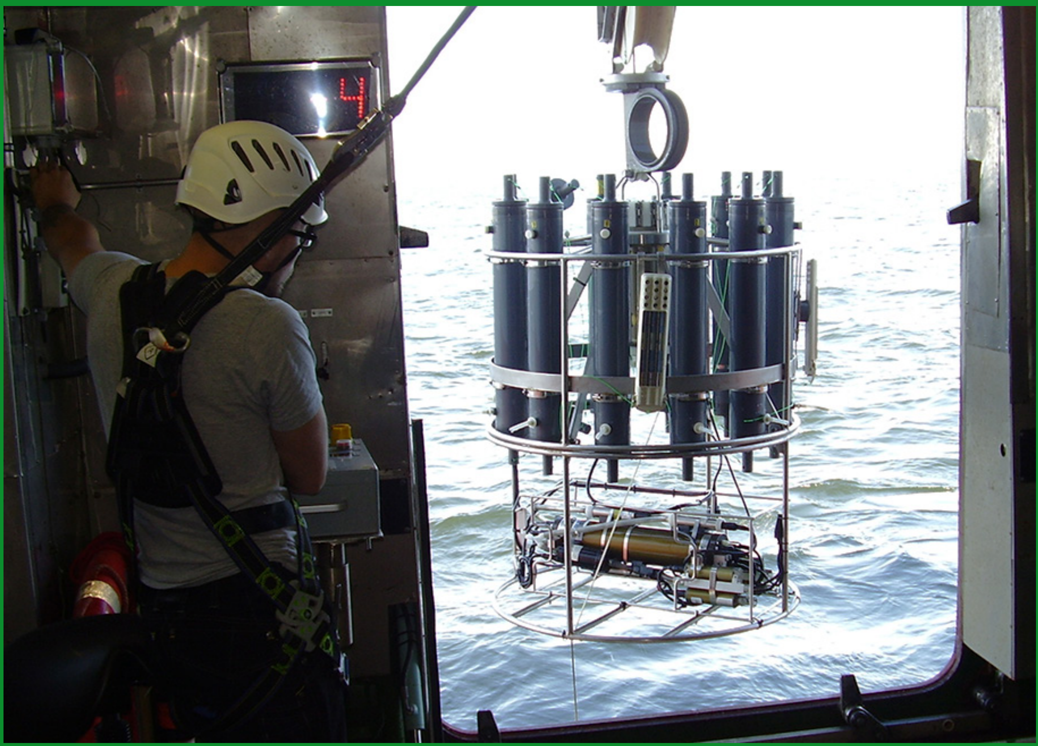
BASE Project - Implementation of the Baltic Sea Action Plan in Russia

Baltic Marine Environment Protection Commission

Preparation of indicators on biodiversity and hazardous substances for Russia



Pilot Activity	Preparation of biodiversity and hazardous substances indicators with targets that reflect good environmental status for HELCOM (including the HELCOM CORESET project) and improvement of Russian capacity to participate in operationalization of those indicators.
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CONTENT

1. EXECUTIVE SUMMARY

This report is a result of study agreement between HELCOM and Saint Petersburg State University (SPbSU or SPbU), prepared in frames of the project BASE, sponsored by EU. The aim of the activities of BASE is to contribute to the harmonisation of assessment methods in the whole Baltic Sea region in order to have comparable and reliable results for environment assessments. Project BASE directed to assistance for Russia in realization of the Baltic Sea Action Plan (BSAP) of HELCOM, it includes several tasks on marine environment enhancement.

The tasks of the given project are: 1) to enhance the participation of Russian partners in development of core set biodiversity and hazardous substances indicators; 2) to improve data provision from Russia to HELCOM for assessment purposes and 3) improvement of Russian capacity to participate in operationalization of those indicators.

This report presents the results, Russian expert's data and assessments of biodiversity and hazardous substances indicators. The set of 33 various indicators has been proposed earlier by the project HELCOM-CORESET (31 from them were included into the study agreement between HELCOM and SPbU and have been examined here) to describe most fully and multilaterally the environment and biota conditions, using so-called 'holistic approach'. In spite of evident advantages for detailed environment assessments using CORESET indicators, untill now the whole set of these indicators is implemented in none HELCOM country.

It is known usually quantitative participation of Russian experts in projects of HELCOM is rather poor. From 56 of international experts, elaborating HELCOM-CORESET project, was only one expert from Russia (HELCOM, 2012 a;b). The data on indicators status within Russian waters of the Baltic Sea was rather poor (or absent at all in some cases) in compare with other countries and the prospect of indicators introduction into national monitoring programmes was very problematic. In such situation the project titled 'Preparation of biodiversity and hazardous substances indicators with targets that reflect good environmental status for HELCOM (including the HELCOM CORESET project) and improvement of Russian capacity to participate in operationalization of those indicators' became very actual. This project can be considered as the prologation and the distribution of HELCOM-CORESET ideas and proposals onto Russian area of water of the Gulf of Finland.

St.-Petersburg State University – main institution and consultant, providing experts for the project from several departments and laboratories of Faculities of Biology, Chemistry, Geology. However when executing this project selected experts from other leading institutions were involved in this work as well. Totally 27 of experts and consultants were integrated into the work; the list of them with the chapters of their contribution is provided on the second page of the report. This is actually very big step to the experts network creation for participation the projects of HELCOM, related to indicators development and implementation.

The indicators were examined and presented in the report in the same order, as it was done in the Table of Terms of Reference by HELCOM secretariat.
All indicators combined into two large groups as follows:

- indicators, based on hazardous substances and their effects (Chapter 3);
- indicators, based on biodiversity and food webs (Chapter 4; this group is much bigger).

In accordance to Terms of Reference when presenting avalable data on each indicator several common clauses (sub-titles) were in use more or less uniformly: Description of the indicator, State of the indicator, Good environmental status (GES) boundaries, Proposal for monitoring (guidelines for the monitoring, schemes for monitoring and data collection).

Preliminary division of the indicators set to two groups as ‘core indicators’ and ‘pre-core indicators’ (like it was in use in CORESET project, HELCOM, 2012 a;b) deliberately wasn’t in use during this work. We suggested, such preliminary division may bring injurious neglect to ‘pre-core indicators’, allowing to consider them as ‘indicators of second chop’; however various experts may have distinctive opinions on the value of indicators. In fact the ranks of ‘core’ and ‘pre-core’ indicators are not yet agreed completely and some shifts in this are still possible. Several of the candidate indicators are expected to be developed into core indicators, what is already can be seen in the next ongoing project CORESET II.

All not numerous components of actual Russian state environmental monitoring (zooplankton abundance, heavy metals and hydrocarbons concentrations) are already belong to HELCOM-CORESET indicators, but they comprise only about 10% from the CORESET indicator’s scope. Recently existing knowledge and data sets from Russian part of the Gulf of Finland varying very much among the indicators. In some cases it coincides well by topics, objects and methods recommended by HELCOM-CORESET (for example, indicators: ‘Metals (lead, cadmium and mercury)’, ‘Population growth rates, abundance and distribution of marine mammals’, ‘Abundance of waterbirds in the breeding season’, ‘Zooplankton mean size and total abundance’). In other cases existing knowledge and data just partly corresponds to HELCOM-CORESET and these parts are varying remarkably from rather little to significant ones (for example, indicators: ‘Polyaromatic hydrocarbons and their metabolites’, ‘Abundance of key fish species’, ‘Abundance of salmon spawners and smolt’, ‘Abundance of sea trout spawners and parr’, ‘State of the soft-bottom macrofauna communities’, ‘Lower depth distribution limit of macrophyte species’, ‘Trends in arrival of new non-indigenous species’. Several indicators were very rarely or even never before implemented for the Russian part of the Gulf of Finland environmental assesments because of various reasons (‘Hexabromocyclododacene (HBCD)’, ‘Lysosomal Membrane Stability – a general stress indicator’, ‘Micronuclei test– a genotoxicity indicator’, ‘Pregnancy rates of marine mammals’, ‘Proportion of large fish in the community’, ‘Cumulative impact on benthic habitats’) and the gaps of information are evident.

Some of these gaps have objective reasons; local population of seals may not provide sufficient material for their pregnancy rates and nutritional status investigations, like it was studied on abundant populations of seals in Bothnian Bay in Sweden. The indicator proportion of large fish in the community was elaborated in western Baltic for most common commercial fish there – the cod and flounder; both of these fishes are very rare (or temporarily penetrating) for Russian part. An other gaps have subjective reasons (‘Micronuclei test– a genotoxicity indicator’, ‘Cumulative impact on benthic habitats’) it means these indicators can be implemented if orders for such implementation will be given.

Insufficient knowledge on marine biota contamination with hazardous substances, on toxicants bioaccumulation in organisms was noted. This has only one explanation – bad integration between biologists and chemists, who are unable to execute this kind of works separately. Some efforts were already undertaken to achieve such integration at least within SPbSU; hopefully it may bear fruits in nearest future.

It should be noted that studied area has substantial differences from the main Baltic Sea basin and even from the western part of the Gulf of Finland by flora and fauna content because of the lower salinity. Most important Baltic species as algae – *Fusus vesiculosus*, barnacles - *Balanus improvisus* and Baltic herring are distributed there only at the wester part, blue mussels beds are absent at all, almost like cod, flounder and many other marine species typical for the central Baltic.

Some of indicators are composed. For example 'Reproductive disorders: Malformed eelpout and amphipod embryos' actually is composed from two, what requires the employment of two experts. Indicator 'Cumulative impact on benthic habitats' seems one of most complicated ones and compised 14-15 of various impacts acting cumulatively, but independently; this indicator assessments need several experts working together.

The State of all HELCOM – CORESET indicators in the Russian part of the Gulf of Finland are summarized in very brief manner ('business card' size) in one table (Annexes, # 8.2).

Bibliography of the given report contains 388 references. Literature data from recent Russian sources of information was carefully analysed, what is important, because many of information presented in the report wasn't published before in English (or other languages besides Russian) and such works are often left unknown to foreign colleagues. Some of data presented in the given report wasn't published at all; it was exctracted from narrowly known departmental reports and manuscripts or from personal archives and databases of the experts.

The consultancies with specialists and with environmental authorities high-level representatives have demonstrated - there are two main clusters of problems to introduce the indicators into practical monitoring in Russia as follows: organizational and financial. The problem of interactions among of the institutions of different authorities and the departamental separation of their budgets is still remains, what needs negotiations, official procedures and agreements. The special chapter 5 of the report 'Ways and problems of improvement of Russian capacity to participate in operationalization of those indicators' describes rather divaricated organizational and bureaucratic obstacles on this field and shows the ways how possible to clear those obstacles. In spite of the presence of several players on this field the organizational priority of the Russian Ministry of Natural Resources on this way is evident judging from the Russian Federation legislation analysis has beed carried out in the Chapter 5 of the report.

The new project CORESET- II was pushed forward by HELCOM in years 2013-2014. The data and information presented in this report and organizational work, which has been done, must serve as a bridge linking CORESET and CORESET- II by improvement of Russian capacity in preparation of biodiversity and hazardous substances indicators national monitoring.

Thanks to activity during the study agreement between HELCOM and SPbSU carrying out 14 Russian experts on biodiversity and hazardous substances indicators were involved into the new CORESET- II project for officiall nomination by Russian Ministry of Natural Resources.

It is a most abundant representation of Russian permanent experts in HELCOM project, whenever has been in the history of HELCOM-Russia colaboration, what is in full accordance with the main tasks and with the Terms of Reference of the project HELCOM-BASE and of the Contract between HELCOM and SPbSU.

2. INTRODUCTION

The area of this report responsibility is the Russian part of the Gulf of Finland (fig. 2.1). It is the easternmost part and the most freshwater region of the gulf. This region is of great importance not only for the environment of the Gulf of Finland, but for the Baltic Sea as a whole. Just few facts are enumerated below to support this statement:

- the European biggest Lake Ladoga has a flowing off to this part of the Baltic;
- the biggest river of the Baltic Sea basin Neva River discharged to this part of the Baltic;
- the biggest Baltic city Saint-Petersbur is placed here;
- first three biggest Baltic Sea ports are situated and act in this area;
- over six millions of people lives directly at the coasts of the Russian part of the Gulf of Finland.

Judging from mentioned above high anthropogenic pressure to marine ecosystems is expected in this area, what is really so. Environmental legislation of the Russian Federation has many documents prescribing the nature protection and considers a big set of special measures to control the quality and to protect marine environment.

Environmental investigations of the Neva Bay and the eastern Gulf of Finland were started in Russia over one hundred years ago (Skorikov, 1910; Derjugin, 1922; 1923). Currently the system of State environmental monitoring is operated in this region by North-West Department of Federal Service for Hydrometeorology and Environmental Monitoring with the aid of few other institutions ('Sevmorgeo' and some other).

This monitoring system in detailes (like list of componets of environment to be analysed; monitoring stations position, sampling frequency, methods to be used, etc.) was created in Soviet Union period for implementation in the Baltic Sea region. It was sufficient and satisfactory during long period and still play its positive role to control the parameters of marine environment – both abiotic and biotic components of it.

However new time brings new problems to the nature together with new challenges to the nature and human health protection. It is a new hazardous substances, new harmful processes within the plants and animals communities and inside the individual organisms as well. Evidently these new processes require also new approaches to monitoring of those, i.e. - new methods, new objects and new indicators for multilateral assessment of marine environment.

In the given report 31 of HELCOM-CORESET indicators were analysed by Russian experts in application to the Russian part of the Gulf of Finland – rather specific area of water with minimum salinity (and also minimum water mineralization within the Neva Bay) and, probably, with maximum anthropogenic pressures (both real and potential ones) known for the Baltic Sea.

Experts tried to estimate the general relevancy of every indicator, its applicability exactly to the conditions of the Russian waters of the Gulf of Finland. They tried to provide the available data on the state of the indicator in the named area, even if it wasn't a subject of a regular monitoring, using their own knowledge and initial researches. Additional tasks to experts were establishment (if possible) the GES (good environmental status) boudaries, the adaptation (or modification) of the indicator to the regional conditions and the proposal of monitoring schemes for each indicator implementation in the Russian part of the Gulf of Finland.

The ways and problems of improvement of Russian capacity to participate in operationalization of those indicators were discussed in special chapter; however that problems have a relation rather to official interactions among the authorities, than to scientific questions.

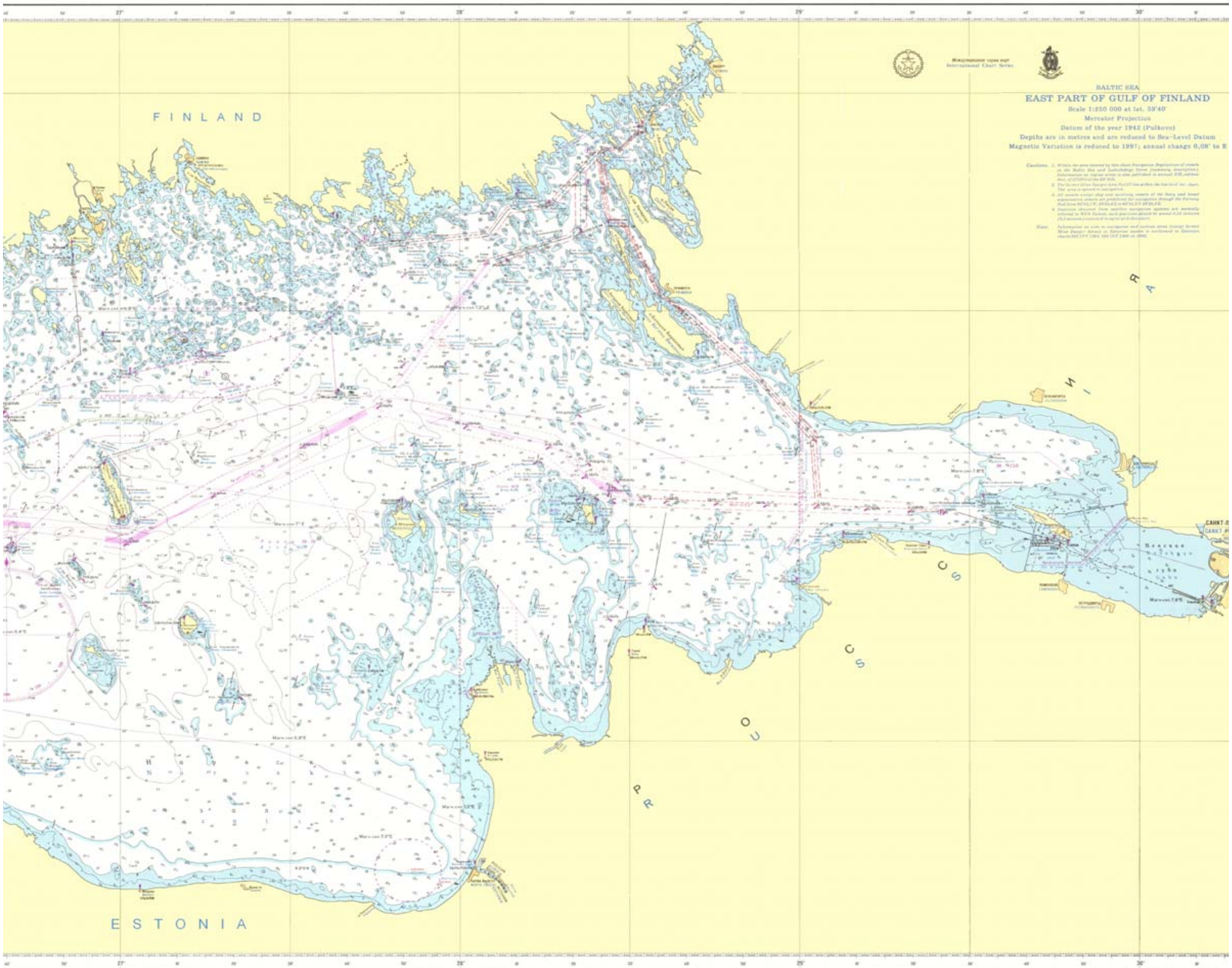


Fig. 2.1. Russian part of the eastern Gulf of Finland – the area of investigations

3. INDICATORS, BASED ON HAZARDOUS SUBSTANCES AND THEIR EFFECTS

3.1. POLYBROMINATED BIPHENYL ETHERS (PBDE): BDE-28, 47, 99, 100, 153 AND 154

3.1. Status of the indicator in the Russian part of the Gulf of Finland

There is no regular monitoring of PeBDE in the Russian Federation.
The only existing norm for its presence in the environment is the MAC for DecaBDE (BDE-209) in water – 10 g/L. This value is nonsense. Such concentration of the substance can not exist due to low solubility. Comparison with EU AA-EQS (0.5 ng/L) shows a 4-fold difference and also indicates a need for re-consideration and harmonization.

Data on PeBDE in the Russian part of the Gulf of Finland are scarce. The only comprehensive set of data is available in the report on 'Identification of Sources of Hazardous Substances in St.Petersburg Area' (http://www.helcom.fi/stc/files/Projects/BALTHAZAR/publications/Final_Report_SRCES_Identification_with_cover.pdf). The study was part of EU-financed HELCOM project BALTHAZAR performed in 2011-2012 by the St.Petersburg Center for Ecological Safety, Russian Academy of Sciences (SRCES RAS).
This report will be a basis for consideration of the PeBDE indicator.

3.1.1. PeBDE in natural waters

Available data is summarized in table 3.1.1. Eight congeners were detected in natural water, six of them are proposed indicator congeners (marked in red).

Table 3.1.1. Concentrations of PBDE in natural water (ng/L)

PBDE	W318 Tolbukhin island	W320 Strelna	W321 Neva mouth	W324 Neva near Slavyanka	W325 Neva near Sapernyi
28	**0.04**	<0.02	<0.03	<0.03	<0.03
47	**0.04**	<0.03	<0.03	<0.03	<0.01
66	**0.03**	**0.08**	**0.02**	<0.03	<0.01
85	<0.03	<0.03	<0.04	<0.07	<0.04
99	**0.10**	**0.02**	**0.05**	**0.03**	**0.03**
100	**0.04**	**0.04**	**0.02**	**0.02**	**0.02**
153	**0.03**	<0.03	<0.04	<0.07	<0.04
154	**0.02**	<0.02	<0.02	<0.04	<0.02
Sum	**0.3**	**0.14**	**0.1**	**0.05**	**0.05**
Sum of 6 indicator congeners	**0.27**	**0.06**	**0.07**	**0.05**	**0.05**

Low concentrations of PBDE were detected in water samples (0.05 – 0.3 ng/L). In the Neva river and inside the dam concentration are near the detection limit of the method. There is only one data point for the open part of the Russian part of the Gulf of Finland. There, near Tolbukhin island, significantly higher concentrations of six indicator BDEs were found (0.27ng/L). However, this is below EU AA-EQS (0.5ng/L).

