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A SURVEY OF DATA PUBLISHED ON THE LITTORAL ZOOBENTHOS OF THE GULF OF RIGA

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Abstract. This paper compiles available literature on the macrozoobenthos and nectobenthos (especially mysids) of the Gulf of Riga. Although emphasis is placed on the recent works, some historically important surveys are also cited. The following information is provided: list of species in the area, maps of abundance and biomass distribution, sensitivity of the communities to pollution, and population dynamics of nectobenthos.

Key words: Baltic Sea, Gulf of Riga, macrozoobenthos, nectobenthos.

INTRODUCTION

In recent years, due to the deterioration of the Baltic marine environment, a considerable research effort has been focused on the ecosystem of the Gulf of Riga. The Gulf of Riga is situated in the easternmost part of the Baltic Sea and it ranks among the most eutrophic regions of the Baltic.

Numerous papers dealing with the communities of the Gulf of Riga were written in Russian. Today, at the dawn of scientific co-operation between the East and the West, a necessity to compile the accumulated knowledge into an English article has arisen.

No concise publication is available about the macrozoobenthos of the Gulf of Riga. Up to now only Laganovskaya & Kachalova (1990) have dealt with the hydrobiological research in the Gulf of Riga.

Here we try to give a survey of the existing knowledge on the macrozoobenthic and nectobenthic communities of the region. The following topics are discussed: species composition, abundance and biomass distribution, pollution and eutrophication impacts.

MACROZOOBENTHOS

Species composition

The first published record on macrozoobenthic species (molluscs) in the Gulf of Riga dates from 1819 (F. S. B., 1819). Since then attention has been primarily focused on the taxonomic composition and distribution of macrozoobenthos. Järvekülg (Yarvekyulg, 1979b) concluded that the macrofauna in the Gulf of Riga is characterized by a small number of species due to low salinity and uniformity of habitat, especially in the southern part of the gulf. More than 50% of the gulf is occupied by the *Macoma balthica* association or that of *Cerastoderma lamarcki*, *Mya arenaria*, and *Macoma balthica*. Freshwater species may be very abundant in the photic zone of the gulf.

Yarvekyulg (1979b) found 139 zoobenthic species in the Gulf of Riga. Other authors (Shurin, 1953; Kachalova, 1974b; Lagzdinsh, 1975) added *Unio* sp., *Gammarus locusta*, *Calliopius laeviusculus*, and *Nemertini* (*Prostoma obscurum*). Recently Lagzdinsh & Pallo (1994) reported on the colonization of an alien polychaete species *Marenzelleria viridis* into the southern part of the gulf. Turbellarians were found in the northern part of the Gulf of Riga (I. Kotta, pers. comm.).

In addition, the following papers contain information on the taxonomic composition of zoobenthos: in the **whole gulf** – Shurin, 1960; Yarvekyulg, 1975; the **southern part of the gulf** – Kachalova & Lagzdinsh, 1974, 1982; Lagzdinsh & Saule, 1983; the **northern part of the gulf** – Järvekülg, 1960; Kotta, 1980, 1995. A list of all macrozoobenthic taxa found in the Gulf of Riga is presented below.

List of zoobenthic species in the Gulf of Riga by Shurin (1953), Kachalova (1974b), Lagzdinsh (1975), Lagzdinsh & Pallo (1994), and Yarvekyulg (1979b)

Ph. Cnidaria
Cl. Hydrozoa
Chlorohydra viridissima (Pallas)
Laomeda loveni (Allman)
L. flexuosa Alder
Ph. Priapulida
Halicryptus spinulosus (Siebold)
Ph. Annelida
Cl. Polychaeta
Nereis diversicolor (O. F. Müller)
Pygospio elegans Claparède
Manayunkia aestuarina (Bourne)
Fabricia sabella (Ehrenberg)
Marenzelleria viridis (Verrill)
Cl. Oligochaeta
Stylaria lacustris (L.)

