Fauna associated with detached kelp in different types of subtidal habitats of the White Sea

Article *in* Hydrobiologia · October 1997

DOI: 10.1023/A:1003098616811

Hydrobiologia **355:** 91–100, 1997.
A. D. Naumov, H. Hummel, A. A. Sukhotin & J. S. Ryland (eds), *Interactions and Adaptation Strategies of Marine Organisms.*

Fauna associated with detached kelp in different types of subtidal habitats of the White Sea

A. B. Tzetlin[1], V. O. Mokievsky[3], A. N. Melnikov[1], M. V. Saphonov[2], T. G. Simdyanov[1] & I. E. Ivanov[1]
[1] *Department of Invertebrate Zoology, Moscow State University, 119899, Vorobievy Gory, Moscow, Russia*
[2] *White Sea Biological Station, Moscow State University*
[3] *Shirshow Institute of Oceanology, Moscow*

Key words: kelp decomposition, White Sea, benthic communities, sea urchins, cyanobacteria

Abstract

The fauna, associated with Laminaria and other large brown macroalgae was studied by using SCUBA and dredging in two different types of underwater habitats of the White Sea.

In shallow water fjords and bays, with a depth of no more than 30–40 m, detached kelp (mainly *Laminaria saccharina*, *L. digitata* and *Alaria esculenta*) formed large accumulations. One of these benthic accumulations, which has existed more than 20 years, was studied. It covers about 2000 m^2, and is about 2 m thick. The upper layer of the accumulation of fronds is characterized by high turbulence and is well aerated. The lower layer is characterized by anoxic conditions. Mats of sulphur bacteria were not observed, although fronds in the middle layer were covered by layers of cyanobacteria. About 50 species of macroinvertebrates were found, mainly species that are normally associated with living kelp, such as the detritivorous species *Ophiura robusta* and *Gammarus oceanicus*, and few species that are specific inhabitants of organic-rich biotopes in the White Sea such as *Capitella capitata*, *Ophryotrocha irinae* and *Nebalia bipes*. It was remarkable that in the shallow water basins of the White Sea, the process of decomposition of brown algae in the sublittoral takes place without sea urchins, and no other macrofaunal form plays an ecological role in the mechanical breakdown of the plant substratum, even not in the large accumulations of detached kelp.

Along the open rocky shoreline, communities associated with dead detached kelp were situated at a depth of 60–90 m, 40–50 m below the belt of living kelp. In this deep zone, no macroinvertebrates typical of the kelp community in the photic zone were found. During the passage from the shoreline to the deeper benthic community, where sea urchins were dominant, all plant debris became fragmented. These deeper benthic communities appeared to be the zone for decomposition of the detached kelp.

Introduction

In waters and on rocky coasts of temperate areas large brown algae (Phaeophyta) are the dominant sublittoral macrophytes. The fronds of these algae resemble moving belts of tissue (Mann, 1972). Erosion from the senescent distal region of the algal frond is compensated for by meristematic activity at the frond base. In a single year, these fronds may replace their length up to five times (Mann, 1972), contributing large quantities of dissolved organic matter and particulate detritus to the sediments and water column. In addition to these processes, winter storms can detach large numbers of intact kelp plants (Bedford & Moore, 1984). Such plants can either be washed ashore, fuelling intertidal detritus food chains, or sink to the sea bed below the zone of brown algae.

Fauna associated with sea bed accumulations of decomposing brown algae is well studied and normally resembles the epifauna on living attached kelp with the addition of a few specialized detritivorous species. Sea urchins (Diademata), such as *Psammechinus* spp. or *Strongylocentrotus* spp. are dominant (Bedford & Moore, 1984; Breen & Mann, 1976; Ivanjushina et al., 1991)

In the sublittoral zone of the White Sea, brown algae (Phaeophyta) form well developed belts. The average wet biomass of kelp is estimated at 10–15 kg m^{-2} (Vozhinskaya, 1986). Macrofaunal invertebrates associated with kelp in the sublittoral zone of the White Sea are described by Derugin (1928) and Golikov et al. (1985a). Unlike the communities associated with kelp in the boreal zone of the Pacific and Atlantic, similar communities in the White Sea are devoid of sea urchins. Although two species of Diademata are described for the White Sea, specimens of sea urchins, such as *Strongylocentrotus pallidus* which is common in the White Sea, do not live above 40–50 m because of the low salinity in the upper part of the sublittoral zone (Golikov et al., 1985a, b; Bazhin, 1995). As a result, the macrofaunal communities of shallow sea bed accumulations of detached kelp here show remarkable differences from similar ones in the North Atlantic or even with those in the neighbouring Barents Sea.

Therefore, in this study we present a first description of these communities at different types of (shallow versus deeper open) coasts of the White Sea, indicating the different interactions between habitat, macrofaunal composition, and kelp decomposition.