3.1.2. PeBDE in sediments

PBDE in sediment were measured in 9 locations, including one location in the open part of the Russian part of the Gulf of Finland (Tolbukhin island). These are listed in the Table 3.1.2.

Table 3.1.2. Concentrations of PBDE congeners in sediments (ng/g)

PBDE	S148 Tolbukhin island	S149 Strelna	S150 port	S151 Utkina Zavod’	S153 Elagin bridge	S154 Golovin bridge	S155 Duderhof	S157 Neva near Ostrovki	S158 Ohta river mouth
17	<0,02	<0,01	<0,02	<0,02	0.11	<0,02	<0,02	<0,02	<0,02
28	0.22	0.02	0.13	0.10	0.15	<0.009	<0,02	<0,02	0.13
47	0.77	0.03	0.22	0.12	0.46	0.13	1.00	0.18	0.18
49	0.02	<0,005	<0,02	<0,02	0.08	0.009	0.75	<0,02	0.90
66	<0,01	<0,007	<0,02	<0,02	0.06	<0.005	<0,02	<0,02	<0,02
71	0.09	<0,005	<0,02	0.09	0.08	<0.005	<0,02	<0,02	0.50
77	<0,03	<0,02	<0,03	<0,03	<0,03	<0.02	<0,03	<0,03	<0,03
85	<0,03	<0,02	<0,03	<0,03	0.07	<0.03	<0,03	<0,03	<0,03
99	0.12	0.02	0.06	0.02	0.03	0.02	<0,02	0.02	0.02
100	0.08	0.015	0.07	<0,02	<0,02	0.03	<0,02	0.02	<0,02
119	<0,02	<0,01	<0,02	<0,02	<0,02	<0.01	<0,02	<0,02	<0,02
153	<0,03	<0,02	<0,03	<0,03	0.08	<0.03	<0,03	<0,03	<0,03
154	<0,03	<0,008	<0,03	<0,03	0.08	<0.03	<0,03	<0,03	<0,03
Sum	1.30	0.09	0.50	0.33	1.20	0.19	1.80	0.22	1.70
Sum of 6	**1.19**	**0.09**	**0.48**	**0.24**	**0.80**	**0.18**	**1.00**	**0.22**	**0.33**

Sum of 6 indicator congeners may reach up to 1.19 ng/g, BDE-47 clearly is a major contributor into the polution.

Location of sampling sites can be found on the map below (fig. 3.1.1):

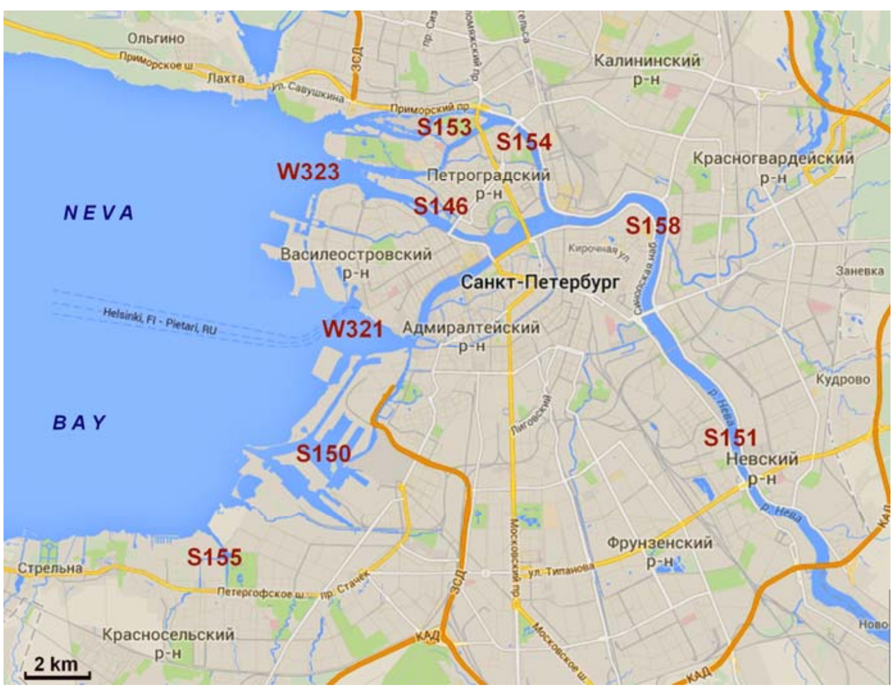


Fig. 3.1.1. Sediment sampling sites in St.-Petersburg for PeBDE, SRCES, 2011-2012

3.1.1.3. PeBDE in WWTPs

PBDEs were also measured at 3 different WWTPs of St.-Petersburg (Table 3.1.3).

Table 3.1.3. Concentrations of PBDE in WWTP water (ng/L)

PBDE	W334 WWTP 1 Influent	W335 WWTP 1 Effluent	W336 WWTP 2 Influent	W337 WWTP 2 Effluent	W338 WWTP 3 Influent	W339 WWTP 3 Effluent
17	<5	0.001	<5	<0,001	7.1	0.001
28	7.4	0.002	18.5	<0,001	11.7	0.002
47	39	0.025	238	0.025	83.7	0.02
49	<5	<0,002	<5	<0,004	8.7	<0,003
66	<5	<0,002	<5	<0,004	<5	<0,004
71	<5	<0,002	<5	<0,004	<5	<0,003
77	<5	<0,03	<5	<0,05	<8	<0,03
85	<5	<0,05	<5	<0,1	<10	<0,1
99	35.8	0.025	11.4	<0,03	4.2	<0,03
100	<5	<0,02	<5	<0,008	3.7	<0,008
119	<5	<0,01	7.5	<0,008	4.9	<0,008
153	<10	<0,05	<10	<0,1	<10	<0,3
154	<10	<0,1	<10	<0,3	<10	<0,1
Sum	**82.2**	**0.06**	**275**	**0.03**	**124**	**0.02**
Sum of 6	**82**	**0.05**	**270**	**0.03**	**104**	**0.02**

In wastewater concentrations of 6 indicator congeners varied from 82 to 270 ng/L, major congener being BDE-47. In effluenet, dramatic improvement was observed, with concentrations down 3-4 fold, to 0.02 – 0.05 ng/L.

This indicates a low risk from WWTPs, but significant risk from untreated waters with high concentrations of PBDEs. The data indicates there are sources of PBDEs in St.Petersburg; therefore this indicator is relevant for monitoring in the Russian Federation.

Current findings of the CORESET project suggest biota (fish and mollusks) as primary matrix for monitoring and sediment as secondary.

No data for PeBDE in biota is available for the Russian part of the Gulf of Finland.

3.1.2. Relevancy of PeBDE as indicator for Russian Federation.

PeBDE is a relevant indicator:
Even limited available data clearly supports the existence of national sources of pollution.
The occurrence of BDEs is widespread in the Baltic marine environment.
The substance's harmful properties are well established.

3.1.3. Current state of monitoring of PeBDE in the Russian Federation

Monitoring program does not exist. Available data were obtained as a result of independent research. The data is non-systematic, limited spatially and temporally.
No data is available for biota samples.

Available data is not sufficient for conclusions on the status of this indicator in the Russian part of the Gulf of Finland.

3.1.4. Suggestion for GES for PeBDE in the Russian part of the Gulf of Finland

No data suggests the Russian part of the Gulf of Finland is a specific region in relation to PeBDE. Therefore GES for the Russian part of the Gulf of Finland should be the same as for other parts of the Baltic Sea.

EQS boundary proposed by EC is currently 0.0085 µg/kg fish ww. This can be taken as provisional quality status for the Russian part of the Gulf of Finland as well.
After 3 years of initial monitoring this value can be corrected.

The GES boundary for sediment (a secondary approach) is proposed to be 4.5 µg kg^{-1} dw. This value has been suggested by the working group on priority substances for the protection of the benthic community. The highest observed concentration in sediment from the Russian part of the Gulf of Finland is 1.19; nearly 4 times lower, however more measurements, including coastal areas are certainly required prior to making careful conclusions.

No information on PeBDE in mollusks in the Russian part of the Gulf of Finland is available. Therefore it is impossible at this stage to discuss GES parameters for PeBDE in mollusks.

3.1.5. Suggestions for monitoring.

In scarcity of existing data more extensive monitoring is plausible in the first 3 years. Later, based on the results, the frequency and geographical coverage can be limited.

<u>For the first 3 years:</u>

Stations

- Near Vyborg
- Near Primorsk
- Gulf of Luga
- Island of Moshchny (or Malyj)
- Island of Kotlin, outside the dam (or one of small islands nearby)
- Secondary sleeves in Neva delta (Zhdanovka, Smolenka)
- Ladoga lake near Schlisselburg (as a reference point)

Samples

- bivalve mollusks s (if available)
- fish (herring, if available)
- sediment

Frequency

- 2 pooled mussel samples
- 5 individual fish samples
- 2 sediment samples

The sampling is suggested at each station once a year; preferably in the same time of the year.

Besides monitoring of the environment, regular control on all WWTPs (2-4 times per year) is strongly recommended.

3.2. HEXABROMOCYCLODODECANE (HBCD)

3.2.1. Status of the indicator in the Russian part of the Gulf of Finland

HBCD (also HBDD or HBCDD) is under review by the Persistent Organic Pollutants Review Committee (POPRC) as a proposed substance to be listed under the Stockholm Convention.

There is no regular monitoring of HBCD in the Russian Federation.
There is no official information on production or use of this chemical in the Russian Federation.

However, HBCD is available on the market, for instance, in 25 kg bags as 'flame retardant for plastic foams of different kind'(http://www.chemsystem.ru/catalog/164/).
Its potential negative environmental impact is widely acknowledged in commercial and consumers information (http://library.stroit.ru/articles/ecstrmat/index.html, http://stroy-materialy.com/pokupka/vrednye-i-opasnye-stroimaterialy.html, http://www.isoshell.ru/articles/1/art13.html, http://my-remsovet.ru/okna/350-evroremont-obratnaya-storona-medali.html, http://expertizanewru.livejournal.com/, http://www.utrospb.ru/articles/24232/).

There is very little data on levels of HBCD in environmental samples from Russia. The only project, known to us, that targeted HBDD was 'Identification of Sources of Hazardous Substances in St.Petersburg Area' (http://www.helcom.fi/stc/files/Projects/BALTHAZAR/publications/Final_Report_SRCES_Identification_with_cover.pdf). The study was part of EU-financed HELCOM project BALTHAZAR performed in 2011-2012 by the St.Petersburg Center for Ecological Safety, Russian Academy of Sciences (SRCES RAS).

HBCD was not detected in natural waters (Fig. 1, 5 samples, LOD – 0.4ng/L), in sewage water (3 samples, LOD – 0.4ng/L) or in WWTP effluent (3 samples, LOD – 0.4ng/L).

HBCD was detected in WWTP sludge:

HBCD in WWTP sludge

	S159 WWTP 1	**S160 WWTP 2**	**S161 WWTP 3**
	ng/g	ng/g	ng/g
beta-HBCDD	3.12	2.44	0.48
gamma-HBCDD	<0.4	5.02	<0.4

Also gamma-HBCD was found in two of nine sediment samples: in the Gulf of Finland near Strelna (2.8 ng/g) and in Utkina Zavod' of Neva river (5.1 ng/g) within the city limits of St.Petersburg.
It has to be noted that analytical method for HBCD was not fully established (there is no official method in the Russian Federation), therefore the above mentioned results just indicate potential presence of HBCD at moderate levels.

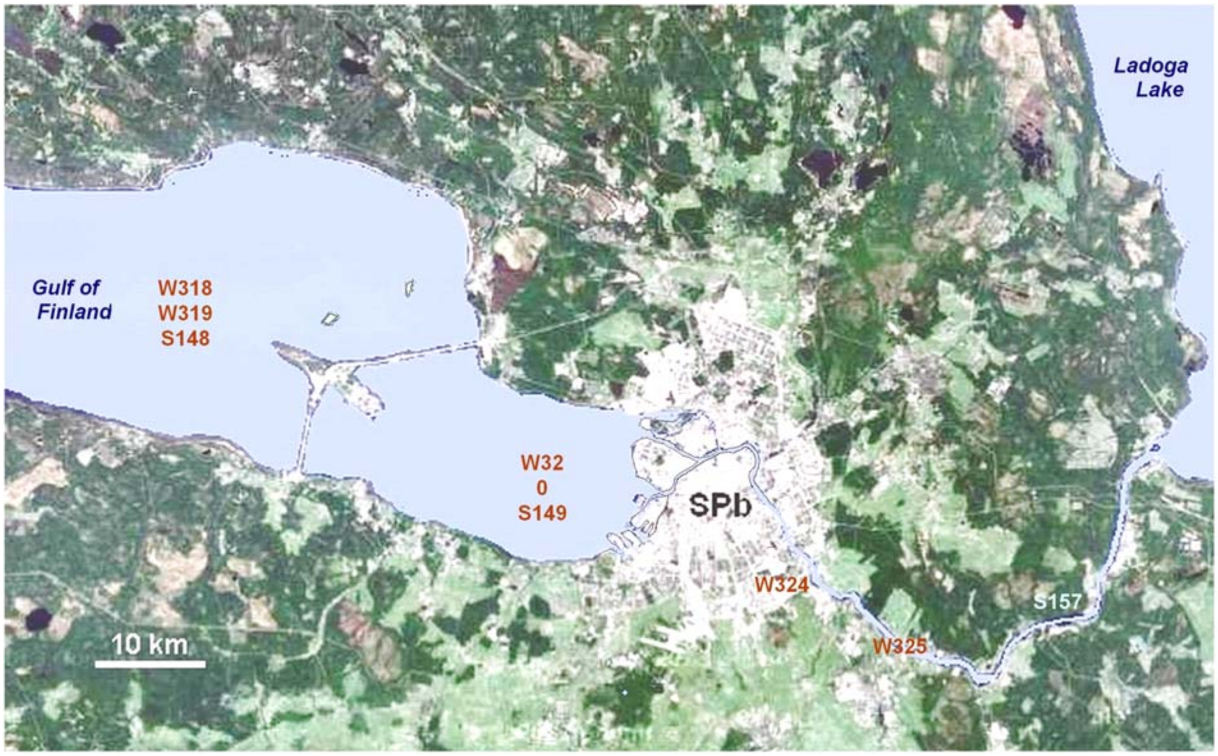


Fig. 3.2.1. Map of water sampling sites, SRCES, 2011 (no HBDD found)

In scarcity of national data it is important to discuss information from neighboring countries with common historical roots – Latvia, Lithuania, Estonia. Screening results were obtained in course of COHIBA project.

HBCD was found in wastewater – up to 7ng/L.
HBCD was found in bottom sediments – up to 10.4 µg/kg (or 10.4 ng/g). This correlates well with above mentioned values for Utkina Zavod' and Strelna samples.
HBCD was found in rainwater – up to 6.48 ng/L. We consider this as an important warning. There is no reason to expect different levels in neighboring parts of Russia.

Data on HBCD in sediment and biota in other parts of the Baltic Sea is also rather limited. Preliminary conclusions of the HELCOM CORESET expert group are as follows:
'The average concentration of HBCD in 2005-2010 does not exceed the threshold level in any of the monitoring stations. Thus, the substance indicates Good Environmental Status (GES) in blue mussel, herring muscle and cod liver. However, the spatial distribution of the assessment is very limited.'

This conclusion clearly calls for effort from other Baltic countries including Russia.

'The Swedish results show that HBCD levels in Baltic Sea herring muscle are generally low and always lower than the GES boundary, which is the EU Environmental Quality Standard (167 µg kg-^{1} ww) (http://www.helcom.fi/BSAP_assessment/ifs/ifs2011/en_GB/hbcd_biota/). The highest concentrations (25 µg kg^{-1} lw or around 1 µg kg^{-1} ww) were found from the southern sea areas (Bornholm Basin and Western Gotland Basin) and the lowest levels in Kattegat (2 µg kg^{-1} lw).'

This conclusion gives hope that first years of monitoring may lead to exclusion of this indicator from the list.

'Also the levels in the sediments of the Swedish coastal area are very low compared to the GES boundary for sediments (170 µg kg^{-1} dw).'

‘The spatial analysis of HBCD levels in herring muscle during 1999–2004 does not show any firm geographical differences, except that the level in the Southern Baltic Proper seems to be higher than another six sites from Skagerrak to Bothnian Bay. In general, HBCD seems to be more evenly distributed in the Swedish marine environment compared to, e.g. PCBs (*Bignert, A., Nyberg, E., Asplund, L., Eriksson, U. & Wilander, A. 2006. Metals and organic hazardous substances in marine biota, trend and spatial monitoring. 122 p. Swedish Museum of Natural History.*).’
If the hypothesis is confirmed, the monitoring of the herring muscle in the future can be limited to a few samples per year from the whole Baltic Sea.

EC AA-EQS for HBDD is 0.0016 µg/L for inland waters and 0.008 µg/L for other surface waters.For marine samples, CORESET experts suggest adoption of the GES boundary -the Environmental Quality Standard (EQS), proposed by the European Commission to the revised EQS Directive (31.1.2012). The EQS is 167 µg kg^{-1} fish ww. An alternative approach is to use the Quality Standard for sediment (170 µg kg^{-1} dw) (WFD WG E Dossier 19.1.2012).
Upon collection of reliable systematic information on HBDD levels and trends in the Russian part of the Gulf of Finland adjusted GES boundaries can be set.

No data for HBCD in biota is available for the Russian part of the Gulf of Finland.

3.2.2. Relevancy of HBCD as indicator for Russian Federation.

HBCD is a relevant indicator, though its significance appears to be secondary in comparison with PeBDE.

3.2.3. Current state of monitoring of HBCD in the Russian Federation

Monitoring program does not exist. Available data is limited and needs confirmation; obtained as a result of independent research. The data is non-systematic, limited spatially and temporally.
No data is available for biota samples.

Available data is not sufficient for conclusions on the status of this indicator in the Russian part of the Gulf of Finland.

3.2.4. Suggestion for GES for HBCD in the Russian part of the Gulf of Finland

No data suggests the Russian part of the Gulf of Finland is a specific region in relation to HBCD. Therefore initial GES for the Russian part of the Gulf of Finland should be the same as for other parts of the Baltic Sea.

GES boundary proposed by CORESET is currently 167 µg kg^{-1} fish ww and for sediment 170 µg kg^{-1} dw. This can be taken as provisional quality status for the Russian part of the Gulf of Finland as well.
After 3 years of initial monitoring this value can be corrected.

3.2.5. Suggestions for monitoring.

In scarcity of existing data more extensive monitoring is plausible in the first 3 years. Later, based on the results, the frequency and geographical coverage can be limited.

Despite HBCD seems to be less relevant than other proposed core indicators, like PeBDE, it is wise to suggest its monitoring for at least 3 years. There will be no significant extra cost in addition to analysis of PeBDE.

For the first 3 years:

Stations

- Near Vyborg
- Near Primorsk
- Luga Bay
- Island of Moshchny (or Island Malyj)
- Island of Kotlin, outside the dam (or one of small islands nearby)
- Secondary sleeves in Neva delta (Zhdanovka, Smolenka rivers)
- Ladoga lake near Schlisselburg (as a reference point)

Samples

- fish (herring, if available)
- bottom sediment

Frequency

- five individual fish samples
- two bottom sediment samples

The sampling is suggested at each station once a year; preferably in the same time of the year.

Besides monitoring of the environment, a screening of St.Petersburg wastewater and rainwater is recommended.

3.3. PERFLUOROOCTANESULFONATE (PFOS)

3.3.1. Status of the indicator in the Russian part of the Gulf of Finland

There are no known local producers of PFOS, while imported consumer goods, containg fluoroorganic substances are present on the market. Public awareness of PFOS as an environmental contaminant is low; however, basic warnings can be easily retrieved by a responsible consumer (http://www.himiinet.com/news_text/stati/kamennaya_posuda_-_eto_bezopasno/, http://www.greenpan-shop.ru/?k=txt&id=52, http://www.aromasuper.ru/2011/03/kislorodnaja-kosmetika.html).

There is no official analytical method for PFOS in the Russian Federation and few laboratories offering PFOS measurements.