Nais elinguis O. F. Müller
Paranais litoralis (O. F. Müller)
P. frici Hrabě
Clitellio arenarius (O.F. Müller)
Limnodriloides prostatus (Knöllner)
Limnodrilus hoffmeisteri Claparède
Euilyodrilus hammoniensis (Michaelsen)
E. bavaricus (Oeschmann)
Psammoryces barbatus (Grube)
Tubifex costatus (Claparède)
Peloscolex heterochaetus (Michaelsen)
P. benedeni (d`Udekem)
Cl. Hirudinea
Piscicola geometra (L.)
Ph. Nemertini
Ph. Arthropoda
Cl. Crustacea
O. Copepoda
Caligus lacustris Steenst. et Lütke
Eucyclops macruroides (Lilljeborg)
Paracyclops fimbriatus (Fischer)
Nitocra spinipes Boeck
Mesochora rapiens (Schmeil)
Nannopus palustris Brady
Laophonte mohammed Blanch. et Rich.
Tachidius discipes Giesbrecht
Ectinosoma curticorne Boeck
O. Ostracoda
Candona neglecta Sars
C. angulata G. W. Müller
C. compressa (Koch) Brady
C. protzi Hartwig
Cyclocypris ovum (Jurine) G. W. Müller
Ilyocypris biplicata (Koch)
Heterocypris salina (Brady)
C. aculeata (Costa)
Limnocythere inopinta (Baird)
Cyprideis torosa (Jones)
Heterocyprideis sorbyana (Jones)
Paracyprideis fennica (Hirschm.)
Hirschmannia viridis (O. F. Müller)
L. lacertosa (Hirschm.)
Cytheromorpha fuscata (Brady)
Cytherura gibba (O. F. Müller)
C. nigrescens (Baird)
Xestoleberis aurantia (Baird)
O. Branchiura
Argulus foliaceus (L.)
O. Cirripedia
Balanus improvisus Darwin
O. Isopoda
Idotea balthica (Pallas)

I. viridis (Slabber)
Saduria entomon (L.)
Jaera albifrons Leach
Asellus aquaticus (L.)
Monoporeia affinis Lindström
Pontoporeia femorata Kröyer
Galliopius laevisculus (Kröyer)
Bathyporeia pilosa Lindström
Gammarus oceanicus Segerstråle
G. locusta Sars
G. salinus Spooner
G. zaddachi Sexton et Spooner
G. duebeni Lilljeborg
Leptocheirus pilosus Zaddach
Corophium volutator (Pallas)
O. Mysidacea
Mysis relicta Lovén
M. mixta Lilljeborg
Praunus flexuosus (O. F. Müller)
P. inermis (Rathke)
Neomysis integer (Leach)
O. Decapoda
Palaemon adsperus (Rathke)
Crangon crangon (L.)
Cl. Arachnida
Halacarus balticus Lohmann
H. basteri (Johnston)
Lohmanella falcata (Hodge)
Cl. Insecta
O. Lepidoptera
Acentropus niveus (Oliver)
O. Heteroptera
Corixa striata L.
Notonecta sp.
O. Coleoptera
Haliplus confinis Stephens
H. immaculatus Gerh.
Dytiscus sp.
Gyrinus substriatus Stephens
O. Diptera
Procladius Skuze
Clunio marinus Haldiv
Cricotopus ex gr. *algarum* Kieffer
C. biformis Edwards
C. latidentatus Tschern.
C. ex gr. *sylvestris* (Fabricius)
Orthocladius consobrinus (Holmgren)
O. ex gr. *saxicola* Kieffer
Psectrocladius ex gr. *psilopterus* Kieffer
P. simulans Johannsen
Chironomus annularius (Meigen)
Ch. f. l. *bathophilus* Kieffer

Ch. f. l. *halophilus* Kieffer
Ch. f. l. *plumosus* (L.)
Ch. f. l. *salinarius* Kieffer
Cryptochironomus ex gr. *anomalus* Kieffer
C. ex gr. *conjungens* Kieffer
C. ex gr. *defectus* Kieffer
C. ex gr. *viridulus* Fabricius
Einfeldia ex gr. *pagana* Meigen
Endochirionomus ex gr. *tendens* (Fabricius)
Halliella ex gr. *taurica* Tschern.
Limnochironomus ex gr. *nervosus* (Staeger)
L. ex gr. *tritomus* Kieffer
Polypedilum breviantennatum Tschern.
P. ex gr. *scalaenum* (Schrank)
Pseudochironomus ex gr. *prasinatus* Staeger
Stictochironomus ex gr. *histrio* (Fabricius)
Micropsetctra ex gr. *praecox* Meigen
Tanytarsus ex gr. *gregarius* Kieffer
T. ex gr. *mancus* v. d. Wulp
T. ex gr. *mancus* No 2 Zvereva
T. ex gr. *lauterborni* Kieffer
Culicoides sp.
Ph. Mollusca
Cl. Gastropoda
Theodoxus fluviatilis (L.)
Viviparus contectus (Millet)
Valvata piscinalis (O. F. Müller)
V. cristata O. F. Müller
Bithynia tentaculata (L.)
Hydrobia ulvae (Pennant)
H. ventrosa (Montagu)
Potamopyrgus jenkinsi (Smith)
Lymnaea stagnalis (L.)
L. palustris (O. F. Müller)
L. peregra (O. F. Müller)
L. auricularia (L.)
Planorbis planorbis (L.)
Planorbarius corneus (L.)
Embletonia pallida (Alder et Hanc.)
Cl. Bivalvia
Unio sp.
Mytilus edulis L.
Dreissena polymorpha (Pallas)
Cerastoderma lamarcki (Reeve)
Macoma balthica L.
Mya arenaria L.
Anodonta cygnea (L.)
Sphaerium corneum (L.)
Ph. Tentaculata
Cl. Bryozoa
Electra crustulenta var. *baltica* Borg
Plumatella fungosa (Pallas)