Material and methods

The study is based on more than twenty years of SCUBA diving observations in the vicinity of the White Sea Biological Station of Moscow State University along the Karelian Coast of the White Sea. During this period we studied the sublittoral zone along the coast of Kandalaksha Bay (Figure 1). During the two last summer seasons (1995–1996) a set of 42 qualitative samples were taken by means of SCUBA diving. Besides these samples, about one hundred hours of SCUBA underwater observations were made by the authors during these two years. Samples of living and detached kelp were taken by divers. Fronds were packed into plastic bags with a volume of 10 litres, and analysed for faunal content in the laboratory directly after transportation to the surface. In summer 1995, three quantitative samples in the accumulations of detached kelp situated at depths of 12–15 m were taken with a special sampling device, consisting of a nylon cylinder (mesh size 0.5 mm, 3 m long) with a heavy metal ring of 50 cm diameter near the opening. Divers pushed the cylinder down into the 1.5 to 2 m thick swell of kelp and cut fronds along the perimeter of the ring. After transportation to the surface, wet fronds from these samples and the total of all extracted animals were weighed. Animals were then fixed in formalin for species identification.

In the deeper areas (from 40 to 130 m) 43 benthic samples were taken by dredging with a Sigsby trawl of 1,25 m width (mesh size 1.0 mm). This zone is too deep for divers and because of the hard substrate, corers or grabs could not be used successfully for quantitative sampling.

The direction of tidal currents was measured by a Vallyport current meter of the propeller type with distant result indication. Redox values were measured by a Hanna Instrument Redox potential value tester.

Results

Open shoreline

Large brown algae *Laminaria saccharina*, *L. digitata* and *Alaria esculenta* inhabit the upper 12 m of rocky shores. A list of fauna species associated with the living Laminaria is given in Table 1. Detached thalli moved down the slope and could be found to a depth of 60–90 m (Figure 2). Here accumulations of detached kelp occurred and the associated fauna was well developed. Thirty three species of macroinvertebrates were found (Table 1, Figure 3); *Strongylocentrotus pallidus* dominated. In the deeper community it was notable that species typical for the epifaunal community of kelp in the photic zone were absent (Figure 3). Sea urchins were not found below a depth of 90 meters.

Shallow water fiords and basins

The shoreline of Kandalaksha Bay and Onega Bay is characterized by shallow water fiords and bays, with depths of 30–40 m and a salinity of 24–28‰ (Figure 2B). Specimens of sea urchins (*S. pallidus*) can be found only occasionally. In these basins, large accumulations of kelp, produced by tidal currents and local irregularities of the bottom, are typical at a depth of about 10–30 meters. One of these benthic accumulations is situated near the White Sea Biological Station of the Moscow State University (Figure 1) in the strait between Veliky Island and Cape Kindo (Figure 4).

Table 1. Macrofauna associated with kelp in the White Sea. Frequencies of species in the samples: + = rare (less then 5% of samples), ++ = frequent (5 to 50% of samples), +++ dominant (> 50%).

	Living kelp (depth 0–12 m)	Detached kelp Open shoreline (depth 60–90 m)	Detached kelp Shallow fiord/basin (depth 12–15 m)
PORIFERA			
Amphoriscus kukentali	+		
Haliclona gracilis	+		
Halichondria sitiens	+		
Polymastia mammillaris	+		
Suberites domuncula	++		
Sycon sp.	+		
CNIDARIA/Coelenterata			
Dynamaena pumila	+++		+
Lucernaria quadridentata	+++		+
Obelia longissima	+++		+
TURBELARIA			
Notoplana atomata	+++		+++
NEMERTINI			
Lineus sp.			+
PRIAPULOIDEA			
Priapulus caudatus			+
ANNELIDA			
Ampharete sp.		+	
Anobothrus gracilis	+		
Autolytus prismaticus		++	
Arenicola marina	+		
Aricidea nolani	+		
Brada granulata	++		
Bylgides sp.		++	
Capitella capitata			+++
Chaetosone setosa	+	+	
Cirratulus sp.	++		
Eteone longa	+		+
Euchone analis		+	
Eulalia viridis			+
Flabelligera affinis	+++		+
Glycera capitata	+		
Harmothoe imbricata	+++		+++
Laena abranchiata		+	
Lepidonotus squamatus			+
Myriochele oculata		+	
Neoamphitrite figulus	+++		
Nereimyra punctata	+++		+++
Nereis pelagica			+
Nicomache minor	+		