Russian scientists have recently shown possibility of extracting perfluorooctansulfonate from water matrix by metal-affinity chromatography on the new sorbents containing iron (III) (E. N. Chernova, O. A. Keltsieva, V. D. Gladilovich, Ya. V. Russkikh, N. G. Sukhodolov, A. A. Selutin, V. A. Nikiforov, Z. A. Zhakovskaya, E. P. Podolskaya, APPLICATION OF CHROMATO-MASS-SPECTROMETER OF HIGH RESOLUTION LTQ ORBITRAP FOR DETERMINATION OF PERFLUORINATED ACIDS IN NATURAL WATER WITH THE TRADITIONAL SOLID-PHASE AND METALL-AFFINE SORBENTS: METHOD DEVELOPMENT AND OPTIMIZATION, Nauchnoe priborostroenie, 2013, 23, 1, 30-37, http://213.170.69.26/mag/2013/full1/Art3.pdf)

The only one source of available data on PFOS in environmental samples from Russia. The only project, known to us, that targeted PFOS was 'Identification of Sources of Hazardous Substances in St.Petersburg Area' (http://www.helcom.fi/stc/files/Projects/BALTHAZAR/publications/Final_Report_SRCES_Identification_with_cover.pdf). The study was part of EU-financed HELCOM project BALTHAZAR performed in 2011-2012 by the St.Petersburg Center for Ecological Safety, Russian Academy of Sciences (SRCES RAS).

PFOS was found in two (of 5) water samples: near Strelna – 1.7 ng/L, in the Neva mouth – 2.4 ng/L. In other samples PFOS was not detected beyond LOD, 0.5ng/L.

In sediment, PFOS was found only once (9 sediment samples were investigated), in a sediment taken under Elagin bridge, its concentration was 5.2 ng/g. LOD was 0.5 ng/g.

PFOS was not found in WWTP effluent.

Some data is available for related substances -PFOA and higher perfluoroalkanoic acids in rivers of North-Western Russia (Igumnova et al., Determination of trace amounts of perfluoroalkanoic acids in water samples. Proceedings of Ecoanalytica-2011, Arkhangelsk, June 2011). Samples were taken from rivers Luga, Velikaya, Volkhov and Chudskoe Lake near Spitcyno (see map below). These rare samples just partly belongs to the Baltic Sea (the Gulf of Finland) catchment area, but not to the sea itself.

Concentrations of acids ranged from 3.2 to 250 ng/L.

No data is available on PFOS in biota, though SRCES has recently participated in the NCP-III intercalibration, that included two fish tissue samples for PFOS analysis.

3.3.2. Relevancy of PFOS as indicator for Russian Federation.

PFOS is a relevant indicator.

It reflects the pollution by perfluorinated substances – a novel class of environmental contaminants with unique, amphyphylic properties, and proven negative health effects. Moreover, it is an emerging contaminant, released as a result of consumer use of fluorinated materials.

It is important to know, that other perfluorinated compounds may be present at higher concentrations than PFOS. Therefore parallel monitoring of other perfluoroalkylsulfonates and perfluoroalcanoic acids is strongly recommended.

3.3.3. Current state of monitoring of PFOS in the Russian Federation

Monitoring program does not exist. Available data is limited and needs confirmation; obtained as a result of independent research. The data is non-systematic, limited spatially and temporally.
No data is available for biota samples.

Available data is not sufficient for conclusions on the status of this indicator in the Russian part of the Gulf of Finland.

3.3.4. Suggestion for GES for PFOS in the Russian part of the Gulf of Finland

No data suggests the Russian part of the Gulf of Finland is a specific region in relation to PFOS. Therefore initial GES for the Russian part of the Gulf of Finland should be the same as for other parts of the Baltic Sea.
GES boundary proposed by CORESET is currently 9.1 µg kg^{-1} fish ww. This can be taken as provisional quality status for the Russian part of the Gulf of Finland as well.
After 3 years of initial monitoring this value can be corrected.
There is no suggestion for GES in sediment. More monitoring data is required to establish such criterion in the future.

3.3.5. Suggestions for monitoring.

In scarcity of existing data more extensive monitoring is plausible in the first 3 years. Later, based on the results, the frequency and geographical coverage can be limited or expanded.

<u>For the first 3 years:</u>

Stations

- Near Vyborg
- Near Primorsk
- Luga Bay
- Island of Moshchny (or Malyj)
- Island of Kotlin, outside the dam (or one of small islands nearby)
- Secondary sleeves in Neva delta (Zhdanovka, Smolenka)
- Ladoga lake near Schlisselburg (as a reference point)

Samples

- fish (common species)
- bottom sediment
- water (optional, for parallel monitoring of Perfluoroalcanoic acids)
- mussels (if available)

Frequency

- 5 individual fish samples
- 2 sediment samples
- 1 water sample

The sampling is suggested at each station once a year; preferably in the same time of the year.

Water samples can be taken more often.

Besides monitoring of the environment, a screening of St.Petersburg wastewater and rainwater is recommended.

3.4. POLYCHLORINATED BIPHENYLS (PCB) AND DIOXINS AND FURANS: CB-28, 52, 101, 118, 138, 153 AND 180; WHO-TEQ OF DIOXINS, FURANS +DL-PCBS

3.4.1. Status of the indicator in the Russian part of the Gulf of Finland

There is significant difference in status of two parts of this complex indicator in the Russian Federation, therefore these two parts will be discussed separately

3.4.1.1. Polychlorinated biphenyls (PCBs): CB-28, 52, 101, 118, 138, 153 and 180

PCBs have been monitored in the Russian Federation and monitoring data was reported on numerous conferences, seminars and international meetings. Extensive measurements were undertaken in connection to construction of NorthStream pipeline (http://dspace.vniro.ru/bitstream/handle/123456789/1954/Самсонов.pdf).

There exists some historical data on PCB level in the Gulf of Finland as well.
For example, in 1999, Research Center 'Monitoring of the Arctic' determined PCB concentrations in water of the Gulf of Finland. (http://esimo.oceanography.ru/esp2/index/index/esp_id/1/section_id/8/menu_id/4625).
Total PCBs ranged from 0.60 to 1.94 ng/L, with average concentration – 1.25 ng/L. Higher levels were detected in the Eastern part of the Gulf of Finland. Higher concentrations of PCBs 101, 118, 138 were detected in the South-Eastern part, while that of PCB-153 – in the North-Eastern part.

Most recently PCBs have been measured in water, sediment and WWTP sewage/effluent/sludge within BALTHAZAR project ('Identification of Sources of Hazardous Substances in St.Petersburg Area', 2011-2012, http://www.helcom.fi/stc/files/Projects/BALTHAZAR/publications/Final_Report_SRCES_Identification_with_cover.pdf).

In water samples maximal concentration of the six proposed congeners was 6 ng/L at Tolbukhin island, of which 2.6 ng/L was PCB-28. The minimal concentration (0.2ng/L) was found in Neva water upstream of St.Petersburg (near Sapernyj).
In open water sediment samples sum of indicator PCBs was 2-4 ng/g. Sediments in Neva or its tributaries within St.Petersburg were more heavily polluted – up to
930 ng/g (Golovin bridge).
Sewage water contained up to 120 ng/L of indicator PCBs, while WWTP effluent – not more than 6ng/L.

Some information on PCBs in the Gulf of Finland is available from Sevmorgeo (http://www.sevmorgeo.com/rus/index_e.htm).

Limited data is available on PCBs in fish from the Gulf of Finland (O.A. Strygina, V.V. Shenderyuk, O.L. Dubova, L.P. Baholdina, N.L. Chernysheva. ESTABLISHING CRITERIA FOR IDENTIFYING AREAS OF FISHING ON POLLUTION OF WATER RESOURCES OF BIOLOGICAL CONTAMINANTS OF DIFFERENT NATURE, Izvestiya KGTU, 2013, 28, 44-48. http://www.klgtu.ru/science/magazine/2013_28/strygina.pdf). PCBs were found in smelt at level of 40ng/g ww.

In fact, data on PCBs is plentiful, and, despite its non-systematic character can be used for pilot status assessment of the Russian part of the Gulf of Finland, provided data is scrutinized for reliability and compatibility. Such assessment would present a separate research project and is beyond the scope of the current consideration.

PCBs in sediment are regulated, presumably, in accordance with 'Norms'
(http://www.bestpravo.ru/leningradskaya/ew-pravo/y6p.htm).

3.4.1.2. WHO-TEQ of dioxins, furans +dl-PCBs

These parameters are being monitored in the Russian Federation; official results, however, are not easily accessible.

There was one study on the PCDD/Fs and dl-PCBs in the 'Russian' Baltic fish, published in 2008 (*Contamination of Russian Baltic fish by polychlorinated dibenzo-p-dioxins, dibenzofurans and dioxin-like biphenyls // A.A. Shelepchikov, V.V. Shenderyuk, E.S. Brodsky, D. Feshin, L.P. Baholdina, S.K. Gorogankin // Environmental Toxicology and Pharmacology, 2008 25(2) 136-143.*).

Nineteen species of fish products caught and produced in the Russian economic zone of the Baltic region in 2002–2005 were analyzed for polychlorinated dibenzo-*p*-dioxins (PCDDs), dibenzofurans (PCDFs) and dioxin-like biphenyls (WHO-PCBs). Samples were analyzed according to the national certified test method (Methodical guideline, 1997; MPM LAE-04/05, 2006; Cheleptchikov et al., 2002). Among samples were Baltic salmon, Baltic flounder, European smelt, cod, sprat, herring, eel including several samples of processed (canned) fish.

Levels of WHO-TEQ varied between few ng/kg to 124.4 ng/kg (cod liver).
However, none of the studied fish or fish products can be clearly assigned to the Russian part of the Gulf of Finland.

Sevmorgeo is responsible for state monitoring of the shelf and has made some of the data publicly available (***ENVIRONMENT OFFSHORE CONDITIONS IN THE BARENTS, WHITE and BALTIC SEAS, SVEMORGEO, SPb, 2009*** http://www.sevmorgeo.com/rus/bull_new.pdf).
In 2009 a number of sediment samples were analyzed for the presence of Dioxins in the trace analysis laboratory of the Centre for Ecological Safety (SRCES RAS) (fig. 3.4.1).

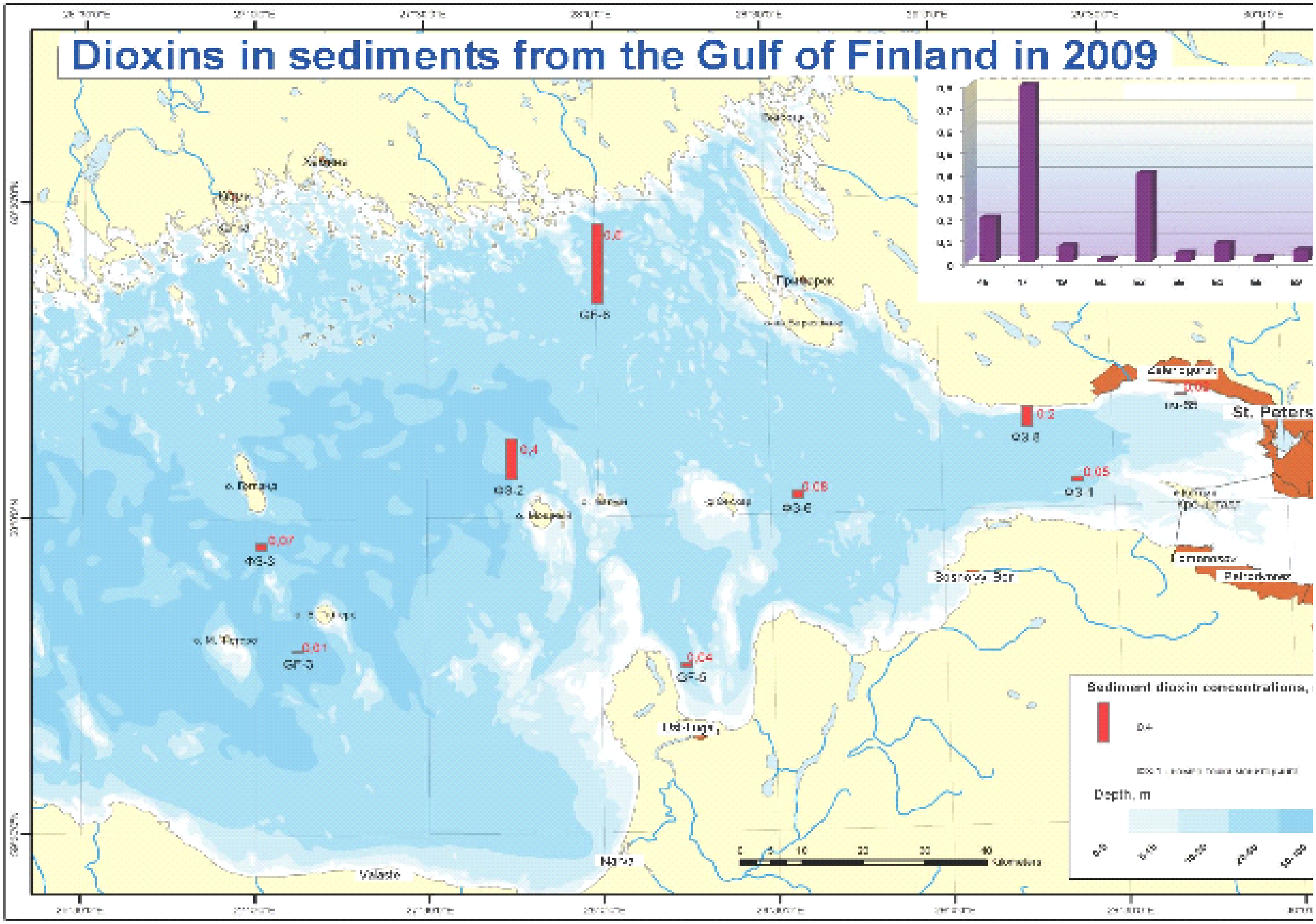


Fig. 3.4.1. Dioxins in sediments from the Gulf of Finland in 2009.

In most of the sediments dioxin content was in the range 0.01-0.08 mg/kg, while it was 0.2 mg/kg in the narrow part, near Northern coast, 0.4 mg/kg near island of Moshchnyj and 0.8 mg/kg near the Russian-Finnish border.

Reported values in 'mg/kg' are, obviously misprinted and real concentrations must be in ng/kg TEQ.

The most recent information (October – December 2011) on PCDD/Fs and dl-PCBs can be found in the report on 'Identification of Sources of Hazardous Substances in St.Petersburg Area' (http://www.helcom.fi/stc/files/Projects/BALTHAZAR/publications/Final_Report_SRCES_Identification_with_cover.pdf).
5 water samples were analyzed. In four of them total concentration was below 0.08 pg/L TEQ, while in the sample taken at Neva river mouth this value was 2.07 pg/L TEQ. In all cases the contribution of dl-PCBs was predominant.

Dioxins were found in two sediment samples, including a sample from port of St.-Petersburg (see table below).

Toxicity in TEF (sediments)

	S148 Tolbukhin island	**S149 Strelna**	**S150 port**	**S151 Utkina Zavod'**	**S153 Elagin bridge**	**S154 Golovin bridge**	**S155 Duderhof**	**S157 Neva near Ostrovki**	**S158 Ohta river mouth**
	pg/g	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**
PCDD/Fs	-	-	0.38	0.11	0.45	13.71	0.36	0.01	17.89
Non-orto PCBs	0.10	0.20	0.61	0.21	0.10	14.15	15.05	0.41	1.32
Mono-orto PCBs	0.02	0.02	0.12	0.03	0.01	3.19	0.38	0.02	0.79
Sum	0.12	0.22	1.11	0.35	0.56	31.05	15.79	0.44	20

The most polluted sediments were found in minor rivers within the city of St.Petersburg. Noteworthy, in Duderhof contribution of non-otro PCBs into total TEQ was predominant, while at Golovin bridge PCDD/Fs and non-orto PCBs have equal contribution. This indicates presence of local, possibly historical, sources.

Samples from WWTPs (sewage water, sludge, effluent) were also analyzed. Concentration in effluent were found between 0.37 and 3.17 pg/L TEQ.

Based on this and other scarce and non-systematic data it is possible to draw a preliminary conclusion that PCDD/Fs are not a major problem for the Russian part of the Gulf of Finland.
Nevertheless, systematic and regular monitoring of PCDD/Fs and dl-PCBs is highly recommended for at least 3 years.
It is recommended to monitor biota (fish) and sediment and not water.
In view of rather high cost of dioxin analysis a stepwise approach can be taken: full-scale sampling and analysis of selected samples. Other samples rest frozen in a sample bank and analyzed if a need arises or additional funds become available.

3.4.2. Relevancy of Polychlorinated biphenyls (PCB) and dioxins and furans: CB-28, 52, 101, 118, 138, 153 and 180; WHO-TEQ of dioxins, furans +dl-PCBs as indicator for Russian Federation.

Both Dioxins and PCBs are relevant as indicator for Russian Federation
For PCBs existing historical data might allow to determine not only current status, but a long-term trend as well. It is highly recommended to launch a project aimed to collection and critical assessment of all data accumulated in the past 20 years.

3.4.3. Current state of monitoring of Polychlorinated biphenyls (PCB) and dioxins and furans: CB-28, 52, 101, 118, 138, 153 and 180; WHO-TEQ of dioxins, furans +dl-PCBs in the Russian Federation

Monitoring of dioxins formally exists, but little data had been collected so far. Available data were obtained largely as a result of independent research. The data is non-systematic, limited spatially and temporally.
No data is available for biota samples.

Available data is not sufficient for conclusions on the status of 'dioxin part' of this indicator in the Russian part of the Gulf of Finland.

PCBs are monitored on a regular basis, but majority of data is not in public domain.
It might be possible, if all data becomes available, to make a pilot status assessment on PCBS in the Russian part of the Gulf of Finland.

3.4.4. Suggestion for GES for Polychlorinated biphenyls (PCB) and dioxins and furans: CB-28, 52, 101, 118, 138, 153 and 180; WHO-TEQ of dioxins, furans +dl-PCBs in the Russian part of the Gulf of Finland

There are internationally agreed «safe levels» of dioxins in fish or sediment. These can be suggested as GES boundaries.

Sediment: 0.85 ng / kg dw (Σ PCDDs+PCDFs)

Fish muscle or mussels tissue: 4.0 ng WHO_{98}-TEQ / kg ww (Σ PCDDs+PCDFs), 8.0 ng WHO_{98}-TEQ / kg ww (Σ PCDDs+PCDFs+dl-PCBs)

Perhaps, after several years of initial monitoring a number of boundaries can be limited to one. On the other hand, standard dioxin analysis presumes determination of all congeners and use of more complex indicator might be rational.

As concentrations of PCDD/PCDFs are very low in water, it is wise not to monitor their concentration in water at all – as indicator parameters.

Use of WHO_{98}-TEQ and not more recent TEQ schemes would not change the status significantly.

For PCBs CORESET project considers sum of six PCBs or PCB 118 + 153 as indicator parameters.
For Russia it may 'improve' ecological status as in sediments PCB 28 and 52 often dominate.
For fish samples it is important to use fat fish (salmon, herring) and for sediment – to normalize PCB content by TOC(total organic carbon).

GES boundary of 75 ng/g ww for seafood (fish, mussles) is a reasonable target; it should be reassessed, however, after initial period.

Suggestion to use PCB 118 and 153 only in GES boundary for sediment is more controversial and must be justified by independent national research project.
It can be accepted only as 'provisional' or 'temporary'.

3.4.5. Suggestions for monitoring.

Monitoring of this indicator can be likely accommodated into existing monitoring activities of Sevmorgeo.

The main task for the first three years should be achievement of reproducible and compatible results, therefore extensive intercalibration and international cooperation is essential.

Due to relatively high cost of dioxin analysis and possible need for repeated measurements more samples can be taken and stored in a sample bank until analyzed later on.

For the first 3 years:

Stations

- Near Vyborg
- Near Primorsk
- Gulf of Luga
- Island of Moshchny (or Malyj)
- Island of Kotlin, outside the dam (or one of small islands nearby)
- Secondary sleeves in Neva delta (Zhdanovka, Smolenka)
- Ladoga lake near Schlisselburg (as a reference point)

Samples

- mussels (if available)
- fish (salmon, herring, if available)
- sediment

Frequency

- 2 pooled mussel samples
- 5 individual fish samples
- 2 sediment samples

The sampling is suggested at each station once a year; preferably in the same time of the year. If possible, more samples can be taken and stored frozen for possible additional measurements in the future.

