the eastern and southern Laptev Sea.

Whatley et al. (1996, 1998) list 61 species from the Greenland Sea and Scoresby Sund fjord system. Some of these species occasionally also occur in samples from the deep western and central Laptev Sea area associated with Atlantic waters.

Neale and Howe (1975) describe Recent ostracods collected in fjords from the Western Greenland coast and Eastern Canadian Arctic. This rather diverse fauna does not have much in common with the assemblages from the Laptev Sea (Table 7). In the western Greenland coastal area, all species that are also found in the Laptev Sea, are extremely rare and occur at shallow-water locations.

Ostracods of the Beaufort Sea have been studied in great detail. Neale and Howe (1975) describe ostracods from the Colville River delta that represent a very typical shallow-water assemblage. It is very similar to the southern Laptev Sea inner shelf assemblage and consists of shallow-water euryhaline species (Table 7). Reimnitz et al. (1993) give a list of 13 ostracods entrained by sea ice from the shallow middle shelf of the Beaufort Sea. Nine of these species were identified in the Laptev Sea (Table 7). As noted above, this assemblage is very similar to that from the eastern Laptev Sea shelf, where the polynya forms during wintertime. Cronin et al. (1991) analysed more than 300 samples from the Beaufort Sea obtained from water depths ranging between 1 and more than 1000 m. Nearly all species (>90) listed in the MAPD (Cronin et al., 1991) occur in the Beaufort Sea, 34 of them are in common with the Laptev Sea. Thus, nearly all species found in the Laptev Sea are also present in the Beaufort Sea, with the exception of some rare deep-living species of mainly North Atlantic origin (*Pseudocythere caudata*, *Cytheropteron testudo*, *C. porterae*).

Based on the comparisons above, it can be concluded that the Laptev Sea ostracod assemblages form a link between the western Arctic assemblages, affected by North Atlantic waters, and shallow-water assemblages also known from the Alaskan coast. Although many species occur throughout all Arctic seas, their abundance, combination of species in certain assemblages and presence of indicator species allow to distinguish between two geographically different assemblage groups in the Laptev Sea. The most characteristic feature of the western and central Laptev Sea is the presence of relatively deep-living species with clear affinities to the North Atlantic and the Arctic Ocean. On the other hand, due to similar environmental conditions (considerable river discharge, ice coverage, existence of polynya and ice-rafting), ostracod assemblages from the southern and eastern Laptev Sea have many species in common with the inner and middle shelf assemblages of the Beaufort Sea.

6. Conclusions

We have investigated Recent ostracods from surface samples of the Laptev Sea shelf and upper slope in an attempt to provide a more complete list of species from an area which thusfar has remained practically unstudied in terms of its ostracod fauna. Moreover, the spatial distribution patterns of ostracods in relation to different environmental parameters were evaluated.

The recognised ostracod fauna consists of a total of 41 species, of which 35 were identified to species level. Three different assemblages were established according to their water depth. The western–central assemblage from the upper continental slope, related to Atlantic waters, is the richest in specimens abundance and diversity. It includes deep-living species that are absent in the shallow eastern and southern shelf regions.

The western–central assemblage exhibits the closest affinity to the North Atlantic and Arctic Ocean faunas (*Cytheropteron biconvexa*, *C. testudo*, *C. simplex*, *C. nodosoalatum*, *C. inflatum*, *C. porterae*, *Krithe glacialis*, *K. minima*, *Pseudocythere caudata*, *Polycope punctata*, *P. orbicularis*). The eastern shelf region is occupied by the *Acanthocythereis dunelmensis* assemblage consisting of several shallow, normal-marine species. This assemblage occurs in the region where a flaw polynya forms during winter season. Since ostracods of the middle shelf area were shown to be entrained into sea ice, some species of this assemblage may be involved into distant drift-ice transportation. The southern inner shelf assemblage is dominated by shallow-water euryhaline species (*Paracyprideis pseudopunctillata* and *Heterocyprideis sorbyana*) with admixture of the brackish-water species *Roundstonia macchesneyi*.

Thus, the distribution of recent ostracods over the Laptev Sea shelf and upper continental slope appears to be mainly dependent upon water depth, salinity variations and water-mass distribution. The presence of shallow-water species on the upper continental slope points to sea-ice transportation as an important mechanism of Arctic-wide distribution of ostracods. The high abundance of live specimens of shallow-water ostracods (*Rabilimis septentrionalis*, *Heterocyprideis sorbyana*, *Paracyprideis pseudopunctillata*) in the relatively deep western and central Laptev Sea regions probably indicates the ability of these species to survive ice-rafting.

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