Table 1. Continued

	Living kelp (depth 0–12 m)	Detached kelp Open shoreline (depth 60–90 m)	Detached kelp Shallow fiord/basin (depth 12–15 m)
Nicomahce lumbricalis		+	
Ophelia limacina	+		
Pectinaria hyperborea		+	
Pectinaria koreni	+		+++
Pholoe minuta		++	
Phyllodoce maculata	+++		
Phyllodoce groenlandica			+++
Phyllodoce mucosa	+		
Polycirrus medusa	+	+	
Polydora quadrilobata	++		
Potamilla reniformis	+++		+
Pterocirrus finmarchica			+
Pterosyllis finmarchica	+++		
Spio cf. *filicornis*	+		
Spirorbis spirillum	+		
Syllis sp.		+	
Travisia forbesii	+		
Tubificoides benedeni	+++		
MOLLUSCA			
Admete couthouji	+		
Ariadnaria borealis	+		
Astarte crenata		+	
Ciliatocardium ciliatum	+		
Coryphella rufibranchialis			++
Coryphella verrucosa	+++		
Cryptonatica clausa	+++		
Cylichna alba	++		
Dendronotus arborescens	+		
Dendronotus robustus			+
Elliptica elliptica		+	
Epheria vincta	+++		+++
Hyatella arctica		+	
Leda pernula		+	
Lepeta caeca		+	
Littorina littorea	+++		
Macoma balthica			++
Margarites groenlandicus			+
Margarites helicinus	+		+
Musculus discors	++		+++
Mytilus edulis	+++		++
Oenopota harpularioides	+		
Portlandia arctica		+	
Testudinalia tesselata	+++		+
Tonicella marmorea		+	
Velutina velutina	+		

Table 1. Continued

	Living kelp (depth 0–12 m)	Detached kelp Open shoreline (depth 60–90 m)	Detached kelp Shallow fiord/basin (depth 12–15 m)
CRUSTACEA			
Acanthostepheia malmgteni		+++	
Amphithoe rubricata	+		+
Amphithopsis longicaudata	+		
Anonyx nugax	+		
Apherusa bispinosa			+
Apherusa tridentata			+
Caprella septentrionalis			++
Corophium bonelli	+++		+++
Diastylis glabra	+		
Eualus gaimardi	+	+	+
Gammarellus homari			+
Gammarus oceanicus			+++
Haligradia fulvocinatus	+++		
Hyas araneus	+		+++
Ischyrocerus anguipes	+		
Lamprops fuscata	+		
Lysianassidae gen. sp.	+		
Monoculoides borealis	++		
Munna fabricii	+++		+
Mysis oculata	+		
Nebalia bipes			+++
Oediceridae g. spp.		+	
Orchomenella minuta	+		
Paroediceros sp.		+	
Paroediceros lynceus	++		
Pleustes panoplus			+++
Pleustidae g.sp.		+	
Praunus inermis			+
Rhachotropis aculeata		+++	
Sabinea sp.		+	
Sclerocrangon boreas		+++	
Spirontocaris turgida	+		
Unciola planipes			+
PANTOPODA			
Nymphon mixtum	+		
Phoxichilidium femoratum	+++		+++
Pseudopolene spinipes			+
ECHINODERMATA			
Asterias rubens	+++		+++
Ophiacanta bidentata		+	
Ophiopholis aculeata			+
Ophiura robusta	+	+++	+++
Stegophiura nodosa	+		+
Strongylocentrotus pallidus		+++	
Urasterias lincki		+++	
BRACHIOPODA			
Rhynchonella psittacea		+	