3.5. POLYAROMATIC HYDROCARBONS (PAHs) AND THEIR METABOLITES: US EPA 16 PAHS / SELECTED METABOLITES.

3.5.1. Status of the indicator in the Russian part of the Gulf of Finland

'Sevmorgeo' (institution of Ministry of Natural Resources of RF) is carrying monitoring of the shelf and has made some of the data publicly available.
http://www.sevmorgeo.com/rus/bull_new.pdf

In 2009 high sediment levels of PAHs was found in sediments of the St. Petersburg and Vyborg harbours (in the range 3000 – 4500 mg/kg at some stations), and significant levels near Primorsk (500 – 1000 mg/kg).
The map below shows location of monitoring sampling stations in 2009 (Fig. 3.5.1).

There exists also historical data on pollution of the Gulf of Finland.
In particular, 'Monitoring of the Arctics'(nowadays – NW branch of NPO 'Typhoon') monitored PAHs for some 20 years. (http://esimo.oceanography.ru/esp2/index/index/esp_id/1/section_id/8/menu_id/4644, http://esimo.oceanography.ru/esp2/index/index/esp_id/1/section_id/8/menu_id/4625)

In 1998, 10 out of 24 PAHs had been detected. Maximal levels of benzo[a]pyrene were found in water of Petrovsky fairwater. Hghest levels of naphthalene were found in open part of Sea Channel, highest levels of phenanthrene - in northern part of Luga bay, highest levels of anthracene – near Western end of Kotlin island.

Most polluted sediments were those from open part of Sea Channel and from Petrovsky fairwater.

PAHs in water of the Eastern part of the Gulf of Finland, 1997-1999, ng/L

	1997	1998	1999, near surface	1999, near bottom
Naphthalene	0,1 – 10,1	2,6 – 64,7	2.5-84.6	2.0-17.4
Phenanthrene	0,1 – 16,1	0,3 – 56,2	1.0-22.3	1.35-8.10
Fluoranthene	0,7 – 2,1	0,24 – 9,1	0.2-4.2	0.2-1.6
Benzo(k)fluoranthene	0,2 – 0,85	0,10 – 5,5	0.1-0.4	0.1-0.2
Benzo(a)pyrene	<0,5 –0,85	0,5 – 6,6	-	-
Anthracene	< LOD	0,05 – 10,2	0.1-1.5	0.1-0.3
Benzo(a)anthracene	< LOD	0,14 – 10,3	-	-
Chryzene	< LOD	0,3 – 9,0	-	-
Indeno(123cd)pyrene	< LOD	1,0 – 7,3	-	-
Benzo(ghi)perylene	< LOD	0,5 – 8,4	-	-

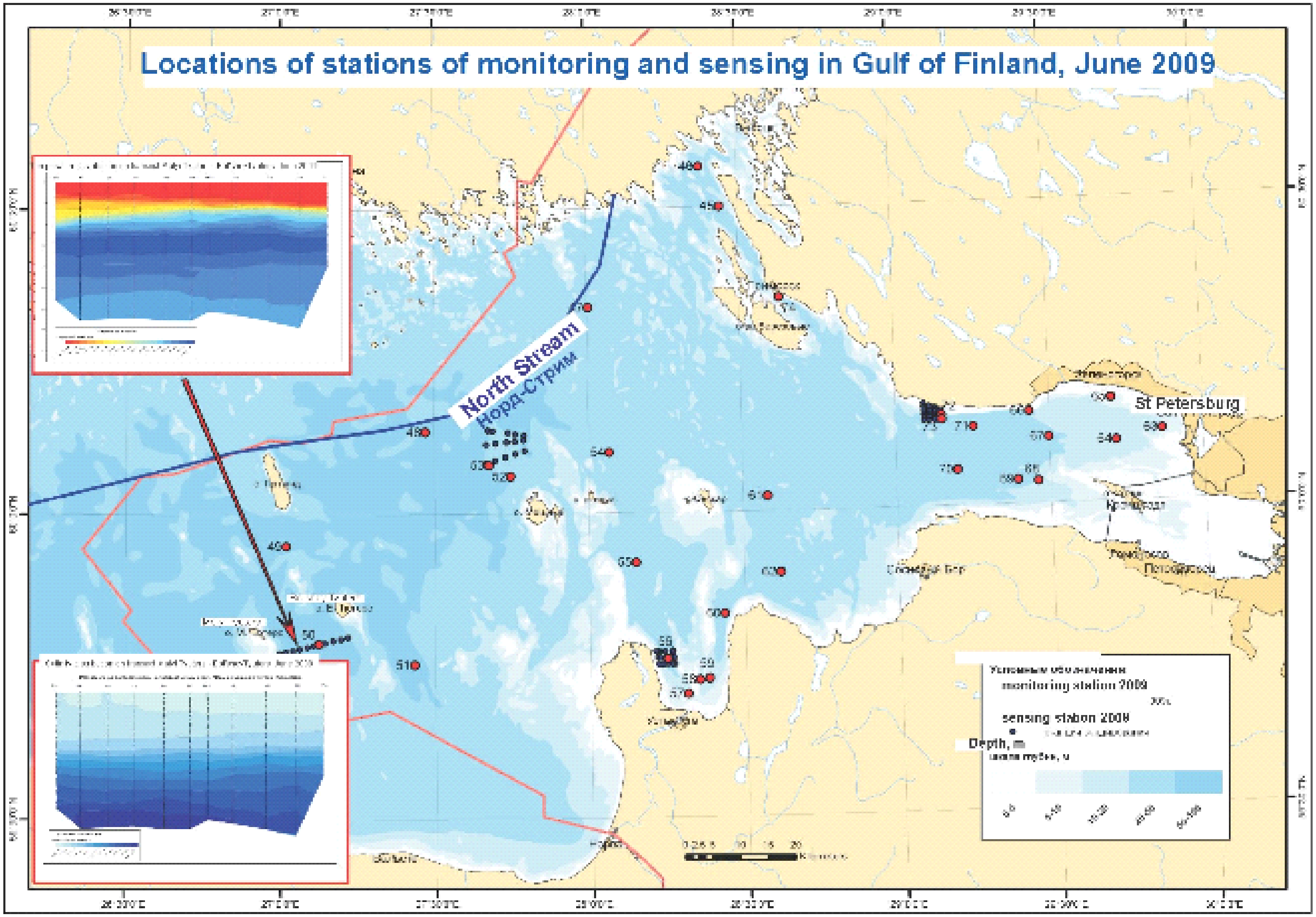


Fig. 3.5.1. Location of ‘Sevmorgeo’ monitoring stations

PAHs in bottom sediments of the Eastern part of the Gulf of Finland, 1997-1998, ng/g

	1997	1998
Naphthalene	3,1 – 80,5	1,92 – 149,0
Phenanthrene	16,6 – 34,3	2,28 – 344,0
Fluoranthene	10,1 – 60,2	0,20 – 200,0
Benzo(k)fluoranthene	-	0,02 – 78,0
Benzo(a)pyrene	6,0 –23,0	0,02 – 101,0
Anthracene	-	0,04 – 38,4
Benzo(a)anthracene	-	0,05 – 133
Chryzene	-	0,12 – 104,0
Indeno(123cd)pyrene	-	0,8 – 91,1
Benzo(ghi)perylene	15,2 – 58,5	1,3 – 61,4

Benzo[a]pyrene was detected in 96% of sediment samples taken along the waterway Ladoga lake – Neva river - Eastern part of the Gulf of Finland (Krylenkova N.L., Aromatic and polycyclic aromatic compounds in water system Ladoga lake – Neva river - Eastern part of the Gulf of Finland: case study of phenols and 3,4-benzopyrene. Ph.D. Thesis, St.Petersburg, 2004, http://www.dissercat.com/content/aromaticheskie-i-politsiklicheskie-aromaticheskie-soedineniya-v-vodnoi-sisteme-ladozhskoe-oz

In 2004 PAHs were detected in water samples from the Gulf of Finland. Average sum of PAHs was 14.2 ng/L, the highest level – 132ng/L was detected in the port of Primorsk. Maximal level of benzo[a]pyrene was 1.87ng/L(40% of MAC).

In bottom sediments total PAHs were found at concentrations between 8.5 to 14500 ng/g. The most polluted sedment sample was from the Vyborg port (Island of Bolshoy Beryozovyj), concentration of benzo[a]pyrene reached 1123ng/g, exceeding MAC by a factor of 56. Average concentration of benzo[a]pyrene was 96.2ng/g, of sum of 16 PAHs – 810 ng/g.
http://esimo.oceanography.ru/download/ezh/2004/part_5.3.pdf

PAHs were measured in Luga bay, in connection with construction of the port of Luga (2008). Concentration of PAHS in surface waters was 5.17-107.6ng/L (average – 21.7ng/L), in bottom waters – 2.98 – 87.7ng/L(average – 20.08 ng/L). Highest concentrations in water were measured in April, lowest – in June.

In bottom sediments total PAHs were in the range 5.4-173 ng/g, with avergae value of 26ng/g (http://oceanography.ru/index.php/ru/component/jdownloads/finish/38/189).

Most recently PAHs have been measured in water, sediment and WWTP sewage/effluent/sludge within BALTHAZAR project ('Identification of Sources of Hazardous Substances in St.Petersburg Area', 2011-2012,
http://www.helcom.fi/stc/files/Projects/BALTHAZAR/publications/Final_Report_SRCES_Identification_with_cover.pdf).

Sum of PAHs along Neva river and to Tolbukhin island varied between 37 and 195 ng/L in water.
In sediment high concentrations were observed in samples from Neva tributaries (Okhta river mouth – 3400 ng/g, Elagin bridge – 8300 ng/g, Golovin bridge – 3300 ng/g). Concentration of 16 PAHs in sediment from Tolbukhin island was 15.2 ng/g.

Very low concentrations of PAHs were detected in WWTP effluents. In contrast, rather high concentration were found in WWTP sludge (up to 4000ng/g).

There is a plenty of data on PAHs in water and sediment of the Gulf of Finland, collected in the past 20 years. The data is non-systematic, and its quality can not be easily verified. Raw data is not in the open access. There seem to be no data on PAHs in fish or other biota samples.

Despite its non-systematic character existing data on PAHs can be retrieved and used for pilot status assessment of the Russian part of the Gulf of Finland, provided data is scrutinized for reliability and compatibility. Such assessment would present a separate research project and thus is beyond the scope of the current consideration.

No information is available on PAH metabolites.

3.5.2. Relevancy of PAHs and selected metabolites as indicator for Russian Federation.

<u>PAHs are relevant as indicator for Russian Federation</u>
For PAHs existing historical data might allow to determine not only current status, but a long-term trend as well.
No doubt, at least all 16 US EPA PAHs have to be monitored for correct assessment of this indicator.
No conclusion can be made on usefulness of PAH metabolites as indicator until more data on fish is available, structures of metabolites are specified and justified and analytical methods are established and tested.
Therefore it is necessary to arrange monitoring of this parameter in the coming years.

3.5.3. Current state of monitoring of in the Russian Federation

PAHs are being monitored on a regular basis, but majority of data is not in public domain.
It might be possible, if all data becomes available, to make a pilot status assessment on PAHs in the Russian part of the Gulf of Finland.
It is strongly recommended to launch such a project, aimed at compilation and harmonization of all available data and identification of status and trends of this indicator in the Russian part of the Gulf of Finland.

3.5.4. Suggestion for GES for PAHs and selected metabolites in the Russian part of the Gulf of Finland

OSPAR-EAC values for PAHs can be accepted as provisional GES boundaries (http://www.ospar.org/documents/dbase/publications/p00563_cemp_2011_assessment_report.pdf).
Presumably, upon initial period of harmonization only few of 16 PAHs would be left as indicator substances.
There is no sufficient information to suggest GES boundaries for PAH metabolites in fish.

3.5.5. Suggestions for monitoring.

Monitoring of this indicator can be likely accommodated into existing monitoring activities of Sevmorgeo or NW branch of NPO ‘Typhoon’.

As no method exists in Russian Federation for PAH metabolites in fish, fish samples should be collected and kept frozen in a sample bank until such method becomes available.

<u>For the first 3 years:</u>

Stations

- Near Vyborg
- Near Primorsk
- Luga Bay
- Island of Moshchny (or Malyj)

- Island of Kotlin, outside the dam (or one of small islands nearby)
- Secondary sleeves in Neva delta (Zhdanovka, Smolenka)
- Ladoga lake near Schlisselburg (as a reference point)

Samples

- mussels (bivalves, if available)
- fish (common species)
- bottom sediment

Frequency

- 2 pooled mussel samples
- 5 individual fish samples
- 2 sediment samples

The sampling is suggested at each station once a year; preferably in the same time of the year. If possible, more fish samples can be taken and stored frozen for possible additional measurements in the future.

3.6. METALS (LEAD, CADMIUM AND MERCURY)

3.6.1. Suitability and appropriateness of heavy metals for use as indicators in Russian part of the Gulf of Finland

Heavy metals, including mercury, cadmium and lead, in the Russian Federation are main pollutants that have toxic effects on living organisms, so these metals should be included in the compulsory program of monitoring of the Gulf of Finland. Heavy metals mostly come from sewage of industrial enterprises and precipitation, and there is a constant exchange of heavy metals between the water and bottom sediments.

3.6.2. Monitoring of this indicator in Russian part of the Gulf of Finland:
The concentrations of heavy metals are monitored in a water and bottom sediments of the Gulf of Finland.

3.6.2.1. Monitoring of heavy metals in the water of the Gulf of Finland

Federal Service for Hydrometeorology and Environmental Monitoring of the Department Roshidromet on Nort-West Federal District performs regular monitoring of heavy metals in the waters of the Gulf of Finland at 31 stations (Anonymous, 2009) (Table 3.6.1; for the positions of monitoring stations see Fig. 3.6.1.-3.6.2). The program includes regular monitoring of lead and cadmium, mercury is determined sporadically. Long-term observations on the content of heavy metals are absent in the published version, while aggregated results are freely available. Observations at many of the sampling stations are conducted for more than 100 years.

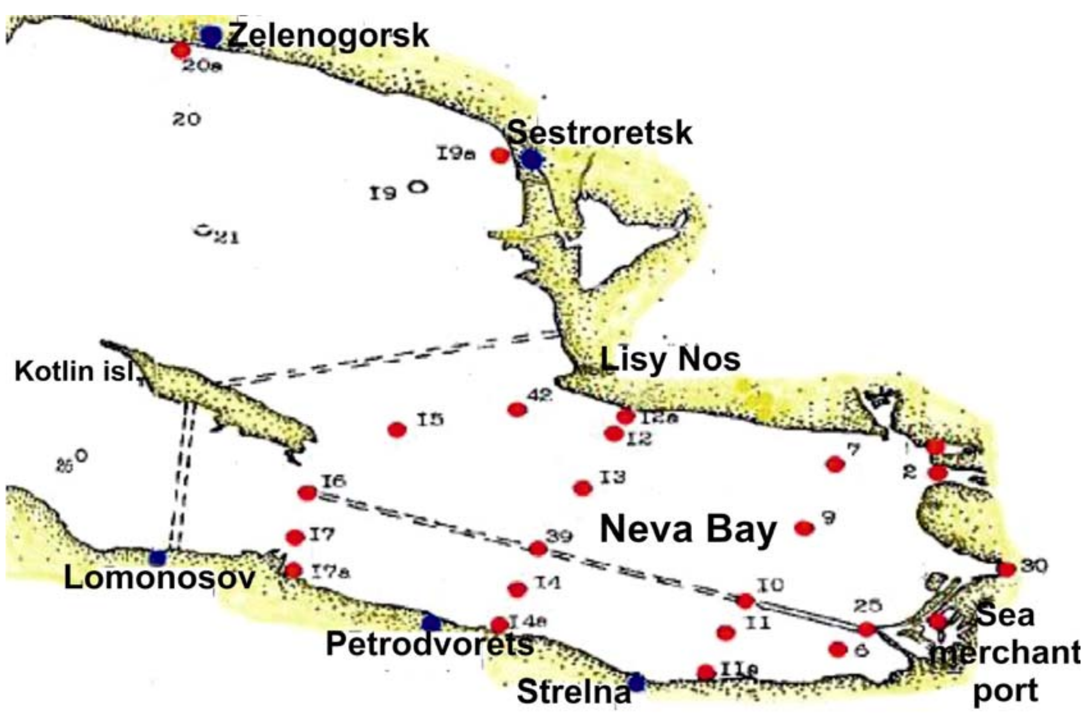


Fig. 3.6.1. Location of the stations of Federal Service for Hydrometeorology and Environmental Monitoring of the Department Roshidromet on Nort-West Federal District in the Neva Bay of the Gulf of Finland

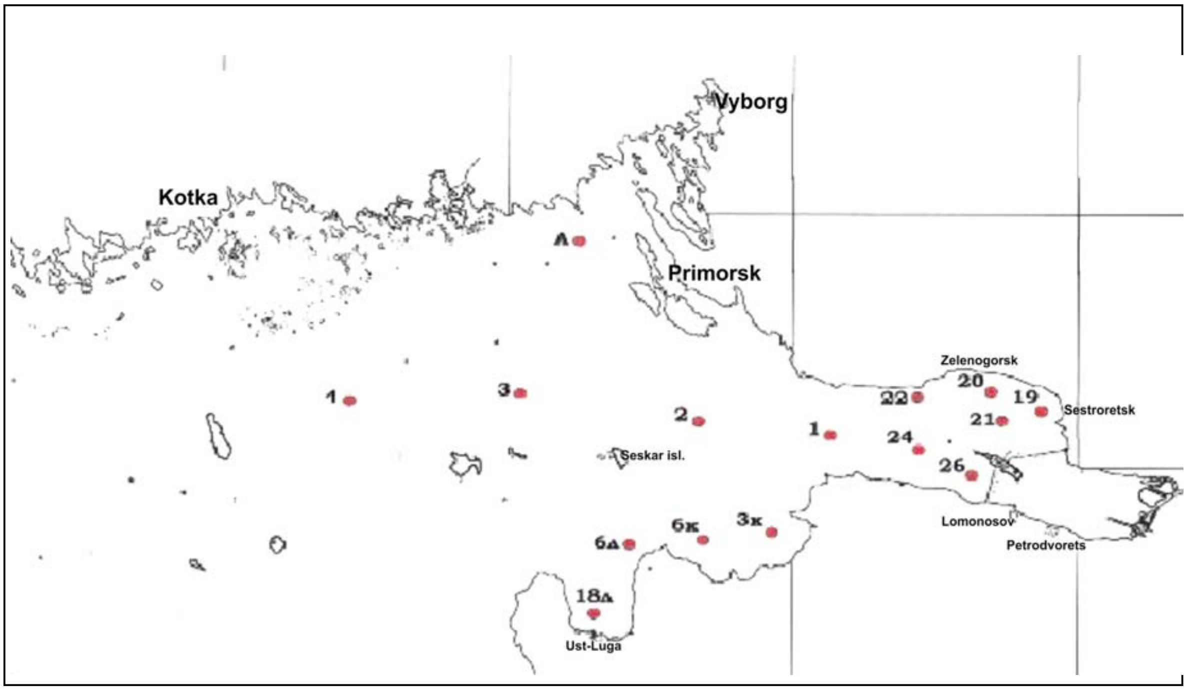


Fig. 3.6.2. The same as on Fig.1, but for the E part of Gulf of Finland

Table 3.6.1: Sampling stations of the monitoring program on hydrochemical conditions and level of contamination in the eastern part of the Gulf of Finland.