Abudance and biomass distribution

The frequencies of different zoobenthic species around the whole coast of the Gulf of Riga were estimated by Shurin (1961). Three depth levels and the areas of abundant benthic vegetation were distinguished (Table 1). Most frequent species were the bivalves *Macoma balthica*, *Cerastoderma lamarcki*, *Mya arenaria*, and *Mytilus edulis*; but also the crustaceans *Gammarus* spp. and *Idotea* spp. *Lymnaea peregra* was frequently found between 0 and 3 m; *Gammarus* spp., *Leptocheirus pilosus*, *Idotea viridis*, *Jaera albifrons*, and *Balanus improvisus* between 0 and 10 m; *Monoporeia affinis*, *Saduria entomon*, and *Corophium volutator* between 10 and 20 m.

Table 1

Frequencies (%) of macrozoobenthic species at different depths and in areas of abundant vegetation (after Shurin, 1953)

Species	0–3 m	0–10 m	10–20 m	Rich vegetation
Macoma balthica	22	43	84	–
Mytilus edulis	10	46	41	54
Cerastoderma lamarcki	14	26	13	–
Mya arenaria	+	22	12	–
Theodoxus fluviatilis	39	41	11	64
Hydrobia spp.	12	+	+	–
Bithynia tentaculata	12	+	–	–
Lymnaea peregra	32	17	+	45
Asellus aquaticus	+	+	–	–
Gammarus spp.	44	39	+	95 (27% *G. duebeni*)
Leptocheirus pilosus	22	29	–	64
Corophium volutator	–	12	19	–
Monoporeia affinis	–	+	43	–
Pontoporeia femorata	–	–	+	–
Bathyporeia pilosa	+	+	+	27
Saduria entomon	–	14	53	27
Idotea balthica	+	+	+	64
I. viridis	31	22	+	64
Jaera albifrons coll.	17	30	+	54
Crangon crangon	–	+	+	23
Halicryptus spinulosus	–	+	18	–
Balanus improvisus	34	46	25	77
Neomysis integer	51	46	+	100
Praunus flexuosus	12	11	–	45
P. inermis	10	12	+	41
Nereis diversicolor	10	14	10	23

+ designates species mentioned in the text.

Shurin (1961) estimated the total abundance and biomass of zoobenthic species at depths to 10 m. Similar calculations at depths between 0 and 20 m were made by Yarvekyulg (1970a) (Table 2). The dominant species of the region was obviously *Macoma balthica*. The selection of subdominants depended either on authors or whether abundance or biomass values were considered. According to Shurin (1961) bivalves had the highest biomass and abundance values. Yarvekyulg (1970a) added here Oligochaeta as the most abundant and *Monoporeia affinis* as a species dominating both in biomass and abundance.

Local freshwater species were prevalent in the nearshore areas (50–70%) and euryhaline marine species in the open part of the Gulf of Riga (40–60%) (Kachalova & Lagzdinsh, 1974; Yarvekyulg, 1979b).