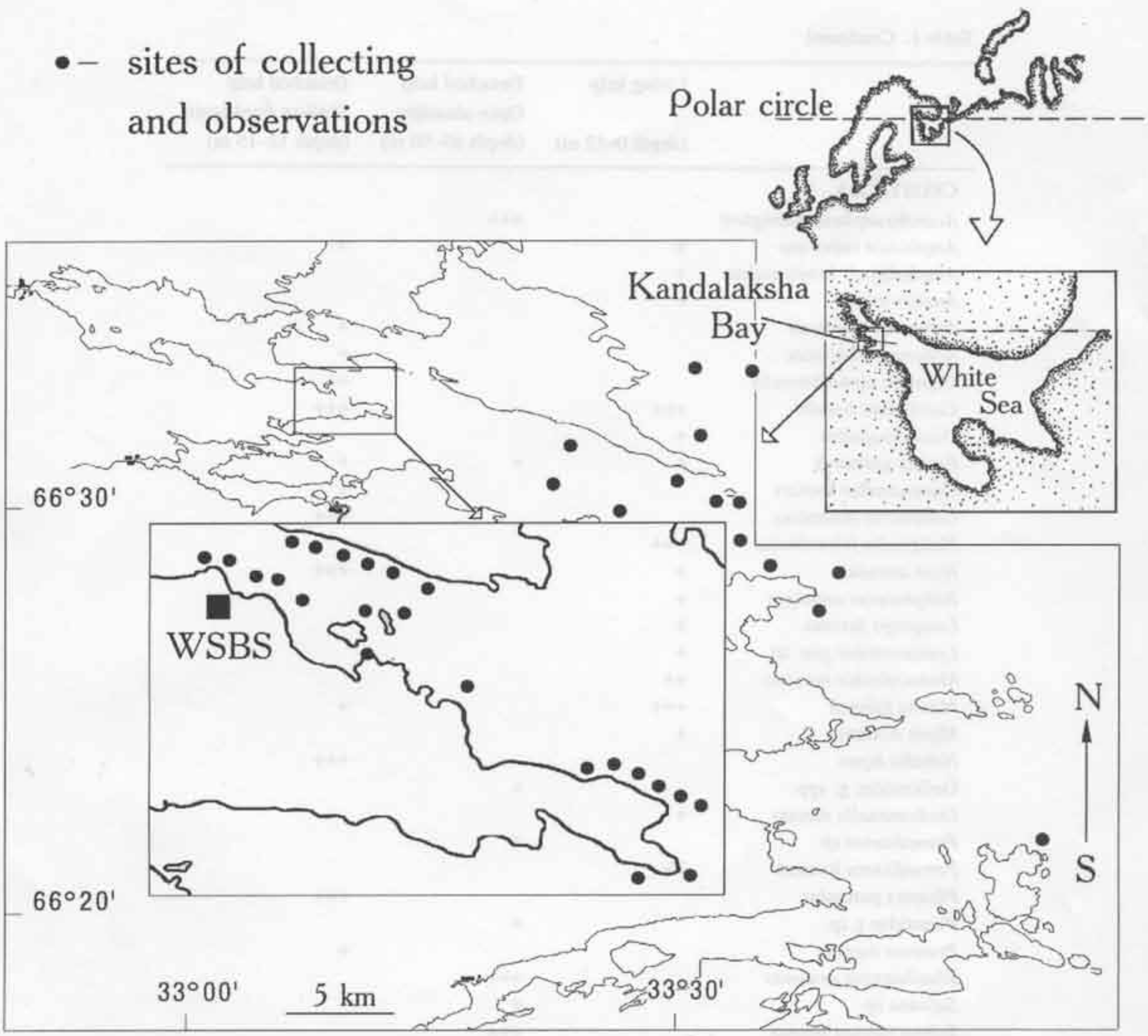

Figure 1. Sampling stations in the Kandalaksha Bay. WSBS: The White Sea Biological Station of Moscow State University.

According to our SCUBA underwater observations this accumulation has existed for at least 20 years. The accumulation (about 100 m in length, 25 m in width, and 2 m thick) is situated on the slope of the strait at a depth of 12 to 15 m, just below the zone of living kelp (Figures 4, 5). The average wet biomass of kelp in the accumulation is 90 kg m^{-2}; the total biomass of the invertebrates in the accumulations is 401,5 g m^{-2}.

Measurements of currents in the area of the accumulation showed the presence of local circulations of tidal currents and constant water upflow from greater depths (Figure 5). The accumulation appears to be formed by these currents.

The accumulation of detached kelp consisted of three layers without distinctive borders (Figure 6). The upper layer, formed by fresh and in most cases living fronds, was 1 to 1.5 m thick and well aerated (Eh = +45). The middle layer (about 20 cm thick) was anoxic (Eh = −131 to −345) and consisted of small pieces of fronds covered by layers of cyanobacteria. Seventeen species of cyanobacteria were found in this layer (Table 2). The lower layer was anoxic (Eh = −345 to −360) with a strong smell of hydrogensulfide. This layer was black with semi-liquid organic matter and remains of kelp stalks. Its thickness was difficult to define, but in all cases it was more than 0.7 m. Coverage by cyanobacteria was not found in the lower layer.