Station number	Station name	Latitude	Longitude	Sampling horizons	Description of the position
5	St.Petersburg port.	59°53	30°13	Surface; bottom	Commercial Sea Port, Neva river discharge
1	Neva bay	59° 58	30°13	Surface; bottom	Neva river discharge
2	Neva bay	59°58	30°13	Surface; bottom	Neva river discharge
30	Neva bay	59°55	30°15	Surface; bottom	Neva river discharge
25	Neva bay	59°53	30°10	Surface; bottom	Marine channel
6	Neva bay	59°52	30°09	Surface; bottom	The southern part of the Neva bay
7	Neva bay	59°58	30°09	Surface; bottom	Nothern part of the Neva bay
9	Neva bay	59°56	30°07	Surface; bottom	Central part of the Neva bay, the impact of municipal wastewater
10	Neva bay	59°54	30°05	Surface; bottom	Marine channel, the impact of municipal wastewater
11	Neva bay	59°53	30°04	Surface; bottom	The southern part of the Neva bay
11a	Neva bay	59°51	30°03	Surface; bottom	The southern part of the Neva bay
12a	Neva bay	59°59	30°00	Surface; bottom	Nothern part of the Neva bay
12	Neva bay	59°59	30°00	Surface; bottom	Nothern part of the Neva bay

Station number	Station name	Latitude	Longitude	Sampling horizons	Description of the position
13	Neva bay	59°57	29°58	Surface; bottom	Central part of the Neva bay
39	Neva bay	59°55	29°57	Surface; bottom	Central part of the Neva bay,
14	Neva bay	59°54	29°56	Surface; bottom	The southern part of the Neva bay
14a	Neva bay	59°53	29°55	Surface; bottom	The southern part of the Neva bay, the impact of municipal wastewater
42	Neva bay	60°00	29°56	Surface; bottom	Nothern part of the Neva bay, the impact of municipal wastewater
15	Neva bay	59°59	29°51	Surface; bottom	Central part of the Neva bay, the impact of municipal wastewater
16	Neva bay	59°57	29°47	Surface; bottom	Central part of the Neva bay, Marine channel, the impact of municipal wastewater
17	Neva bay	59°56	29°47	Surface; bottom	The southern part of the Neva bay, the impact of municipal wastewater
17a	Neva bay	59°55	29°47	Surface; bottom	The southern part of the Neva bay, the impact of municipal wastewater
19a	Shallow-water area	60°07	29°56	Surface; bottom	Nothern part of the shallow area, the impact of municipal wastewater
19	Shallow-water area	60°06	29°52	Surface; bottom	Nothern part of the shallow area, the impact of municipal wastewater
20a	Shallow-water area	60°11	29°42	Surface; bottom	Nothern part of the shallow area, the impact of municipal wastewater
20	Shallow-water area	60°08	29°42	Surface; bottom	Nothern part of the shallow area, the impact of municipal wastewater
21	Shallow-water area	60°05	29°43	Surface; bottom	Central part of the shallow area north of the Kotlin island
26	Shallow-water area	59°58	29°37	Surface; bottom	Central part of the shallow area, south of the Kotlin island

Monitoring of the status of the Gulf of Finland is also carried out by specialized organizations like the Federal State Unitary Scientific and Production Company for Marine Geological Prospecting 'Sevmorgeo' and the North-West Branch of Research and Production Association 'Typhoon'.

3.6.2.2. Monitoring of heavy metals in bottom sediments of the Gulf of Finland

Sampling of sediments and analysis of heavy metal concentrations has not yet been included in the program of observations of the Federal Service for Hydrometeorology and Environmental Monitoring of Russia (Roshydromet). All information on the contamination of sediments was obtained during scientific expeditions carried out by specialized organizations (the Federal State Unitary Scientific and Production Company for Marine Geological Prospecting 'Sevmorgeo' and the North-West Branch of Research and Production Association 'Typhoon', etc.) (fig. 3.6.3.). Specialized organizations monitor the concentration of heavy metals, as a rule, at the stations of Hydromet in the parts Gulf of Finland with highest anthropogenic pressure: the Gulf of Vyborg, Luga Bay, Koporskaya Bay, area near the Primorsk, Vysotsk, and Vyborg cities, shallow waters of the Gulf of Finland, Shepelevsky Reach (Korshenko et al., 2006; 2008; Newsletter, 2009).

3.6.3. Safe levels of heavy metals and GES

There are several water quality standards In Russian Federation for the content of heavy metals in the water, depending of the ways and goals of water usage. Maximum allowable concentrations (MAC) are defined by the fisheries standards or household and drinking standards depending on the category of water body (see Table 3.1) (Order, 2010; Hygienic standards). The standards for water quality for fisheries goals water use category are the highest and they certainly describe a good environmental status.

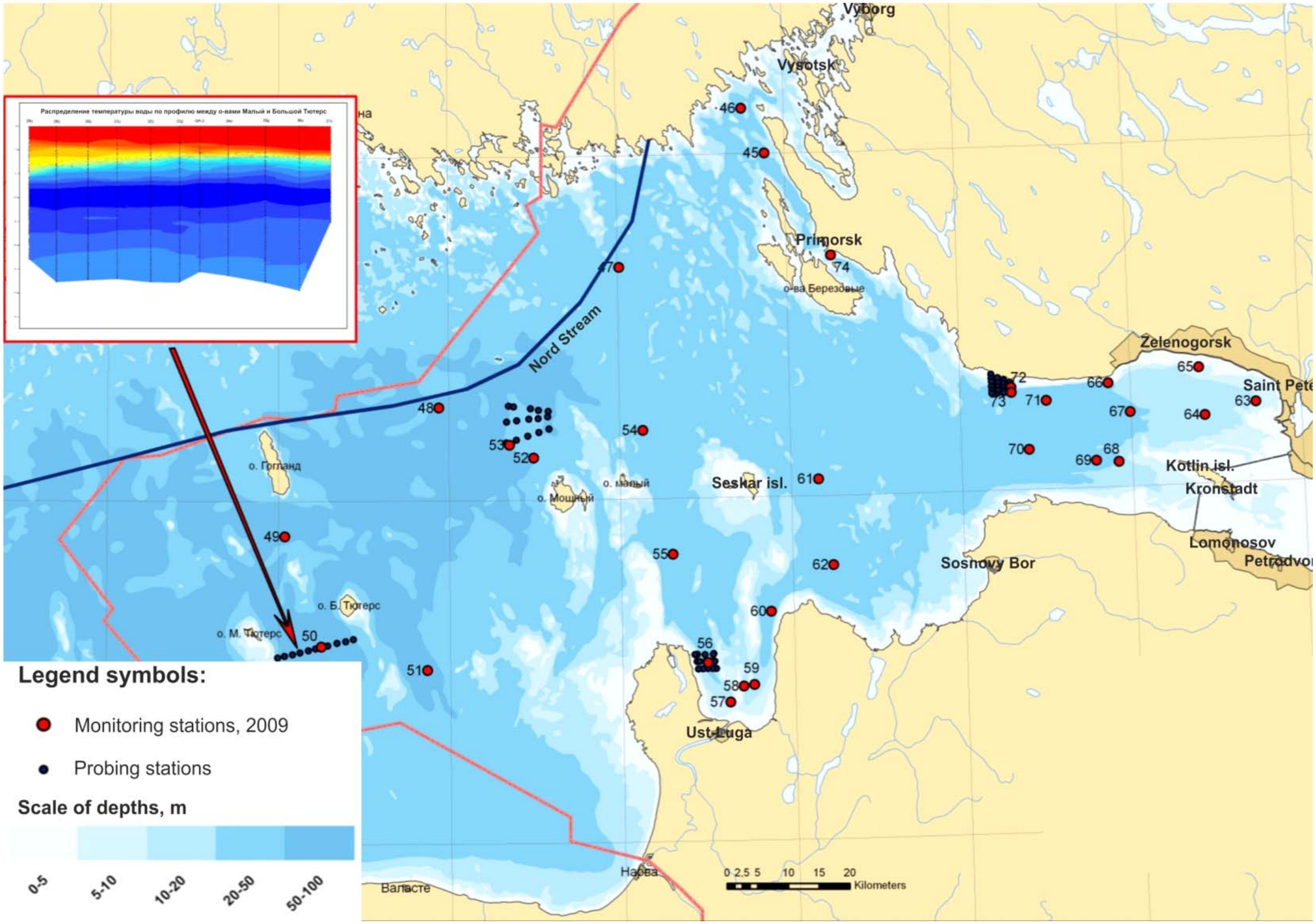


Fig. 3.6.3. Location of the monitoring stations in the Gulf of Finland conducted by the Federal State Unitary Scientific and Production Company for Marine Geological Prospecting 'Sevmorgeo' in 2009.

Table 3.6.2.: MAC for cadmium, lead and mercury for fishery category of water use

№	Pollutant	Fisheries water category of water use		Household and drinking water use category
		MAC mg/dm^3	MAC (for the seas) mg/dm^3	MAC mg/dm^3
1	Cadmium	0.005	0.01	0.01
2	Lead	0.006	0.01	0.001
3	Mercury	absence (0.00001)	0.0001	0.0005

Let us accept the most stringent standards as allowable concentrations of heavy metals in the Gulf of Finland, namely, cadmium 0.005 mg/dm^3; lead 0.001 mg/dm^3; mercury 0.00001 mg/dm^3

Table 3.6.3.: Standards on the content of heavy metals in the bottom sediments (after Anonymous, 2009)

№	Pollutant	Allowable concentrations (AC) of pollutants in the sediments of water bodies in according to Neue Niederlandische Liste. Altlasten Spektrum 3/95), µg/g	MAC according to Russian standards, µg
1	Cadmium	0.8	1.2
2	Lead	85	85
3	Mercury	0.3	-

Let us accept the following allowable concentrations of heavy metals in the Gulf of Finland: cadmium 0,8 µg/g; lead 85 µg/g; mercury 0,3 µg/g what can be considered as GES level.

3.6.4. Dynamics of heavy metals content in the Gulf of Finland

3.6.4.1. Change of the concentation of heavy metals in the waters of Gulf of Finland

As a result of monitoring carried out by Sevmorgeo the concentrations of lead in the bottom waters in 1999-2009 decreased from 18-20 µg/l (in 1999-2001) to 11-12 µg/l (in 2006-2007) up to 3.1 µg/l (in 2008-2009) because of decreased lead input from the shore. The concentration of cadmium during this period has not changed and fluctuated between 0.5-2 µg/l, well below the MAC.

In 2004 and 2005, Regional Center for Arctic Monitoring carried out a survey of anthropogenically loaded sites of the Gulf of Finland [3.4] on the fairway, opposite of Sosnovy Bor, in the Koporskaya Bay, in the operating area of the Ust-Luga port, near Primorsk oil terminal and the adjoining Bjorkezund strait, in the Gulf of Vyborg near the cities of Vyborg and Vysotsk, and in the waters of the Gulf of Vyborg - showed that lead concentrations varied in the range of 2.1-2.7 µg/l, and in 2005 in the range of 2 6-6.8 µg/g. Peak values are common in the coastal area of the Koporskaya Bay and oprerational area of the Ust-Luga. The average content of cadmium in 2004-2005. at all points was below MAC and fluctuated between 1.4-2.2 µg/l in 2004 and 2.6-4.1 µg/l in 2005. Peak concentrations were also noted in the coastal area of the Koporskaya Bay and operational waters of the port of Ust-Luga, besides, high values were observed in all the parts of the Gulf of Vyborg.

The average concentration of mercury in 2004 and 2005 was 0.02 µg/l with the maximum values of 0.13 µg/l in 2004 and 0.06 µg/l in 2005, which were above MAC.

3.6.4.2. The dynamics of heavy metal consentrations in the sediments of the Gulf of Finland

Analysis of the heavy metal contents in the bottom sediments, carried out by Regional Center for Arctic Monitoring (Korshenko et al., 2009) in 2004 and 2005, evidenced that mercury and cadmium did not exceed the established limits in all the research areas. The maximum concentration of mercury was found in the bottom sediments of operational areas of the port Ust-Luga and Primorsk city, as well as in various parts of the Gulf of Vyborg. The concentrations of mercury in the sediments in 2005 decreased compared to 2004, and the peak values decreased from 2.2 µg/g to 0.18 µg/g. The maximum cadmium concentration was noted in the same parts of the Gulf of Finland.

In 2009, Mercury concentration in the sediments substantially exceeded MAC in the Vyborg Bay (0.52 µg/g), in the coastal resort area of St.-Petersburg on Shepelevsky Reach (0.85 µg/g) (see fig. 3.6.4.).

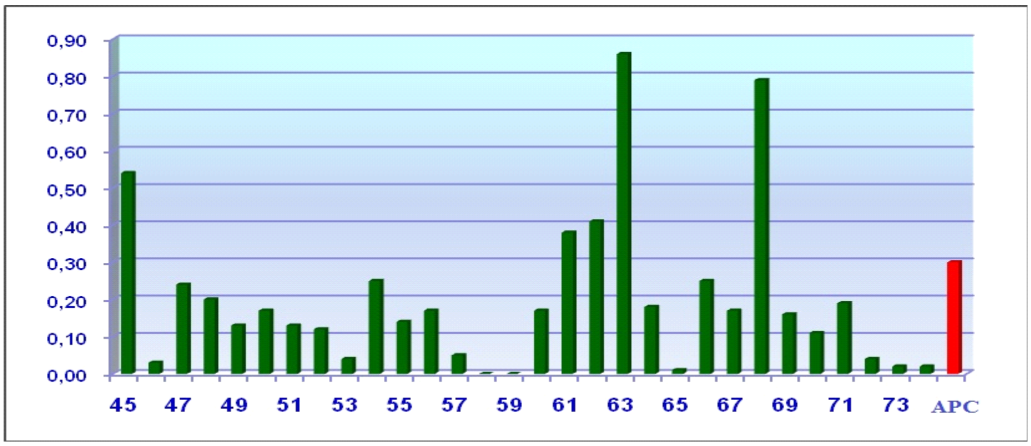


Fig. 3.6.4. Concentrations of mercury (µg/dm^3) in the bottom sediments of the Gulf of Finland (on the abscissa axis are the stations numbers; locations are indicated on a map fig. 3.6.3)

3.6.5. Recommendations for heavy metals monitoring in the Gulf of Finland

An established network of water and sediment quality monitoring stations of the Hydrometheorological Center of Russia in the Gulf of Finland can be used to monitor the heavy metal concentrations in water and sediments. Mercury should be added to the list of pollutants routinely monitored in the water. Concentrations of heavy metals should be determined every six months in the water, and once a year in the sediment.

Monitoring of heavy metals in the Gulf of Finland should be done in the mouth of the Neva river, on the fairway, in the Shepelevsky Reach and Vyborg Bay, where the suspended load from St. Petersburg and Vyborg accumulate, and in the coastal part of the Koporskaya Bay near Sosnovy Bor, in the operational area of Ust-Luga port, in the Strait Berkezunnd, in the Gulf of Vyborg, including operational areas of the Primorsk port and the berths in Vysotsk and Vyborg ports.

3.7. TRIBUTYLTIN (TBT) AND IMPOSEX

3.7.1. Status of the indicator in the Russian part of the Gulf of Finland

There is no official analytical method for TBT in the Russian Federation and there are few laboratories offering TBT measurements.

However, tributyltin chloride can often be detected in sediments of the Russian part even by direct GC-MS analysis (fig. 3.7.1).

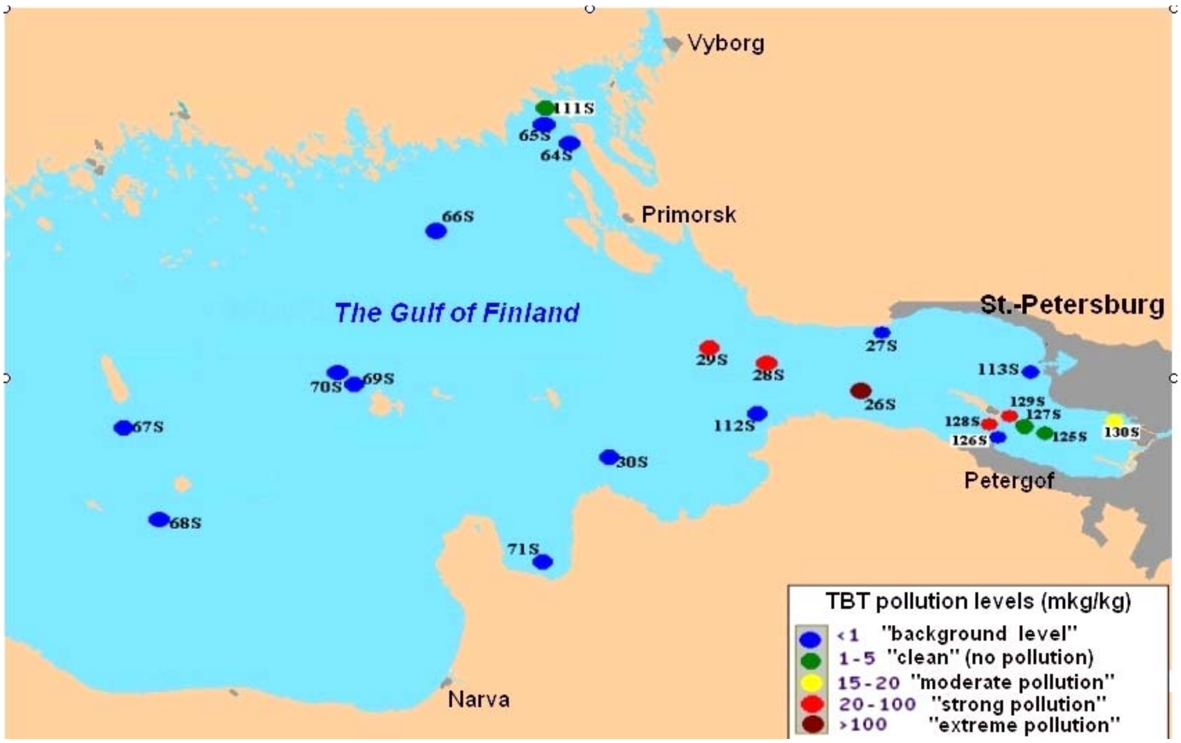


Fig. 3.7.1. Sampling points in the Russian part of the Gulf of Finland and levels of Tributyltinchloride by direct GC-MS determination (http://www.j-analytics.ru/journal/article/3429). Color map – Blue: < 1 g/kg, 'background level'; green: 1-5 □g/kg, 'no pollution'; yellow: 5-20 □g/kg, 'moderate pollution'; red: 20-100 g/kg, 'strong pollution'; brown: > 100 □g/kg, 'extreme pollution'.

Several samples are found to contain dangerous amounts of TBT-chloride. Maximum (6000 □g kg^{-1}d.w.) was registered in the sediment from the St.Petersburg fairway near Krasnaya Gorka (L. Khoroshko, V. Nikiforov, Z. Zhakovskaya, V. Mamontova, G. Kukhareva, Direct determination of tributyltin chloride in bottom sediments of the eastern part of the Gulf of Finland by GC-MS, Analytica, 2012, 5, http://www.j-analytics.ru/journal/article/3429).

More comprehensive study that targeted TBT and related organotin compounds was 'Identification of Sources of Hazardous Substances in St.-Petersburg Area' (http://www.helcom.fi/stc/files/Projects/BALTHAZAR/publications/Final_Report_SRCES_Identification_with_cover.pdf). The study was part of EU-financed HELCOM project BALTHAZAR performed in 2011-2012 by the St.Petersburg Center for Ecological Safety, Russian Academy of Sciences (SRCES RAS).
Organotins were found in both water and sediments of Neva river and Gulf of Finland (Table 3.7.1 – 3.7.2).

Table 3.7.1. Organotins in Neva water

	W324 Neva near Slavyanka	W325 Neva near Sapernyi
	µg/L	**µg/L**
Monobutyltin (MBT)	< 0,01	< 0,01
Dibutyltin (DBT)	0.63	0.97
Tributyltin (TBT)	1.44	1.39
Triphenyltin (TPT)	6.41	1.67
Sum of organotin compounds	**8.48**	**4.03**

Table 3.7.2. Organotins in sediments of Neva river and Gulf of Finland

	S148 Tolbukhin island	**S149 Strelna**	**S150 port**	**S151 Utkina Zavod'**	**S153 Elagin bridge**	**S154 Golovin bridge**	**S155 Duderhof**	**S157 Neva near Ostrovki**	**S158 Ohta river mouth**
	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
MBT	3.71	0.15	0.32	0.38	0.05	< 0,01	< 0,01	0.06	0.04
DBT	1.62	1.25	2.02	9.51	0.22	0.57	0.23	1.71	0.09
TBT	33.6	0.04	0.34	0.15	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01
TPT	0.14	0.11	0.06	0.17	0.07	0.04	0.05	0.04	0.09
Sum	**39.1**	**1.55**	**2.74**	**10.2**	**0.34**	**0.61**	**0.28**	**1.81**	**0.22**

Noteworthy, TBT was not a major organotin contaminant in low or moderately polluted sediments. Only in the most contaminated sediment, from Tolbukhin island area, TBT comprised ca 85% of total organotin pollution.

TBT or its analogs were found only on one of the three studied WWTPs of St.-Petersburg (Table 3.7.3). This indicates presence of a local source of pollution.