Table 2

Mean abundance (ind m^{-2}) and biomass (g m^{-2}) of dominant zoobenthic species at depths up to 10 m (Shurin, 1961) and up to 20 m (Yarvekyulg, 1970a)

Taxa	Abundance		Biomass	
	0–10 m	0–20 m	0–10 m	0–20 m
Macoma balthica	150	602	31	15
Cerastoderma lamarcki	40	–	15	–
Mya arenaria	20	–	12	–
Mytilus edulis	62	–	8	13
Nereis diversicolor	3	–	0.3	–
Saduria entomon	2	–	0.9	–
Corophium volutator	15	–	0.1	–
Monoporeia affinis	28	587	0.1	1
Bathyporeia pilosa	11	–	3.1	–
Hydrobia spp.	6	–	0.04	–
Oligochaeta	–	410	–	–

Shurin (1953) distinguished six different communities in the Gulf of Riga. The distinction was made on the basis of most abundant species (Fig. 1). Three bivalves (*Macoma balthica*, *Cerastoderma lamarcki*, and *Mya arenaria*) inhabited the widest area of the Gulf of Riga. *Mytilus edulis* was fairly abundant on the hard substrate at depths up to 20 m (south-western and partly eastern part of the gulf), but likewise occurred sparsely on various sediment types over the whole gulf.

Based on his earlier investigation (Järvekülg, 1961, 1962; Yarvekyulg, 1961, 1962b, 1962c, 1968) Yarvekyulg (1979b) presented a generalized map of the dispersion of total biomass and abundance distribution of macrozoobenthos in

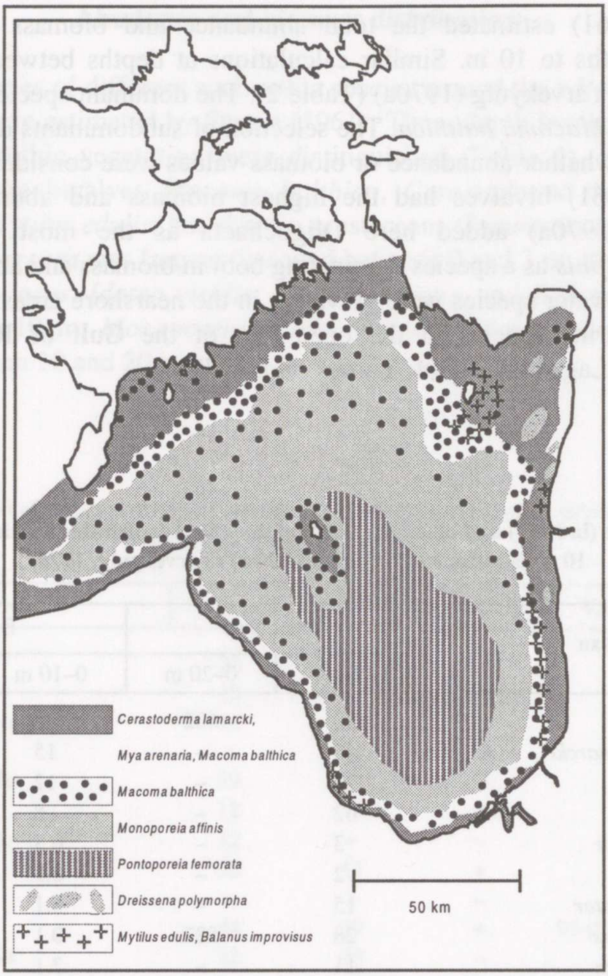

Fig. 1. The distribution of different communities of macrozoobenthos in the Gulf of Riga by Shurin (1953).

the Gulf of Riga and in the aquatory of the Väinameri (Figs. 2 and 3). The highest abundances were found in the southern part of the gulf and the highest biomasses in Pärnu Bay, near Muhu Island, and in the south-western part of the gulf. The same author (Yarvekyulg, 1970a) explained why the density of zoobenthos was lower in the southern part of the Gulf of Riga than in other regions. First, unstable sediments coupled with intensive currents and wave action make the colonization of *Mya arenaria* and *Cerastoderma lamarcki* difficult; secondly, lack of hard substrate, i.e. unfavourable conditions for *Mytilus edulis* and *Balanus improvisus*; and, finally, poor bottom vegetation.