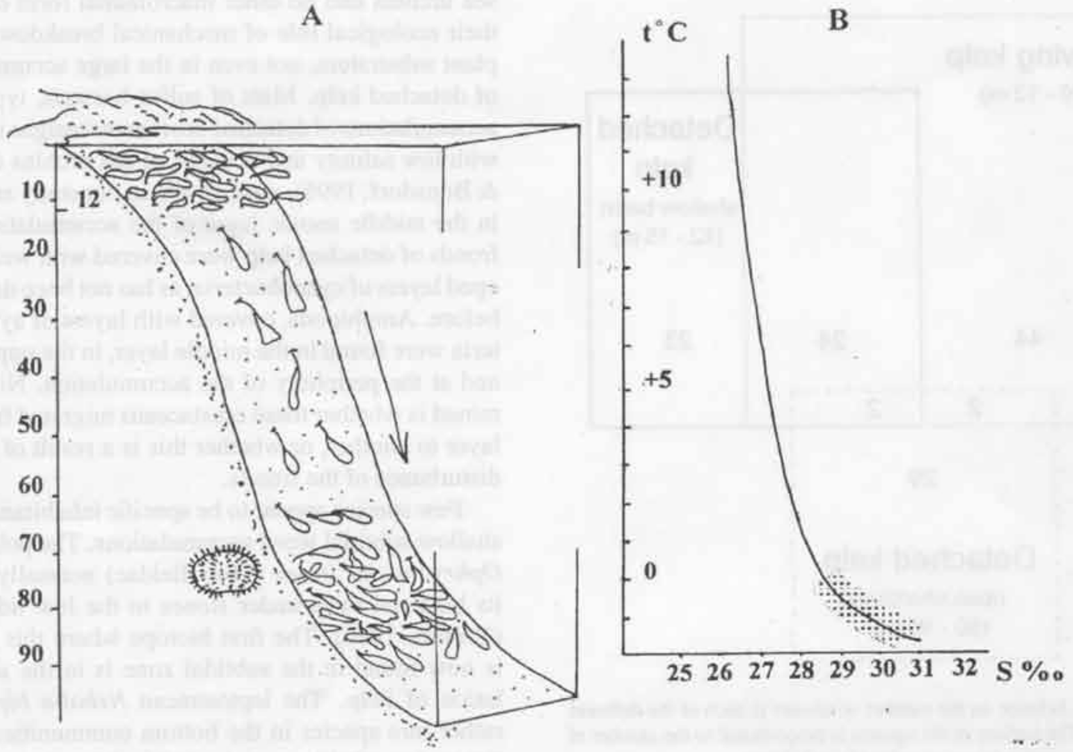

Figure 2. Scheme of the open shoreline in the White Sea. A. Localization of communities, associated with (detached) kelp on the slope. B. Average position of near bottom TS curves during the summer (after Pantulin, 1990). The dotted area is the zone inhabited by *Strongylocentrotus pallidus*.

Mineral particles were practically absent in this layer. Mats of sulfur bacteria were found neither in the middle nor in the lower layers of the accumulation.

Form and borders of the weed accumulation were different every day because its border lines could move several meters, and fronds of *Laminaria* and other large brown algae in the upper aerated layer were constantly mixed. The intensity of these processes is so high, that several attempts to estimate the rate of new algae sedimentation failed. For this estimation, part of the accumulation (about 20 m^2) was covered by nylon net, but moving algae carried the net away together with anchors inside it.

In the accumulation 49 macroinvertebrate species were found (Table 1) Several of them were typical inhabitants of living and attached kelp communities (Table 1, Figure 3), probably transported to the accumulation together with the substrata. Detritivorous species, such as *Ophiura robusta* and *Gammarus oceanicus*, were abundant. The surface of fronds, covered by cyanobacteria in the middle layer, was mainly inhabited by mobile fauna, such as the amphipods *Gammarus oceanicus* and *Pleustes panoplus*. Crustaceans in this zone were also covered by layers of cyanobacteria. Crustaceans, covered by layers of cyanobacteria, could be found not only in the mid-layer, but also in the upper one. At the border of the upper and lower layer numerous crabs (*Hyas araneus)* were present.

Gastropods, polychaetes and *Ophiura robusta* were practically absent in the middle layer of the accumulation. Species, typical for organic-rich substrata, such as *Capitella capitata, Ophryotrocha irinae* and *Nebalia bipes*, inhabited the periphery of the accumulation and did not enter the mass of kelp. Information on the distribution of meiofauna through the accumulation was limited, but the middle layer was inhabited by a single species of nematodes *Monchystea* cf. *disjuncta*. Neither macrofaunal nor meiofaunal animals were found in the lower layer.

Discussion

In the shallow basins of the White Sea, the decomposition of brown algae in the sublittoral proceeded without

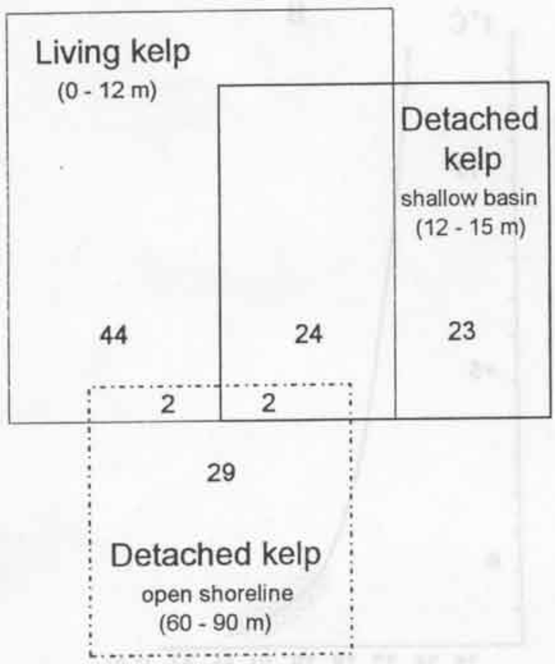

Figure 3. Scheme on the number of species in each of the different habitats. The surface of the squares is proportional to the number of species occurring in one or more of the habitats.