Table 3.7.3. Organotins in St.Petersburg WWTP water samples

	W334 WWTP 1 Influent	W335 WWTP 1 Effluent	W336 WWTP 2 Influent	W337 WWTP 2 Effluent	W338 WWTP 3 Influent	W339 WWTP 3 Effluent
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Monobutyltin	2.09	0.74	< 0,01	< 0,01	< 0,01	< 0,01
Dibutyltin	2.21	0.42	< 0,01	< 0,01	< 0,01	< 0,01
Tributyltin	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01
Triphenyltin	1.33	0.98	< 0,01	< 0,01	< 0,01	< 0,01
Sum of organotin compounds	**5.63**	**2.14**	**< 0,01**	**< 0,01**	**< 0,01**	**< 0,01**

This first ever data on organotins has to be treated with caution, as ISO 17353 method was employed with limitations. It is possible to conclude, however, that organotins are widespread in the area.
A point of concern is that concentrations often exceed Russian MAC (0.01 µg/L) and further exceed EU AA-EQS (0.0002 µg/L).
Existing methods do not allow to analyze such low concentrations (0.0002 µg/L).

No data is available on TBT in biota.

3.7.2. Relevancy of TBT as indicator for Russian Federation.

<u>TBT is a relevant indicator.</u>
Russia is a great marine country, and St.-Petersburg is one of the biggest sea ports of the Baltic Sea. There are other ports besides St.-Petersburg, e.g. Luga, Vyborg, Primorsk, Vysotsk, Kronstadt.
As sea traffic is a major source of organotin compounds, extensive monitoring of the Russian part of the Gulf of Finland - rather narrow and shallow part of the Baltic Sea is critical.

3.7.3. Current state of monitoring of TBT in the Russian Federation

Monitoring program does not exist. Available data is limited and needs confirmation; obtained as a result of independent research. The data is non-systematic, limited spatially and temporally.
No data is available for biota samples.

Available data is not sufficient for conclusions on the status of this indicator in the Russian part of the Gulf of Finland, but it is sufficient to suggest in many areas the status can be declared bad.

3.7.4. Suggestion for GES for TBT in the Russian part of the Gulf of Finland

CORESET project suggest the following GES boundaries:

- Water: 0.2 ng/L
- Sediment: 0.02 g/kg
- Biota: 12 g/kg DW (for mussels)
- Seafood: 15.2 g/kg WW for seafood

The values for sediment and water seem to be too low for established analytical methods. Available data suggests all St.Petersburg area would fall into ‘bad status’ category. Therefore at present such low levels cannot be accepted as GES boundaries.

Instead, more extensive monitoring, including all other related organotin compounds is recommended.

3.7.5. Suggestions for monitoring.

In light of threatening existing data very extensive monitoring is required in the first 3 years. Later, based on the results, the frequency and geographical coverage can be limited.

<u>For the first 3 years:</u>

Stations

- Near Vyborg
- Near Primorsk
- Luga Bay
- Island of Moshchny (or Malyj)
- Island of Kotlin, outside the dam (or one of small islands nearby)
- Secondary sleeves in Neva delta (Zhdanovka, Smolenka)
- Ladoga lake near Schlisselburg (as a reference point)
- 5 stations along St.Petersburg Sea Channel
- 5 other points inside the sity of St.Petersburg
- 5 other points (randomly) in the open part of the Gulf of Finland

Samples

- fish (two common species)
- sediment
- bivalve mollusks (if available)

Frequency

- 5 individual fish samples
- 2 sediment samples
- 1 water sample

The sampling is suggested at each station twice a year or even more frequently for sediment samples.

Additional remark

It is important to monitor related organotin species – dibutyltin, monobutyltin, triphenyltin, dioctyltin, monooctyltin.

4. INDICATORS, BASED ON BIODIVERSITY AND FOOD WEBS

4.1. LYSOSOMAL MEMBRANE STABILITY – A GENERAL STRESS INDICATOR

4.1.1. Possibility of using the indicator 'Lysosomal membrane stability' in the Russian part of the Gulf of Finland

Lysosomal membrane stability (LMS) as an indicator suggested for environmental assessment is really good because of its generality, rapidity and easiness.The indicator can be used for all eukaryotic organisms from yeast and protozoans to humans, and is a universal marker of stressful conditions, as lysosomal functional integrity is a generic common target for environmental stressors (Cuervo, 2004). It takes not more than two hours to test the ecological status of the ecosystem of interest and does not need any complicated equipment (Moore, Depledge et al., 2004; Moore et al, 2004). The problem is that most investigations on the population level need months or even years of observation, whereas modern ecologists need some methods to rapidly test the environmental conditions and predict the situation. The lower the level of organization, the faster the changes occur and accumulate. That is why molecular techniques should be introduced into ecological monitoring.

Unfortunately, in Russia and CIS countries it is not so broadly used for ecological monitoring and for Russian waters of the Gulf of Finlandis not used at all.

However, Black Sea marine environmental quality is monitored exactly using this method (Kostylev et al, 2010), more precisely, the Neutral Red Retention Test in mussels *(Mytilus galloprovincialis*), within the framework of implementation a Pilot 'Mussel Watch' programme to assess the health status of mussel populations and ecosystems in the Black Sea (Goldber et al., 1978; Moore, et al. 1999).It was also suggested to be introduced in practice during international workshops on biological effects of pollutants in in the Black Sea in Plymouth,1995; Odessa,1996; Istambul,1997.

Another Russian Institute - Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO) in cooperation with Akvaplan-niva Companyalso used The Neutral Red Retention Testas a biomarker inecological monitoring of Barents Sea waters.

There are some Russian papers focusing on the activity of lysosomal enzymes in fish but not on lysosomal membrane stability. There are also some data on enzyme systems activities in molluscs (proteolitic enzymes, nucleases, phosphatases and dehydrogenases).

In Russia lysosomal membrane stability as an indicator is much more widely used in biomedical research – for example, investigations focused on cell activation during immune and allergic reactions, cancer biology, stress reactions and such, experiments being carried on intact organism or cell culture.

Ecological monitoring methods generally used in Russia are mostly based on the analysis of taxonomy composition, estimation of abundance and health status of the organisms,on production characteristics, such as annual production, biomass and abundance, or parameters of growth, mortality and survival rates.Such methods are mostly applied in the longitudinal studies on the population level. Thus, Couronian lagoon of the Baltic Sea is still monitored with the help of zooplankton. The ecological situation is assessed on the basis of species composition. Hydrochemical methods are still the most popular ones to indicate the quality of water, although bioindication can be easier and more effective. Species composition and especially detection and investigation of introduced species – these are mostly objects of ecologists' regard.

In Russia another popular way to assess pollution is to estimatethe levels of heavy metals. In this case metals are detected using chemical, spectral, atomic absorption andx-rayfluorescenttechniques. Another technique developed and used in freshwaters, but certainly also applicable for saline with some little modifications, is based on quantitative indicators of phytoplankton species composition and its fluorescence characteristics that have been observed to vary in certain range of values in case of normal ecological environment, but fall outside the limits in case of ecological abnormalities. Thus, fluorescence values may be used as index numbers to diagnose ecological problems in the environment. One more molecular biomarker introduced in Russia is using DNA comet assay to assess physiological and health status of aquatic organisms and thus to monitor the environment.

So in general Russian institutions do not use bioindication for the monitoring and still prefer applying the same range of physical (water transparency, temperature, degree of salinity), chemical (oil products, oxygen, BOD5, detergent agents, PAHs, etc.) and biological (the amount of chlorophyll, primary production and destruction, status and species composition of phytoplankton, zooplankton and benthos, etc.) characteristics. For example long-term monitoring of pollution of South-East Baltic Sea, Kurshski and Vislinsky Gulfs is conducted using above mentioned methods.

Scientists from the Saint-Petersburg State Polytechnical University have developed a special device for express-assessment of water quality, based on nuclear-magnetic relaxation. It is good to estimate the temperature and detect any pollutants in the water of hard-to-reach spots, but does not suit for global ecological monitoring projects. However the methods applied significantly differ and are mostly rather complicated and need much more time and equipment than relatively simple method of testing lysosomal membrane stability.

Publications presenting the results of monitoring obtained by Russian scientists and dealing with above methods are generally in Russian, for example materials of international conference ‘Physiological, biochemical and molecular genetics mechanisms of aquatic animals’ adaptation’ held in 2012 in Borok (Yaroslavsky region), where the Institute of Internal Waters is located or international forum ‘Baltic Sea Day’ held in 2013 in St-Petersburg. Interesting collection of articles is presented in ‘Ecological Physiology and Biochemistry of Aquatic Animals’, publication of Karelian Scientific Center of Russian Academy of Science focused on current problems of physiology and biochemistry of aquatic animals.

Summarizing brief remarks on the methods commonly used in Russia one may conclude that they are rather diverse and not very convenient for the principal goal of comparing the results to those obtained in other regions of the world.

4.1.2. Organizing of monitoring with LMS indicator in Russian part of the Gulf of Finland

It is certain that Russian ecological research will only benefit if indicators used in the world–wide ecological monitoring are applied here. The simplest way to achieve the purpose considering lysosomal membrane stabilitytest is to train Russian ecologists to use the method mastering it to the extent of applying the indicator in the monitoring carried out in the Gulf of Finland.

It would be advisable to organize a little practical course or seminar on using the lysosomal membrane stabilitytest emphasizing the reagents, experimental conditions, preferable tissues etc. to make the results completely comparable. Such practical training could be carried out by our colleagues in neighboring countries - Finland, Sweden, Norway, etc. to demonstrate the method preferably right on the spot.
If it is possible to manage such an enterprise the project and monitoring results will undoubtedly benefit.

As to the process of monitoring itself our suggestions are as following.

The objects of monitoring should represent sessile, coastal and pelagic species. Unfortunately, most of the objects usually taken into monitoring by researchers of above mentioned countries (for example, flounder or blue mussel) are scarce or practically completely absent from the Russian part of the Gulf of Finland.
So in the fresh water part of the Gulf (the Neva Bay) we could use the bivalve mollusc *Anodonta sp*., and two species of fishes – the perch (*Perca fluviatilis*) and the roach (*Rutilus rutilus*). All species enumerated are rather common in that part of the Gulf of Finland.

For monitoring mesohaline western part of Russian waters of the Gulf of Finland we would like to concentrate on animals frequently found in this region - representatives of two mollusc species:the bivalve *Macoma balthica* and the zebra mussel (*Dreissena polymorpha*) and two species of fish – the Baltic herring and perch (cod and flounder are not available in this area).

All the species mentionedare common for the Baltic region so the results obtained by Russian researchers could be easily compared to those of the scientists of other Baltic countries.

The samples should be taken in the region where standard stations of State monitoring in the Neva Bay and E part of the Gulf of Finland are located to compare the results with other kinds of environmental measurements going on simultaneously.

The proposed location of the stations is as following: two of them within the Neva Bay (on the southern and northern coasts) and three stations in the E part of the Gulf of Finland. Their approximate positions are indicated on the scheme (fig 4.1.1.)

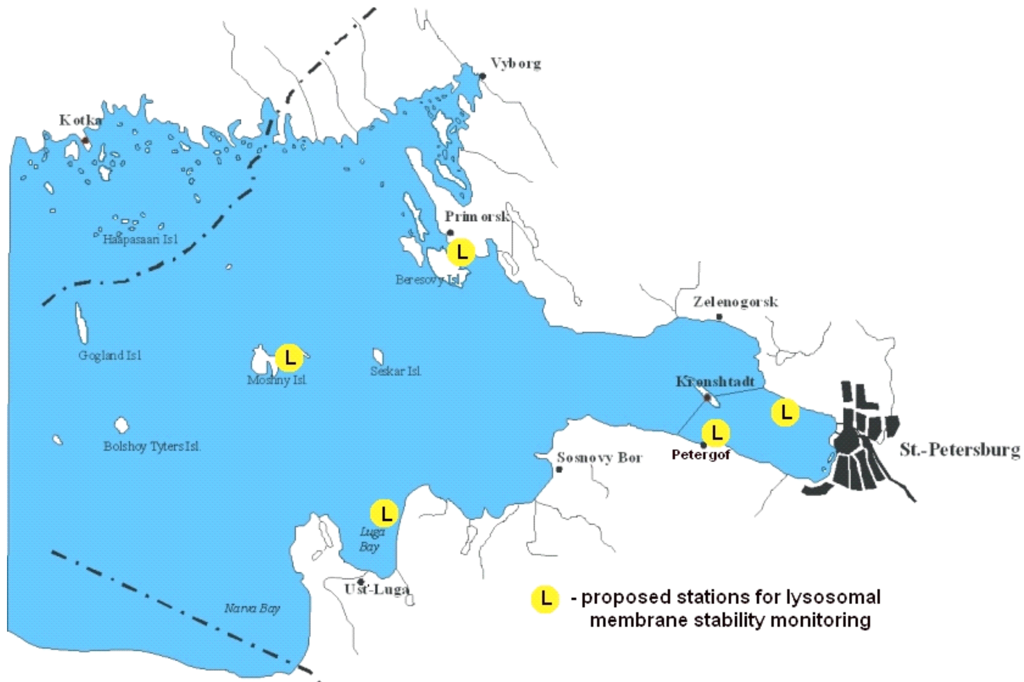


Fig. 4.1.1. Proposed location of the stations using lysosomal membrane stability test.

As to the time schedule of collecting samples for lysosomal membrane stability test it should be coordinated with similar studies carried out by our northern neighbors to make the results comparable and reliable.

4.2. FISH DISEASES AS A FISH STRESS INDICATOR

4.2.1. Description of the indicator

Diseases of wild marine fish have been studied on a regular basis by many ICES Member Countries for more than two decades. Disease surveys are often integrated with other types of biological and chemical investigations as part of national monitoring programs aiming at an assessment of the health of the marine environment, in particular in relation to the impact of human activities (HELCOM, 2012a;b).

Various parasitic diseases, skin and internal organ disorders, as well as adverse environmental changes cause fish stress. In the stressful environment, the fish body produces many hormones, such as cortisol, epinephrine and norepinephrine, that cause physiological changes in the gills. In chronic stress caused, for example, by poor water quality, high levels of cortisol in the blood is stored for a long time, and thus the resistance of fish to disease is markedly reduced (Rahkonen et al., 2000). Fish diseases are a fish stress indicator and a core indicator for aquatic environment as well.

4.2.2. General implementation of the indicator

In the Baltic Sea, fish diseases have been monitored on a more or less regular basis since the beginning of the 1980s. Baltic Sea countries that currently carry out annual fish disease surveys in the Baltic Sea are Germany, Poland and Russia (AtlantNIRO, Kaliningrad) (ICES 2011). While Polish and Russian studies are restricted to national EEZs, the German program covers larger areas of the southern Baltic Sea. Other Baltic Sea countries not mentioned have some experience in fish disease monitoring from studies carried out in the 1980s and 1990s, but have stopped regular activities (HELCOM, 2012)

There are several fish species most commonly studied in this aspect in the Baltic Sea: flounder (*Platichthys flesus*), cod (*Gadus morhua*), herring (*Clupea harengus*); in the western Baltic Sea - the common dab (*Limanda limanda*).

4.2.3. Implementation of the indicator in the Russian part of the Gulf of Finland

In the Russian part of the Gulf of Finland, the first studies of fish parasitic diseases were conducted by a professor at Leningrad State University V.A. Dogel and later were repeated by his disciples (Dogel, Petrushevsky, 1933; Wu Bao-Hua, 1961). Studies of fish diseases are also irregularly conducted by the State Institute of Lake and River Fisheries (GosNIORH), but they do not include the named above species of the Baltic sea fish. Specialists of the Institute mostly study the fish diseases in private fish farms and in other regions (usually in fresh water), which allows to obtain commercial contracts.

In the 1996-2000, GosNIORH performed studies of parasitic diseases of the most abundant coastal fish species (perch, roach, three-spined stickleback) in the Neva Bay and the eastern part of the Gulf of Finland; their main results are summarized below (Barkovskaya, 1998; Petrova, 2000).

After a considerable break, in 2011-2012 the local studies of fish parasites were repeated by GosNIORH specialists in the Neva Bay under a commercial contract. They confirmed the lasting high incidence of coastal fish diseases in the Neva Bay; the results of these recent works have not been published and are not yet publicly available.

4.2.4. State of the indicator in the Russian part of the Gulf of Finland

Recently published works on this topic focused on the study of parasites of the three common fish species: perch - *Perca fluviatilis* (L.), roach - *Rutilus rutilus* (L.) and three-spined stickleback - *Gasterosteus aculeatus* (L.). The fish with disorders were also accounted in an attempt to relate it to the pollution level. The material was collected in 1995 - 1997, in the Neva Bay, as well as in the area of the Vyborg Bay near Vysotsk, in total

655 individuals of these species were examined. A survey of the Neva Bay and the eastern Gulf of Finland in 1995 - 1997 found 28 and 25 species of roach and perch parasites respectively (Barkovskaya, 1998; Petrova, 2000).

Parasites of roach.

There are 28 species of parasites of roach in the Gulf of Finland. Among them, there are 9 species of myxosporeans, 1 species of ciliates, 9 species of Monogenea, 4 species of trematodes, 2 species of nematodes, 1 species of Acanthocephala, 1 species of crustaceans and glochidia.

Among myxosporeans most heavily infecting roach there are Myxobolus *pseudodispar* (extensiveness of 66.6%), *Myxidium rhodei* (extensiveness of 53%), *Myxobolus bramae* (extensiveness of 40%).

In the Gulf of Finland, the roach was frequently infested by the species of parasites that actively invade the host like, for example, the metacercariae of *Diplostomum spathaceum* (73%), *Ichthiocotylurus platycephalus* (65%), *Tylodelphys clavata* (27%). This corresponds to the common pattern of parasite fauna in eutrophic reservoir, and also indicates the mostly benthic lifestyle of roach.

Parasitic ciliate Trichodina nigra also occured in roach – 33%. The high number of ciliates in roach may be associated with low physiological status of fish, as well as with an increased level of organic matter in the water, as the accumulation of organic is favorable for the development of bacterial flora, which is a food for peritrichs (Banina, 1981).

Infestation of roach with metacercariae of *Bucephalus polymorphus* (33%) indicated presence of bivalves in the benthic fauna. Roach infestation by cestodes was never observed apparently because roach's diet does not include oligochaetes and copepods - intermediate hosts of these helminths. Infestation by nematodes *Raphidascaris acus* (11%) and *Rhabdohona denudata* (18%) suggests that the diet included fish mayflies and caddis flies, albeit in small numbers.

Roach was infested significantly with spiny-headed worm *Acanthocephalus anquillae* (25%), infection by which is associated with active consumption of waterlouse *Asellus aquaticus* which inhabits shallow water vegetation, which in itself is a component of eutrophic reservoirs.
In general, roach parasites reflect its biology and are consistent with their diet - mostly zoobenthos and vegetation.

Parasites of roach caught in the area of Strelna, Sestroretsk, and the Vyborg Bay were compared.
Higher infestation by myxosporeans (Table 4.2.1) and higher diversity was detected for area near Strelna, intermediate - near Sestroretsk and minimum - in the Vyborg Bay. Obviously, this is due to the predominance of oligochaetes as intermediate hosts of myxosporeans in macrozoobenthos in the first two areas, whereas in the benthos of the Vyborg Bay oligochaetes play a minor role.

Greater species diversity of monogeneans from genus *Dactylogirus* was described near Strelna - 8 species of Monogenea, against 3 species near Sestroretsk and 2 species near isl. B. Vysotsky (Table 4.2.2). It is related with higher levels of biogenic pollution in the area, since the increase in the number of species with direct development – including monogeneans – is typical for eutrophic water bodies.

Table 4.2.1. Roach infestation by myxosporeans in different areas of the Gulf of Finland (1995-1997).

Parasite	Locali-zation	Strelna			Visotsk			Sestroretsk		
		E	**I**	**M**	**E**	**I**	**M**	**E**	**I**	**M**
Myxidium rhodei	Kidneys	80	399	319	6.6	5	0.3	47	45.6	36.4
Myxobolus bramae	Gills	43	4.9	2.1	6.6	2	0.1	66	13.6	9
M. dispar	Gills	10	2.3	0.23	—	—	—	—	—	—

M. dogieli	Heart	3.3	1	0.03	—	—	—	—	—	—
M. muelleri	Gills Liver Kidney Muscle	37	8.6	3.2	13	3.5	0.5	—	—	—
M. muelleri formis	Gills	—	—	–	6.6	2	0.1	—	—	—
M. musculi	Muscles	43	7.7	3.3	—	—	—	20	6.3	1.3
M. pseudodispar	Gills muscles	70	10	7	53	6	3.2	73	10.6	7.8
M. rutili	Gills	10	3.3	0.3	—	—		13.3	12	1.6

E - incidence of infection (%); **I** - intensity of infection, **M** - index of abundance, '-' no information mentioned in the studies (the legend for Tables 4.2.1- 4.2.3; after Barkovskaya, 1998; Petrova, 2000).