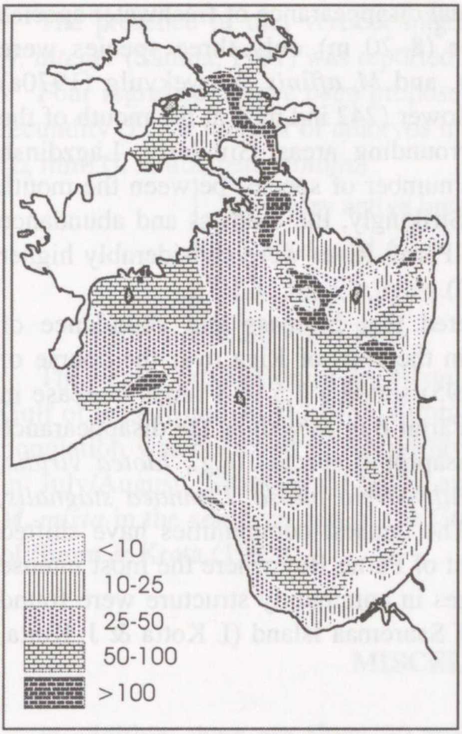

Fig. 2. The distribution of biomass of macrozoobenthos, g m^{-2}, in the Gulf of Riga and in the aquatory of the Väinameri (Yarvekyulg, 1979b).

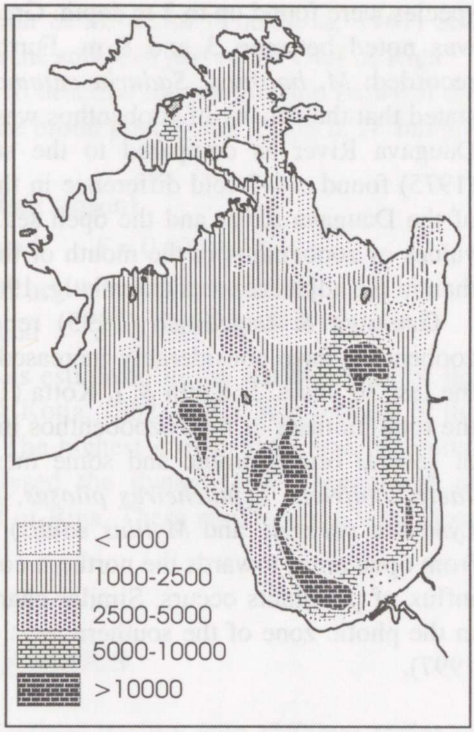

Fig. 3. The distribution of abundance of macrozoobenthos, ind m^{-2}, in the Gulf of Riga and in the aquatory of the Väinameri (Yarvekyulg, 1979b).

Lapin (1972) and Lagzdinsh & Saule (1983, 1984) studied the seasonal dynamics of biomass and abundance of macrozoobenthos in the southern part of the Gulf of Riga. Sampling was performed only at shallower areas of the photic zone (mean 0.6 m, maximum 1.2 m). The total biomass and abundance had higher and fairly constant values between May and October. A crustacean, *Bathyporeia pilosa*, was the dominant species over most time of the year. Oligochaeta, Nematoda, *Macoma balthica*, *Neomysis integer*, *Gammarus zaddachi*, and *G. salinus* were frequently observed.

Studies of eutrophication and pollution

Shurin (1953) demonstrated the impact of the Daugava River on the species composition of macrozoobenthos in the southern part of the Gulf of Riga. Relatively diverse zoobenthic communities with a high proportion of freshwater species were found up to 3 m depth. Gradual disappearance of freshwater species was noted between 3 and 8 m. Further (8–20 m) only three species were recorded: *M. balthica*, *Saduria entomon*, and *M. affinis*. Yarvekyulg (1970a) stated that the density of zoobenthos was lower (242 ind m^{-2}) at the mouth of the Daugava River as compared to the surrounding areas. Similarly, Lagzdinsh (1975) found a 4–7 fold difference in the number of species between the mouth of the Daugava River and the open sea. Strikingly, the biomass and abundance values of zoobenthos in the mouth of the Pärnu River were considerably higher than in the adjacent areas (Järvekülg, 1960).

Gaumiga & Lagzdinsh (1995) reported that biomass and abundance of zoobenthos have considerably increased in the Gulf of Riga over the course of the last 30 years. J. Kotta & I. Kotta (1995) stated a 1.5 to 8 times increase in the total biomass of macrozoobenthos in Pärnu Bay as well as the disappearance of several oligosaprobic and some mesosaprobic species (e.g., *Idotea viridis*, *Jaera albifrons*, *Leptocheirus pilosus*, *Bathyporeia pilosa*, *Lymnaea stagnalis*, *Lymnaea peregra*, and *Mytilus edulis*). The densest communities have shifted from open areas towards the northern coast of Pärnu Bay where the most intense influx of pollutants occurs. Similar changes in community structure were found in the photic zone of the southern bays of Saaremaa Island (I. Kotta & J. Kotta, 1997).