Table 2. Cyanobacteria found on the surface of fronds in the middle layer of the accumulation of detached kelp at a depth of 12 to 15 m in the shallow water strait near the White Sea Biological Sation of the Moscow State University.

Calothrix sp.
Lingbya nordgaardi Wille
L. holdenii Forti
L. infisa Fremy
L. perelegans Lemmermann
Oscillatoria pulchra Lindstrom
O. subuliformis Kutzing
Phoemidium crossbyanum Tilden
Ph. ectocarpi Gomont
Ph. endoliticum Ercegegovic
Ph. hoemoides Setchell et Gardner
Ph. laysanense Lemmermann
Ph. minimum Lindstrom
Ph. mycoudeum Fremy
Ph. papyraceum (Agardh) Gomont
Ph. subsalsum Gomont
Symphoca hydneides Kutzing

sea urchins and no other macrofaunal form occupied their ecological role of mechanical breakdown of the plant substratum, not even in the large accumulations of detached kelp. Mats of sulfur bacteria, typical for accumulations of detached brown macroalgae in waters with low salinity and absence of sea urchins (Norkko & Bonsdorf, 1996), were absent in our study area. Yet, in the middle anoxic layer of the accumulations, the fronds of detached kelp were covered with well developed layers of cyanobacteria, as has not been described before. Amphipods, covered with layers of cyanobacteria were found in the middle layer, in the upper layer and at the periphery of the accumulation. Not determined is whether these crustaceans migrated from one layer to another, or whether this is a result of general disturbance of the fronds.

Few species appear to be specific inhabitants of the shallow subtidal weed accumulations. The polychaete *Ophryotrocha irinae* (Dorvilleidae) normally inhabits bacterial mats under stones in the low tidal zone (Tzetlin, 1980). The first biotope where this species is now found in the subtidal zone is in the accumulation of kelp. The leptostracan *Nebalia bipes* is a rather rare species in the bottom communities of the White Sea (Golikov et al., 1985a, b) and seems also to be associated here with subtidal weed beds. The nematode *Mochistera* cf.*disjuncta* belongs to the small group that inhabits organic-rich substrata in tidal and subtidal areas (Riemann, 1995). They are also found in gelatinous phytodetritus aggregations, which follow the phytoplanktonic spring bloom at depths of 4000 m in the mid-oceanic region of the north-eastern Atlantic (Riemann, 1995).

Along the open rocky shoreline, communities, associated with dead detached kelp, are situated at a depth of 60–90 m, being 40–50 meters below the belt of living kelp. During the passage through the zone with sea urchins all plant debris becomes fragmentated. In the deep basin of the White sea only detritus particles were found, and no pieces of algae (Nevessky et al., 1977). Previously, Golikov et al. (1985a, b) found high densities of *S. pallidus* along the south-east part of the Karelian Coast and in the open part of Onega Bay at the same depth of 60–90 m. So, along the open shoreline, the zone of the benthic community, situated at a depth of 60–90 m where sea urchins were dominant, appears to be the zone of decomposition of detached kelp. It is difficult to estimate how many species, which were found in the samples from this zone, are really associated with the detached kelp communities. The collected data are based only on samples taken by trawl. Most of