Infestation of roach gills by larvae of the fluke *Bucephalus polymorphus* was observed near Strelna - 33%, and Sestroretsk - 66%, whereas near isl. B. Vysotsky this parasite was not generally observed. This is associated with significant eutrophication of the first two sites, and consequently, favorable conditions for the development of lamellibranch mollusks of the genera *Unio* and *Anodonta* – the first intermediate hosts of trematodes of the genus *Bucephalus*. It also confirms the absence of these bivalves near Vysotsk.

Table 4.2.2. Roach infestation by monogeneans of the genus *Dactylogirus* in various parts of the Gulf of Finland (legend as in Table 4.2.1).

Parasite	Strelna			Vysotsk			Sestroretsk		
	E	I	M	E	I	M	E	I	M
Dactylogirus caballeroi	33	7.1	2.1	—	—	—	—	—	—
D. crucifer	67	30.3	20	87	13	11.3	60	4	2.4
D. fallax	33	5	1.7	—	—	—	6.6	2	0.13
D. nanus	33	5.9	2	20	2	0.4	—	—	—
D. rutili	13	2.5	0.33	—	—	—	—	—	—
D. similis	17	6.8	1.1	—	—	—	—	—	—
D. sphirna	17	7.8	1.3	—	—	—	20	5	1
D. suecicus	17	5.8	0.97	—	—	—	—	—	—

Infestation of roach's gills by trichodins was observed near Strelna - 66%, and Sestroretsk - 33%, while near isl. B. Vysotsky roach gills were free of these parasites. It is associated with high eutrophication of the Neva Bay – especially its southern coast, because high organic content is a good substrate for the bacteria that, in turn, are food for trichodins (Banina, 1981). Furthermore, the trichodins can serve as good indicators of water pollution by water-soluble oil fractions (Lom, Lairid, 1969, Kolesnikova, 1996), so that could also be the reason for the higher level of infestation of roaches in the Neva Bay in the most contaminated area.

Parasites of perch.

In the Gulf of Finland there are 25 species of parasites of perch *Perca fluviatilis* (L). They include Flagellates - one species, myxosporeans - one species, ciliates - six species, monogeneans - two species, cestode - two species, trematodes - five species, nematodes - three species, acanthocephalans – two species, and crustaceans - two species. The high infestation of the gills of perch by glochidia of bivalves was also observed.

Most numerous groups of parasites of perch were ectoparasitic ciliates and larval stages of trematodes. The abundance of ciliates is explained with the life history of the coastal perch. The fish spends significant amount of time at shallow depths in the vegetated habitat, where temperature is relatively favorable, and organic is plentiful. Such conditions favor the development of ectoparasitic ciliates, which give a fairly high percentage of perch infection: *Trichodinella percarum* - 60%; *Apiosoma companulatum* typica - 53%; Tripartiella *copiosa* - 47%; *Trichodina nigra* - 33%.

Judging by the composition of helminth fauna, perch diet included zooplankton which transmits infection by *Camallanus lacustris* - 62%; *Bunodera luciopercae* - 57%; *Proteocephalus percae* - 11%; *Triaenophoras nodulosus* – 3%. However, taking abundance into account, we can talk about tangible perch infestation only by fluke *Bunodera luciopercae* (index of abundance 6.6) and nematodes *Camallanus lacustris* (index of abundance 3.7). For the rest of helminths this figure was less than 1, indicating low prevalence of the parasite in the studied populations of perch.

Actively invading trematode larvae were also richly represented among perch parasites, both qualitatively and quantitatively: *Diplostomum spathaceum - 60%, Tylodelphys podicipina* - 57%, *Ichthyocotylurus variegatus* -72%, *I. pileatus* - 30%, the presence of which indicates that there are a lot of mollusks in the habitat of this fish.

Thus, according to the composition of the fauna of parasites, the perch population studied frequently visits vegetated areas of the reservoir, it is carnivorous and feeds mostly on zoobenthos and less on zooplankton. Parasite fauna of perch from different parts of the Gulf of Finland was marked by the following features. The highest infection of perch by flagellates *Trypanosoma percae* was observed near isl. B.Vysotsky – 57%, whereas near Strelna infection was only 10%, and near Sestroretsk such perch parasite was never encountered. This variation is due to difference of perch habitat conditions in these areas. In Vysotsk, perch most likely inhabits sites with dense aquatic vegetation – habitat of leeches, the main vectors of blood parasites.

Gill myxosporeans *Henneguya psorospermica* were found only in the perch near Strelna – 31%, and near Sestroretsk - 10%. It may be related to habitat characteristics in different areas of the Gulf: rich fauna of oligochaetes in the Neva Bay, and poor olygochaete fauna in the Vyborg Bay as possible intermediate hosts of myxosporeans. Infestation of perch by ciliates was observed only for fish caught near Strelna (from 13% to 60%), which is probably due to greater eutrophication in this area.

Infection of perch by intestinal trematodes *Bunodera luciopercae* was relatively high near Strelna and Sestroretsk (Table 3). In the Gulf of Vyborg, this parasite was not observed in the perch which was consistent with the hydrobiological data about the complete absence of bivalves – intermediate hosts of trematodes in the region of isl. B. Vysotsky. The high rate of perch infection by actively invading trematode larvae of genera *Diplostomum* and *Tylodelphys* is also notable (fig. 4.2.1, Table. 4.2.3).

Maximum infection by these species was registered in the area of isl. B. Vysotsky – 100% and 83%, respectively. We associate it with sufficient abundance of pulmonate gastropods in the benthos of the three areas studied, and with quantitative and qualitative variability of the latter in the Vyborg Bay.

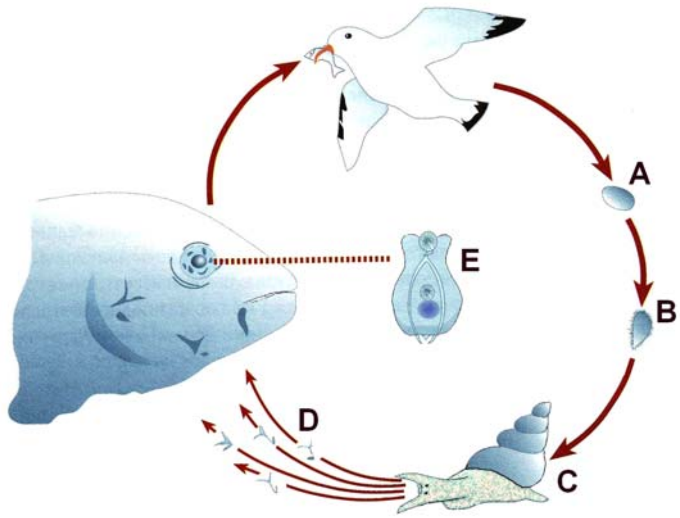


Fig. 4.2.1. The life cycle of trematodes of the genus *Diplostomum.* A - egg, B - miracidium, C - gastropod, D - cercarium (after Bauer et al., 1973).

Highest infestation of the gills of perch by parasitic crustaceans *Achtheres percarum* - 68% was noted near isl. B. Vysotsky, while it was only 10% near Sestroretsk and 5.2% near Strelna. It is most likely due to the fact that this crustacean is highly sensitive to the toxic industrial pollution off the southern coast of the Neva Bay.

Table 4.2.3. Infestation of perch with parasitic trematodes in various parts of the Gulf of Finland (legend as in Table 4.2.1).

Parasite	Localization	Strelna			Vysotsk			Sestroretsk		
		E	I	M	E	I	M	E	I	M
Bunodera luciopercae	gut	74	11.3	8.3	—	—	–	84	12	10.2
Diplostomum spathaceum	eye-lens	84	25.8	21.7	100	140	140	95	41.3	39.1
Tylodeiphys podicipina	vitreous body	74	26	19.2	83	84.2	28	58	46.5	27
Ickthyocotylurus variegatus	mesentery	71	14.3	8.63	100	142	142	87	37.7	8.7
I. pileatus	mesentery	21	15.2	1.3	64	16.8	6	42	12.5	5Д

Different regions had different fish diseases. Roach infestation by microsporidia decreased with distance off St. Petersburg from the Neva Bay (Strelna, Sestroretsk) to Vyborg Bay (Isl. B. Vysotsky). The same pattern was noted in the species diversity of monogenean *Dactylogirus* that infects roach. Roach infestation by larvae of trematode *Bucephalus polymorphus* and gill trichodins in Vyborg Bay was not observed at all, but these parasites were common in the Neva Bay.

A similar pattern was observed in the distribution of perch parasites.

Thus, ichthyopathological data were used to assess fish safety-stress in different areas of the Russian part of the Gulf of Finland. High parasitic infestation of roach and perch in the Neva Bay and the low infestation in the Vyborg Bay is associated with the degree of eutrophication and pollution of various sections of the Gulf of Finland, i.e. anthropogenic pressure on the reservoir.

Parasites whose life cycle is associated with planktonic Copepoda, by contrast, find the best conditions for development in the Gulf of Vyborg, which has relatively clean water and rich plankton copepod community.

4.2.5. Long-term change of the parasite fauna of perch *Perca fluviatilis* (L.) and roach *Rutilus rutilus* (L.) in the Neva Bay

Major long term trends of fish parasite fauna dynamics were tracked. Dynamics of parasite fauna of perch and roach in the Neva Bay indicated increasing eutrophication in the ecosystem since the previous studies 62 and 36 years before 2000 (Dogel, Petrushevsky, 1933; Bao-Hua, 1961). Several facts favor it:

- increased fish infection by ciliates - indicators of biogenic water pollution;
- increased fish infection by myxosporeans, whose intermediate host (benthic olygochaetes) is favored by increasing trophic level;
- increased diversity of dactylogyrids of carps, which is also a hallmark of eutrophic water bodies;
- increased infection of fish by actively invading trematode larvae from genera *Diplostomum*, and *Tylodelphys*;
- eduction of fish infection by parasites whose life cycle is related to zooplankton - *Proteocephalus percae, Diphillobothrium latum, Philometra ovata.*
- reduction of fish infection by parasitic crustaceans, due to the decreased abundance of copepods in zooplankton of the eutrophic reservoir (Telesh, 1986).
- disappearance of species belonging to the Arctic freshwater complex (*Metechinorhynchus salmonis, Neoechinorhynchus rutili*) typical of oligotrophic waters (Barkovskaya, 1997, 1998; Petrova, 2000).

Dynamics of fish parasites in the Neva Bay since its initial studies (in the 30th of XX century) shows that the changes in the composition and structure of parasite communities were related to anthropogenic impacts on the water body. It is evidenced by the increased infection of fish in the area of the Neva Bay by the parasites indicators of hydrocarbon water pollution such as trichodins, by reduced abundance or complete disappearance of parasitic crustaceans that have weak tolerance to external toxicants; by the appearance of large numbers of abnormal myxosporean spores (Figs. 2, 3 after Petrova, 2000).

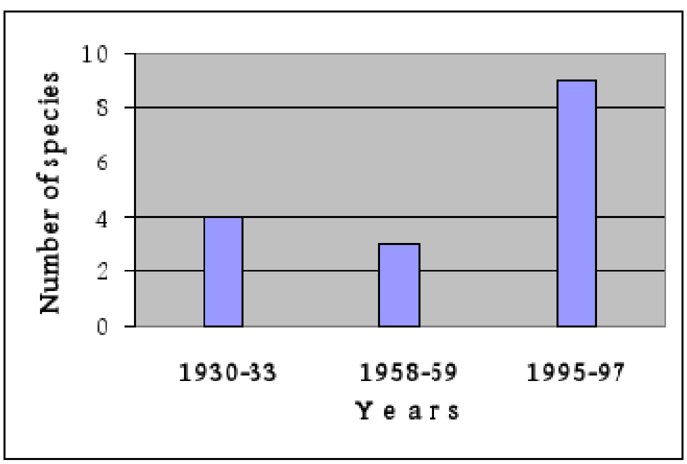


Fig. 4.2.2. Roach infestation by myxosporeans in the Neva Bay in different periods.

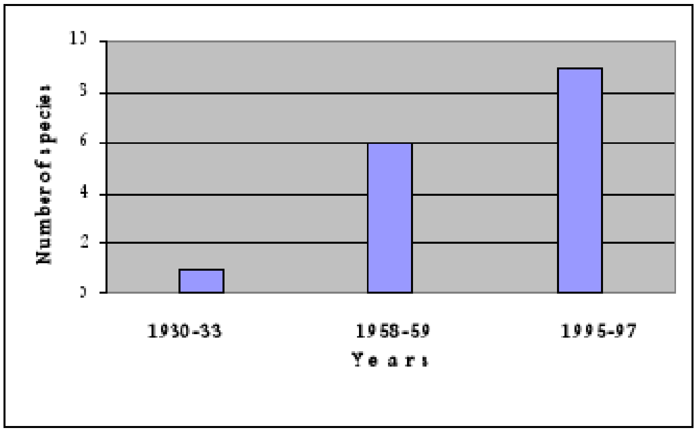


Fig. 4.2.3. Roach infestation by monogeneans in the Neva Bay in different periods.

Increased infestation of roach gill arches by trematode metacercariae *Bucephalus polymorphus* can be associated with the development of lamellibranch mollusk genera Unio and Anodonta - the first intermediate hosts of bucephalids. However, bivalve mollusks dominated here in the 80s, while with increasing trophic index of the Neva Bay the importance of oligochaetes in zoobenthos increased. Therefore, the increasing infection of fish by *Bucephalus* has no explanation and might disappear later.

Perch and roach infestation by trematode larvae of genera *Diplostomum* and *Tylodelphys* remained approximately at the same level. All this indicates an increase in the trophic index of the water body studied over time. Infestation by acanthocephalans decreased or even was completely absent. For example, the species of Arctic freshwater complex of oligotrophic lakes disappeared: *Metechinorhynchus salmonis, Neoechinorhynchus rutili*.

The species diversity of parasitic Crustacea decreased and incidence of fish infection by them declined. Several species disappeared such as *Argulus foliaceus* (the parasite with direct lifecycle, inhabits vegetated intertidal sites), and *Ergasilus sieboldi* (the widespread ectoparasite, whose abundance decreases sharply in the areas overgrown with higher aquatic plants). These ectoparasites have weak resistance to water toxicants which, at least to some extent, can lead to decrease of fish infection (Bogdanov, 1993). These data are consistent with the depleted state of the copepode zooplankton in the Neva Bay, because nauplii of parasitic crustaceans are included in zooplankton composition.

The fish parasite fauna in the Neva Bay have undergone some changes during a long period of time since previous studies. Diversity of parasites of the Arctic freshwater complex decreased, and this trend involved particularly the species whose life cycle is associated with relic crustations. Their absence is one of the characteristic features of eutrophic reservoirs. In present case *Metechinorhynchus salmonis* and *Neoechinorhynchus rutili* are such species. Changes in the ratio of individual groups of parasites accompanied eutrophication: the proportion of ciliates, myxosporeans, and monogeneans increased; abundance of cestodes and acanthocephalans declined; the proportion of parasite species whose development involves zooplankton decreased; role of parasites of carp and perch fish increased; the share of ectoparasites in total fish parasite fauna increased. Qualitative depletion of parasite fauna of eutrophic reservoirs goes along with an increase of infection by some species. In particular, the environmental conditions favor the population growth of the parasites with direct development, as well as actively invading species (Barkovskaya, 1998).

In general, eutrophication of the eastern Gulf of Finland was not accompanied by a sharp decrease in the diversity of parasites owing to increasing dominance of the parasites of faunal complex of boreal plains (specific parasites of carp fishes) or some species belonging there (trematode larvae). Whereas, the simplification of fish trophic interactions and life cycles of parasites was observed in the reservoir.

4.2.6. Levels of several heavy metals in tissues of perch *Percae fluviatilis* (L.), the three-spined stickleback *Gasterosteus aculeatus* (L.), and in some of their parasites from the Neva Bay of the Gulf of Finland

Ecosystem of the Neva Bay and the eastern part of the Gulf of Finland for many years suffered from anthropogenic pollution of various sources. Heavy metals are the most dangerous water pollutants in the Neva Bay. After entering the water and sediments, the heavy metals constantly migrate through the food chain of the reservoir, involving almost all groups of aquatic organisms in their cycle. Elevated concentrations of heavy metals are toxic for fish, and lead to accumulation of these pollutants in organs and tissues.

Analysis showed that among the intestinal helminths of perch heavy metals accumulate most in nematodes, least - in cestodes, and intermediate in acanthocephalans (Table 4.2.4). Various organs of fish also differently accumulate heavy metals. Cadmium and copper more likely concentrate in the liver, zinc – in the guts, and lead – in muscles of perch (Table 4.2.4), which closely corresponds to the pattern of heavy metal localization in other fish. The table below compares the level of heavy metals in the tissues of the parasites and its fish host.

Table 4.2.4. Contents of some heavy metals in the organs of perch and some of its helminths µg / g (wet weight). Strelna, 1996

Samples	Heavy metals (µg / g)			
	Zn	Cd	Pb	Cu
Liver	4.21	0.77	0.23	2.88
Intestines	13.4	0.07	0.12	0.70
Muscles	2.31	0.013	0.34	0.22
Proteocephalus percae	0.88	0.05	0.86	2.95
Acanthocephalus lucii	12.3	0.26	2.74	1.78
Camallanus lacustris	74.4	0.93	6.85	5.81

A significant accumulation of heavy metals in the body of the parasite is explained with the fact that the parasites usually experience both the direct effect of environmental factors, and the indirect effect mediated through the host. Probability of such a double impact is especially high for the parasites with complex life cycles including one or two intermediate hosts, when the accumulation of heavy metals in the body of the parasite is gradual: directly from the environment in free-living stages, and indirectly through intermediate and primary hosts (zooplankton, zoobenthos, planktivorous fish). As for comparing the heavy metal concentrations in the other helminth studied - *Scbistocephalus solidus* - and in its host *Gasterosteus aculeatus*, no increase of heavy metal concentrations was observed in the parasites, compared with their fish host .

Some parasitic systems are more responsive than other components of the water ecosystem to the concentration of toxic substances such as heavy metals. Their use as a method of indication of heavy metal contamination is advantageous because parasites with a relatively short lifespan (up to 1-2 years), allow estimation of contamination during this particular short period of time. Whereas fish accumulate heavy metals, that have been entering the reservoir for a much longer period of time, and water samples – especially in watercourses – can sometimes contain no toxic substances even after a short time after discharge of toxicants in the water.

Nematodes accumulate heavy metals the most among perch intestinal helminths, cestodes – the least, acanthocephalans have the intermediate position. Accumulation of heavy metals differs among parasites and various organs of fish. The nematode *Cammalanus lacustris* absorbs heavy metals several times more than any fish host organ investigated.

The data on heavy metal content evidence that these toxicants accumulate in parasites of fish dozens times more than in their fish hosts or in the water. For example, nematodes *Cammalanus lacustris* contained 20 times more lead than the muscles, 30 times greater than the liver, and more than 57 times greater than the intestine of perch host. In this regard, some parasites of fish can be used for the bioassay of the reservoir even when other known methods – analysis of water samples, analysis of fish muscle homogenate, etc. – do not yet show significant deviations from the normal parameters (Barkovskaya, 1997).

4.2.7. Proposal for monitoring of the indicator

Regular monitoring of this indicator in the Russian part of the Gulf of Finland has not yet been performed, but there is a lot of information obtained over a long period. GosNIORH has also a specialized laboratory and qualified staff capable of conducting such monitoring on governmental or commercial contract.

Based on available information, it is advisable to monitor 4-5 fishing areas in the Russian part of the Gulf of Finland approximately 1 in every 5 years. Sites of monitoring shall be positioned at the outer part of the Neva Bay (near isl. Kotlin and Sestroretsk), as well as the northern and southern coast of the eastern part of the Gulf of Finland (for coastal fish). It is sufficient to consider three common species of coastal fish, such as perch, roach for which historical information is available, and pike *Esox lucius* (L.) – a predator that is necessary to add to monitoring. It is also desirable to include the central part of the Gulf of Finland as a sampling site for the trawling survey of diseases of pelagic fish such as herring and sprat.

4.3. MICRONUCLEI TEST– A GENOTOXICITY INDICATOR

4.3.1. Significance of micronuclei test among other environmental monitoring methods of assessment of genotoxic contaminants.