NECTOBENTHOS

During the last 25 years special attention has been paid to nectobenthos research, especially to Mysidacea in the northern part of the Gulf of Riga. *Neomysis integer* is the most abundant species in the shallower area of the gulf. Deeper regions are inhabited by *N. integer*, *Mysis mixta*, and *M. relicta* (Järvekülg 1960, 1961; Sanina, 1961; Kotta, 1976, 1978, 1979, 1980, 1984, 1995; Yarvekyulg, 1979b). *Praunus inermis* and *P. flexuosus* prevail in the vegetated areas of the Gulf of Riga (Kotta, 1980).

Kotta (1995) observed the dynamics of *N. integer* in Pärnu Bay during the last 20 years. The species had higher abundances and biomasses in 1980 and 1987–91 (> 100 ind m^{-3} and > 500 mg m^{-3}). These peaks coincided with the higher average water temperature of the bay. The highest abundance and biomass values of *M. mixta* and *M. relicta* have been found after very severe winters when the temperature in the bottom layers was noticeably lower than usual in spring.

Seasonal dynamics of *N. integer* and *M. mixta* was studied in the northern part of the Gulf of Riga by Kotta & Simm (1979) and Kotta (1995). The maximum abundance was observed in Pärnu Bay in August/September and in the open parts of the Gulf of Riga in September.

The presence of diel vertical migration of *M. mixta* (Chekhova, 1961) and *N. integer* (Sanina, 1961) was reported in the southern part of the Gulf of Riga.

Four regressions have been proposed to describe the relationship between the fecundity (*F*, the number of embryos in the brood pouch) and length of *N. integer* (*L*, mm) (I. Kotta, pers. comm.):

1. July (very active breeding season)

$$F = 3.5 \times L - 21.6 \quad \text{and} \quad F = 0.620 \times L^{1.40}$$

2. May, June, August (less active breeding season)

$$F = 2.6 \times L - 14.0 \quad \text{and} \quad F = 0.320 \times L^{1.58}$$

The yearly production of *M. mixta* was estimated in the northern part of the Gulf of Riga (Simm et al., 1983; Simm & Kotta, 1982, 1992). Recruitment of the population was observed in April/May. The highest growth ratio was measured in July/August. Shvetsova (1980) analysed the dynamics of recruitment of *M. mixta* in the southern part of the Gulf of Riga. These results agree with those of Simm & Kotta (1992).

MISCELLANEOUS

In addition, there are about 20 publications dealing with different topics of macrozoobenthos that have not been cited above. The results of these studies were either covered by other authors, or these studies concentrate on a very specific item.

1. Studies of historical importance: Kauri, 1934; Haberman, 1938; Bêrzinš, 1949.

2. Distribution, abundance, and biomass of different zoobenthic species: **whole Gulf of Riga** – Yarvekyulg, 1962a, 1970b; Järvekülg, 1973; Lagzdinsh et al., 1987a; **southern part of the gulf** – Karpevich & Shurin, 1970; Lapin, 1974; **northern part of the gulf** – Yarvekyulg, 1963, 1967; Järvekülg, 1964, 1965, 1967.

3. Interannual comparison of abundances of macrozoobenthos: **southern part of the gulf** – Kachalova et al., 1967; Karpevich & Shurin, 1970; Lagzdinsh et al., 1987b; Kostrichkina et al., 1992; **northern part of the gulf** – Ojaveer et al., 1988.

4. Effect of pollution on macrozoobenthos: **southern part of the gulf** – Kachalova, 1974a; Lagzdinsh, 1975.

5. Relation between isolation rank of a bay and the structure of zoobenthic communities: **northern part of the gulf** – Kangur et al., 1982.

6. Ecology of bivalves: Yarvekyulg, 1979a.

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ÜLEVAADE LIIVI LAHE LITORAALI ASUSTAVA ZOOBENTOSE KOHTA AVALDATUD KIRJANDUSEST

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Artiklis on kokku võetud Liivi lahe põhjaloomastiku ja nektobentose (müsiidide) kohta ilmunud uurimused. Põhitähelepanu on pööratud viimastel aastakümnetel avaldatud töödele, kuid ära on märgitud ka mõned varasemad. Lisaks on esitatud Liivi lahe põhjaloomastiku liikide nimekiri, arvukuse ja biomassi leviku kaardid ning hinnatud koosluste reaktsiooni reostuse suurenemisele. Põhjalikumalt on kirjeldatud nektobentose populatsioonidünaamikat uurimisalal.