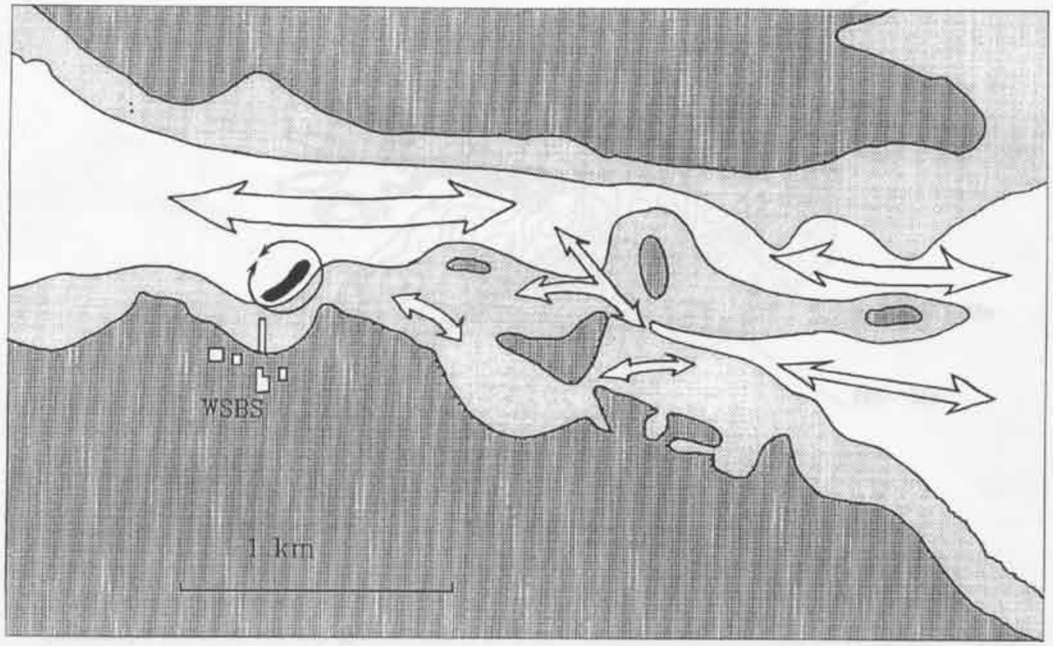

Figure 4. Position of the studied accumulation of detached kelp near the White Sea Biological Station of Moscow State University. The dark dotted area is the coast of Cape Kindo, Island Veliky, and some little islands; the light dotted area is the zone occupied by living kelp, the black area is the position of the accumulation of detached kelp. Thick arrows indicate the main streams of tidal currents in the strait between Cape Kindo and Island Veliky, small arrows indicate local circulation.

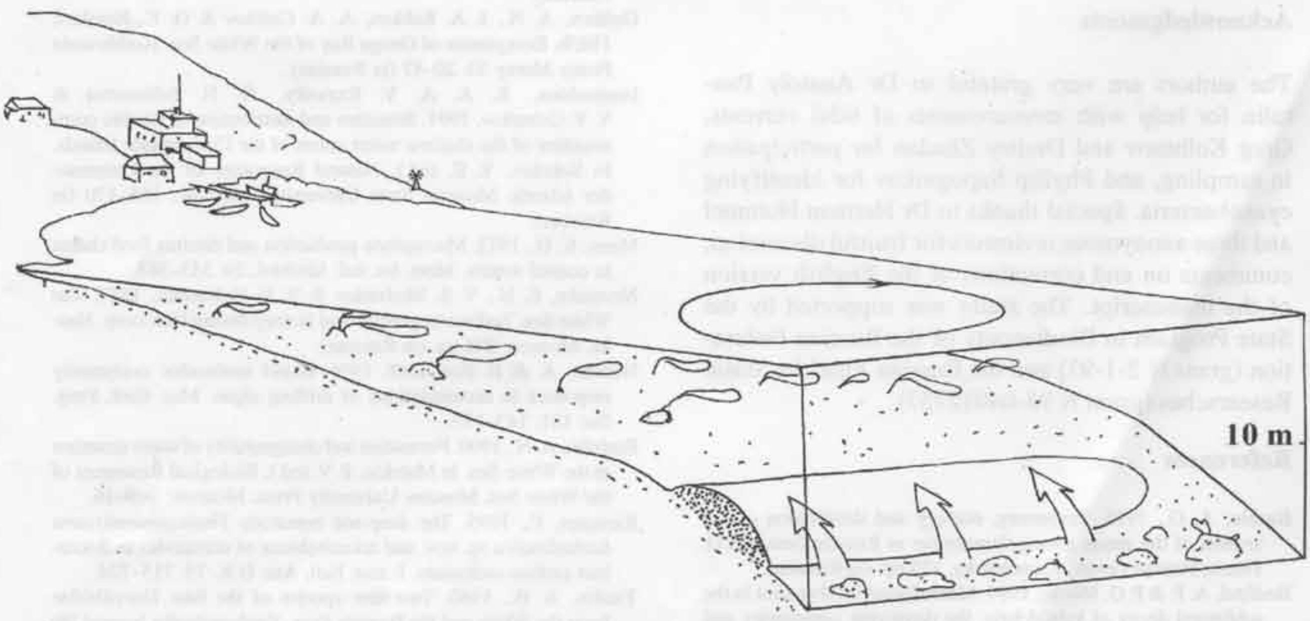

Figure 5. General appearance of the benthic accumulation of detached kelp. Only half of the accumulation is shown. Thick arrows show the water flow coming up from large depths; small arrows indicate the position of the local circulation of tidal currents.

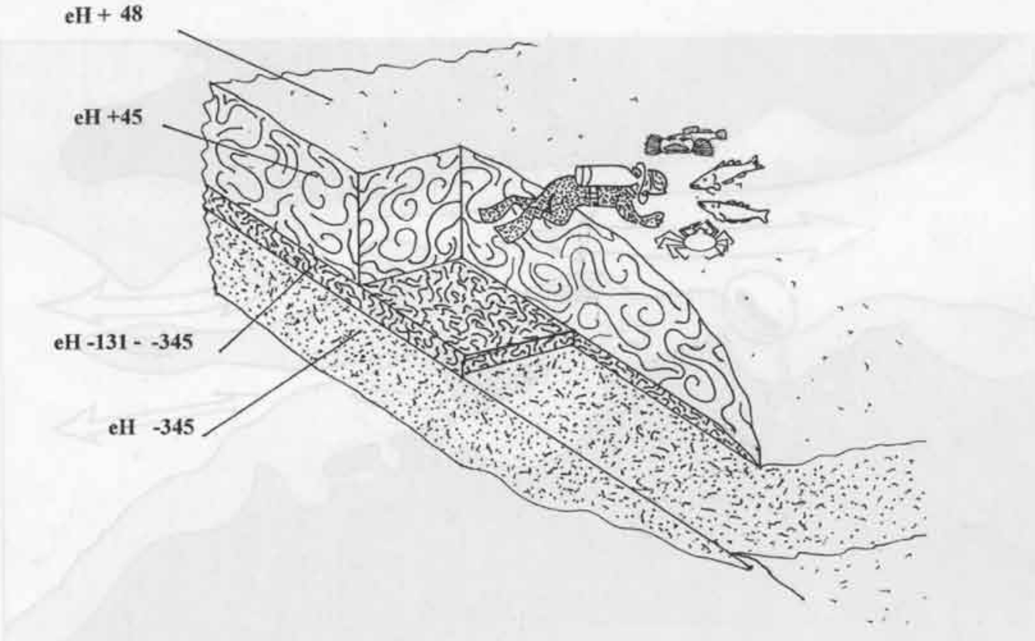

Figure 6. Scheme for the structure of the benthic accumulation of detached kelp (see text for further explanation).

the species found are inhabitants not only of detached kelp but also of different biotopes at the slope, and non of the species, except some eurybiotic species, inhabit the belt of living kelp.

Acknowledgments

The authors are very grateful to Dr Anatoly Pantulin for help with measurements of tidal currents, Greg Kolbasov and Dmitry Zhadan for participation in sampling, and Phyllip Sapognikov for identifying cyanobacteria. Special thanks to Dr Herman Hummel and three anonymous reviewers for fruitful discussion, comments on and corrections of the English version of the manuscript. The study was supported by the State Program in Biodiversity of the Russian Federation (grant N 2-1-93) and the Russian Fund for Basic Researsches (grant N 95-04012737).

References

Bazhin, A. G., 1995. Taxonomy, ecology and distribution of sea urchins of the genus *Strongylocentrotus* in Russian Seas. Ph.D. Thesis, Petropavlovsk, Kamchatsky, 125 pp. (in Russian).

Bedford, A. P. & P. G. Moore, 1984. Macrofaunal involvement in the sublittoral decay of kelp debris: the detritivore community and species interactions. Estuar. coast. Shelf Sci. 18: 97–111.

Breen, P. A. & K. H. Mann, 1976. Destructive grazing of kelp by sea urshins in Eastern Canada. J. Fish. Res. Bd Can. 33: 1278–1283.

Derugin, K. M., 1928. Fauna of the White Sea and condition of its existence. Isseldovania Morey 7–8, 511 pp. (in Russian).

Golikov, A. N., O. A. Skarlato, V. V. Galtsova & T. V. Menshutkina, 1985a. Ecosystems of the Chupa Bay of the White Sea and their seasonal dynamics. Isseldovania Fauny Morey 31: 5–83 (in Russian).

Golikov, A. N., I. A. Babkov, A. A. Golikov & O. K. Novikov, 1985b. Ecosystems of Onega Bay of the White Sea. Isseldovania Fauny Morey 33: 20–87 (in Russian).

Ivanjushina, E. A, A. V. Rzawsky, O. N. Selivanova & V. V. Oshurkov, 1991. Structure and distribution of benthic communities of the shallow water zones of the Commander Islands. In Sokolov, V. E. (ed.), Natural Resources of the Commandor Islands. Moscow State University, Moscow: 155–170 (in Russian).

Mann, K. H., 1972. Macrophyte production and detritus food chains in coastal waters. Mem. Ist. ital. Idrobiol. 29: 353–383.

Nevessky, E. N., V. S. Medvedev & V. V. Kalinenko, 1977. The White Sea. Sedimentogenesis and history during Holocene. Nauka, Moscow, 236 pp. (in Russian).

Norkko, A. & E. Bonsdorff, 1996. Rapid zoobenthic community responses to accumulations of drifting algae. Mar. Ecol. Prog. Ser. 131: 143–157.

Pantulin, A. N., 1990. Formation and changeability of water structure in the White Sea. In Matekin, P. V. (ed.), Biological Resources of the White Sea. Moscow University Press, Moscow: 7: 9–16.

Riemann, F., 1995. The deep-sea nematode *Thalassomonhystera bathislandica* sp. nov. and microhabitats of nematodes in flocculent surface sediments. J. mar. biol. Ass. U.K. 75: 715–724.

Tzetlin, A. B., 1980. Two new species of the fam. Dorvilleidae from the White and the Barents Seas. Zoologichesky Journal 59: 1817–1822 (in Russian).

Vozhinskaya, V. B., 1986. Bottom Macrophytes of the White Sea. Nauka, Moscow, 191 pp.