Environmental factors that have a genotoxic effect on living organisms should be regarded as one of the most dangerous types of pollution. Strengthening of human pressure on the environment due to the appearance of numerous chemical and physical mutagens raises particularly important question of the constant monitoring of environmental condition. Direct measurements of chemical concentrations and physical factors (without careful preliminary study of their biological effects) do not answer the question about the extent of the negative impact on ecosystems and individual species. The possible changes in the ecosystems can be predicted only for already well-studied toxicants and mutagens based on changes in their concentrations (when MPCs are known for particular indicator species). Therefore, the development of methods of bioindication of such contaminants is the primary goal of environmental monitoring. The methods should be based on the analysis of changes in vital functions of a number of bioindicator species in the studied ecosystem. The study should rely on recurring observations of emerging changes.

As the state of the Baltic Sea depends not only on the water pollution, but also on the contamination of surrounding areas, the selection of bioindicator species should capture as much as possible all the ecological niches to assess state of water, bottom sediments, air and soils within the region under study. Indicator species should be widely distributed in the study area, the recorded variables should be quite sensitive to genotoxic contamination.

Genetic indicators which vary depending on the degree of stress, toxic, mutagenic or other impact of environmental pollution and can be obtained during various tests should be called indicators of genotoxic impurities.

Among the various traits used to monitor the viability of the organisms there is a group of biochemical parameters, that reveal the work of antioxidant systems of the body, the activity of enzymes of lipid peroxidation, etc. (Oliveira et al., 2010; Tsangaris et al., 2011). However, such ***functional*** changes are reversible, very labile and therefore variable, thus the significance of results for the ecosystem can be interpreted correctly only when the persistence of these changes is assessed. The use of indicators that evaluate the integrity of the genetic apparatus using various cytogenetic methods seems to be more accurate.

Damage to the genetic apparatus is the most dangerous type of malfunctions in the cells of living organisms as it may lead to increase of genetic load in the next generations. Therefore, the genetic approach is very important for environmental assessment. Damage of the genetic material can be assessed using different methods: classical genetic, molecular genetic, cytological, etc. The use of these techniques is recommended in the evaluation of damage to marine waters (Martinez-Gomez et al., 2010). Nevertheless, the assessment of genotoxic effects of environmental factors has not yet found a fairly wide application in bio-indication and bioassay. There are several advantages of the use of ***'cytogenetic indices'*** (chromosomal aberrations, micronuclei, DNA fragmentation):

- the methods detect only irreversible, already implemented damage leading to loss of genetic material, and hence death of of damaged cells.
- the methods are relatively simple to implement and do not require expensive reagents for analysis.
- the most widely used indicator for assessing genotoxic impurities in seawater is ***micronucleus test*.**

4.3.2. Brief description of micronucleus test.

The cytogenetic analysis methods are widely used in genetic toxicology. They allow to register the genetic disorders at the chromosomal, or at the DNA level. The methods include an analysis of metaphase chromosomes, ana-telophase method, micronucleus test and the single cell gel electrophoresis (comet) assay. However, metaphase analysis requires preprocessing of the material, knowledge of the indicator species karyotype (which should not be too complex), and high qualification of researchers. The comet assay also requires highly qualified researchers, sophisticated equipment, chemical reagents, and fluorescent microscope. Micronucleus test (MNT) is much easier to implement, that is why it is the most often used test in assessing genotoxicity in environmental monitoring (Vicari et al., 2012).

In environmental studies, MNT is used to evaluate the mutagenic effect of anthropogenic, infectious and other environmental factors. The test is based on an assessment of the incidence of micronuclei (MN), usually well-defined rounded bodies of DNA-positive material located outside the cell nucleus (fig. 4.3.1). They are easy to detect the different types of animal and plant cells, regardless of the complexity of the karyotype and mitotic activity of tissues. Anuclear animal and human erythrocytes are especially suitable in this respect. In cells with a complex configuration of the nuclei (such as, for example, polymorphonuclear leukocytes) MN accounting is difficult, and the results depend on the individual experience of researcher.

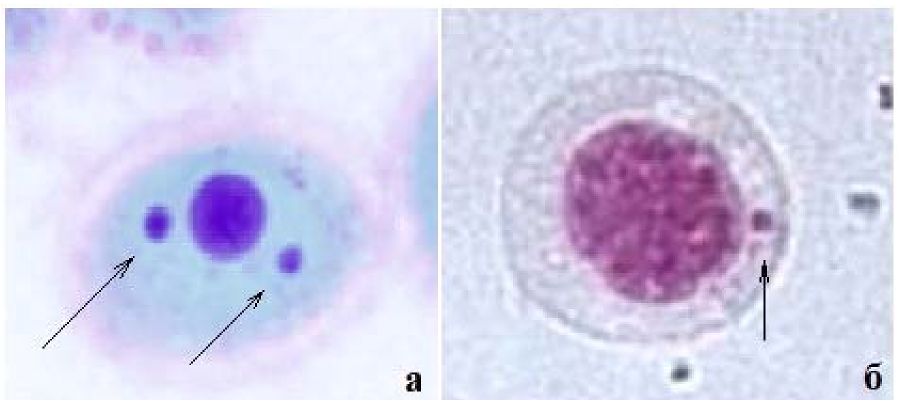


Fig. 4.3.1. Micronuclei in flounder erythrocytes (**a;** after Rybakovas et al., 2009) and in hemocytes of mussels (**b**; after Bolognesi, Fenech, 2012).

It should also be borne in mind that the MN form from whole lagging chromosomes, acentric chromosome fragments or other unidentified chromatin clumps formed during abnormal cell division. Thus, account of micronuclei helps to evaluate aneugenic and clastogenic effect of contaminants (Vicari et al., 2012). However, during the formation of MN most of the initial damage, as well as the cells containing MN can be eliminated. Therefore, the more time passes from the moment of abnormal cell division to analysis of its content, the lower the frequency of MN. Low level of MN requires analysis of a large number of cells (at least 2-5 or even ten thousand) for quality statistical processing and identifying significant differences. Despite the relative simplicity and speed of analysis, MNT does not provide information on the mechanisms of damage and the nature of the operating factors.

4.3.3. Micronuclei test in the evaluation of the genotoxicity in water.

One of the objectives of biomonitoring is to identify sources of pollution. From this perspective, many species of fish, which are able to travel long distances, can not indicate where they had been adversely affected. Therefore, mollusks are more convenient for solving such a problem, because, they move over relatively short distances (except the individuals attached to ships). Research of the oil spill sites off the coast of Italy showed that the MNT is more sensitive when applied to mollusks than to fish, and can be effectively used to assess oil pollution (Bolognesi et al., 2006; Bolognesi, Hayashi, 2011). Furthermore, the level of MN in fish erythrocytes is 5-10 times lower than in mollusks. However, various species are still widely used in genotoxicity monitoring. Individual variability of this index in fish forces to analyze at least 4000-5000 cells per individual. In the case of contaminated sites (due to increased variability) it is recommended to increase this number up to 10 thousand. The recommended sample size for mollusks is usually 1000-2000 cells from 5-20 individuals. One should also take into account the difference in mean temperature, salinity, food habits, that depend on sampling site, season and other factors. Furthermore, the same cell type should be analysed to obtain comparable results.

In the laboratory, MNT can be used to test water samples using the roots of plant seedlings (onion, etc.). This allows to compare the availability of specific contaminants and their concentration level of micronuclei, and helps to identify the mutagenic activity of a pollutant (Pedrazzani et al., 2012).

Tsangaris et al. (2011) studied the gray mullet to compare changes in indicators of oxidative stress (using the activity of antioxidant enzymes) and genotoxicity induced by polluted sea water off the coast of Greece. Having compared the data obtained by all the methods, the authors noted that the MNT of erythrocytes had greatest sensivity. Previously, similar results were obtained when assessing pollution of coastal waters of Turkey and rivers of Brazil (Ergene et al., 2007; De Andrade et al., 2004). It was noted that the cytogenetic response was triggered by a variety of genotoxic impurities and could be analyzed in various tissues (in blood cells, liver, gills). MNT is effectively used in assessing the impact of oil spills off the coast of Spain (Perez-Cadahia et al., 2008). Study of pollution near the gas production platforms in the Adriatic revealed no significant genotoxic effects. The authors described a good correlation between the frequency of MN and the accumulation of organic pollutants in molluscs, mercury concentration and seasonal changes (Gomeiro et al., 2011). Some researchers recommend the use of fluorescent staining with acridine orange in the MNT to increas the resolution of the method (Ueda et al., 1992; Vicari et al., 2012).

4.3.4. Application of micronuclei test to assess pollution in the Baltic Sea.

There is a large array of data on assessment of the genotoxic impurities in the Baltic Sea using bioindicator species. Several indicator species can be used in different regions of the Baltic Sea: fish (flounder *(Platichthys flesus),* dab *(Limanda limanda),* herring *(Clupea harengus),* eelpout *(Zoarces viviparus),* plaice *(Pleuronectes platessa),* atlantic cod *(Gadus morhua),* perch *(Perca fluviatilis),* turbot *(Scophthalmus maximus, Psetta maxima)),* molluscs (blue mussels *(Mytilus edulis, Mytilus trossulus),* Baltic clam *(Macoma baltica),* amphipods *(Gammaridae)* (HELCOM, 2012)

The main bioindicators are molluscs (mussels, *Macoma balthica)* and fish (herring, flounder, hake, cod, etc.). The most often used method is MNT, because of the simplicity of analysis (Barsiene et al., 2012; HELCOM, 2012). The studies of distribution of genotoxic impurities in the Baltic Sea using plaice, burbot and herring in 2010-2011 had shown that about 80% of the samples had excessive levels of micronuclei corresponding to the high level of genotoxicity. About 43% of the samples from the Baltic Sea analyzed in 2009-2011 evidenced very high degree of genotoxicity.

The possibility to conduct ***in vivo*** testing on a large number of samples from the Baltic Sea has allowed to develop general guidelines for a base MN level for different bioindicators (HELCOM, 2012). For several fish species the recommended ‘baseline’ frequency of micronuclei is not more than 0.05 per 1000 cells (Rybakovas et al., 2009). For other marine bioindicator species (molluscs), this frequency in different tissues can vary from 0 to 2.07 per 1000 cells. However, the heterogeneity of the data obtained is extremely high (Table3.21, HELCOM, 2012, p. 141). This may reflect the characteristics of the genetic structure of different populations in which the analyzed feature behaves differently. Therefore, in each case the appropriate statistical procedures should be selected taking into accounting the form of statistical distribution. Normally, it is desirable that the measured error of the indicator did not exceed 5% of the measurement. So, judging by the average errors in Table 3.21 (HELCOM, 2012, page 141), taken, for example, from Rybakovas et al (2009) or Napierska et al (2009), the recommended sample sizes are clearly insufficient for reliable results. Furthermore, it is unclear why such guidelines were recommended for other researchers, without previously conducted comparative assessment of the statistical distribution of the feature. Even if the statistical analysis indicates that the feature has ‘Gaussian’ distribution, this may be due to insufficient sample sizes analyzed, but the authors do not mention choosing the most suitable formula to describes the distribution of the variable in the samples analyzed. All this reflects the lack of precision of the proposed 'model' performance, and lack of a clear algorithm for processing the data received. Based on the foregoing, we conclude that the MNT using marine organisms can and should be applied, but, where possible, data should be supplemented by other methods.

It should be noted that most of the works using MNT were conducted in the central and western parts of the Baltic Sea. In the Russian part of the Baltic there was no systematic work on monitoring of genotoxicity using MNT.

4.3.5. Future direction of development of test systems to assess the genotoxicity of pollution in the Baltic Sea.

More data can be obtained using ana-telophase analysis, which is as simple as MNT, but takes into account not only the damage leading to the formation of MN, but other types of chromosome disorders affecting cell viability. Just as in MNT, the complexity of karyotype does not play a significant role in evaluation of the quality of ana-telophases. At the same time the ana-telophase is the first stage where it is possible to identify different types of chromosomal abnormalities, some of which later lead to the formation of MN.

Analysis conducted almost at the time of cytogenetic damage reveals more violations and thereby increases the sensitivity of the method. Some assumptions about the specifics of the active factor(s) and the mechanisms of its harmful effects can also be made.

In the Baltic, Barents, White and other seas, crustaceans allow the use of ana-telophase analysis in biomonitoring in order to make in-depth assessment of the pressure on aquatic ecosystems. The method was successfully tested in the study of anthropogenic impacts in the basins of the Barents and White Seas (fig. 4.3.2.) (Barabanova et al., 2009, 2011).

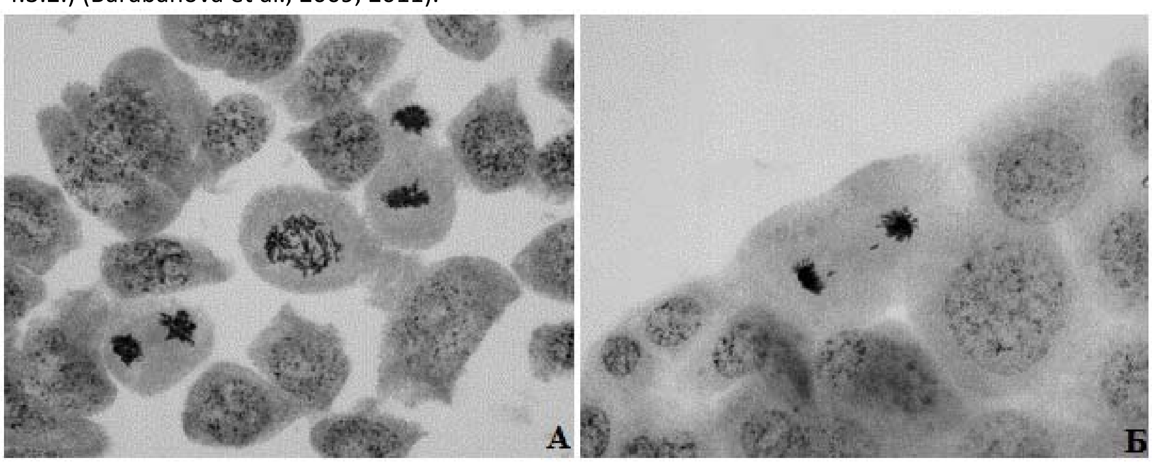


Fig. 4.3.2. General view of the preparation of dividing cells of the amphipod *(Gammarus zaddachi).* A) Two dividing cells at the stage of ana-telophase without anomalies (the cell in metaphase is in the center), B) cell at the stage of ana-telophase with two fragments. Such fragments contain the 'lost' genetic material, resulting in destruction of the daughter cells. However, these fragments can be eliminated quickly before forming micronuclei, i.e. will not be detected by MNT.

For example, under anthropogenic disturbances, the level of anomalies in *Jaera albifrons* increases from 3.5 (in control) to 20% in the contaminated zone (Barabanova et al., 2011). The samples of 7-8 individuals per site and 100-200 cells per individual were analysed. The material was sufficiently homogeneous, and standard errors of frequency of mitotic disturbances amounted to 10-15% of its value where this variable had normal distribution. Increasing the sample size to 10-12 individuals and the number of analyzed cells 200-250 significantly improved the accuracy. Similar studies using ana-telophase analysis of fresh water polution in the Baltic Sea watershed near St.- Petersburg on the aquatic sowbug *Asellus aquaticus* suggest that genome destabilization correlated with the degree of water pollution. The control frequency tested in long-term observations has hovered at about 2% and increased 3-10 times in contaminated areas (Daev et al., 2009; Daev, Dukelskaya, 2011). Similar data were obtained on marine amphipods of the Baltic Sea. Preliminary data are similar to the results obtained for the isopods of the White Sea and freshwater reservoirs of the St.- Petersburg region. They need detailed rechecking for further use in the monitoring on an ongoing basis.

4.3.6. Recommendations for conducting micronucleus test in the Russian part of the Gulf of Finland

There is no doubt that the MNT should be carried out alongside with the selection of other tests in monitoring of the state of the Baltic Sea. However, it is not used systematically in the Russian part of the Gulf of Finland. Several teams of researchers are testing ana-telophase method for some species of crustaceans of the Baltic Sea and adjacent regions. We can conclude that the level of anomalies detected by ana-telophase analysis of chromosomal aberrations in dividing cells, can be used in environmental monitoring and supplement the data of MNT where applicable. With appropriate financial support, at the initial stage of the ana-telophase method testing, it is enough to check the 3-5 places with contrasting levels of anthropogenic stress annually (later, probably less frequently) for monitoring of pollution with genotoxicants. The optimal location of sampling sites includes a single site in the vicinity of the metropolis and two sites on the southern and northern shore of the Gulf of Finland, respectively, sufficiently remote from St. Petersburg. They may be located in the port areas, near the construction sites of offshore facilities as well as in recreational areas, away from polluting industrial facilities.

4.4. REPRODUCTIVE DISORDERS: MALFORMED EELPOUT AND AMPHIPOD EMBRYOS

4.4.1. Malformed eelpout

4.4.1.1. Introduction

Marine organisms, and fish in particularly,are not easy to use for environmental monitoring because of their migratory behavior. Majority of organisms migrate while they are on larval stage, and many also as adults. Because developmental abnormalities may arise at any stage of ontogenesis and then sustain during all the life of an organism, they may reflect conditions over very large area and thus can be not very informative. From this respect, eelpout *Zoarces viviparus* is a good candidate species for environmental monitoring due to its non-migratory behavior. Adult eelpout have a snake-like body and live usually in a shallow coastal zone with soft bottoms preying on invertebrates. Eelpout are benthic fish. Females are ovoviviparous and give a birth to quite large juveniles which also live on the bottom without distant migrations. Due to this, eelpouts are often used in environmental monitoring in the North Europe.

4.4.1.2. Justification of utility of proposed indicators for environmental monitoring

Two types of reproductive, or developmental disorders were studied in the eelpout of the Russian part of Gulf of Finland: fluctuating asymmetry of cranial bones (Lajus et al, 2003) and vertebrae abnormalities (Yershov, 2008).

Fluctuating asymmetry refers small random deviations from perfect, usually bilateral symmetry. It is caused by developmental instability, which is the inability of an organism to produce an 'ideal' form consistently under the same environment (Zakharov, 1992). Developmental stability, which is the converse of developmental instability, is a component of developmental homeostasis. The other component of developmental homeostasis is developmental canalization, which is the stability of development in different conditions (Waddington, 1957). Many authors, based on experimental and observational data, argue that fluctuating asymmetry can be used as an indicator of stresses of genetic or environmental origin (Jones, 1987; Leary &Allendorf 1989; Zakharov, 1989; Parsons, 1990; Graham & al., 1993; Leung & Forbes, 1996; Møller& Swaddle 1997, Pollak, 2003, Lajus, 2010). Other researchers, however, express doubts concerning the utility of fluctuating asymmetry for assessing stress (Bjorksten& al., 2000a; see also comments on this paper by Møller (2000), Van Dongen& Lens (2000) and the reply by Bjorksten& al. (2000b)]. Because there is no ideal measure of stress, fluctuating asymmetry may still be considered an informative measure. In any case, fluctuating asymmetry represents a stochastic component of phenotypic variance, which contributes to morphological variation, together with genotypic and environmental components (Lajuset al., 2003). Use of fluctuating asymmetry for monitoring of populations is discussed in number of papers (Leung et al.., 2000, see Van Dongen 2006, Graham et al., 2010, Allenbach, 2011 for reviews).

Skeletal deformities may result from various damage to eggs, embryos, larvae, or to cytotoxic effects on different life stages of fish, and authors discussed a possible association between them and environmental stress (Valentine and Bridges, 1969; Dahlberg, 1970; Dawson, 1971; Bengtsson, 1975; Valentine, 1975; Sindermann 1979; Malabarba et al. 2004; Villeneuve et al. 2005; Boglione et.al., 2006; etc.). At the same time, skeletal deformities are not specific to one particular factor, but may appear due to range of various factors such, for instance, as aquaculture conditions of different species (Berg et al., 2006; Fjelldal et al., 2007; Lein, Poppe, 200; Totland et al., 2005).

4.4.1.3. Methodology of analysis of the indicators

To prepare material for analysis of fluctuating asymmetry, fresh or frozen specimens were treated with 2 % NaOH for 10-30 hours at a temperature of 40 - 50°C. After treatment, soft tissues were washed out with water and the clean bones were dried. A total, of 17 characters were counted. These characters refer to the number of fat-filled lacunae within the bone matrix (Fig. 4.4.1.1).

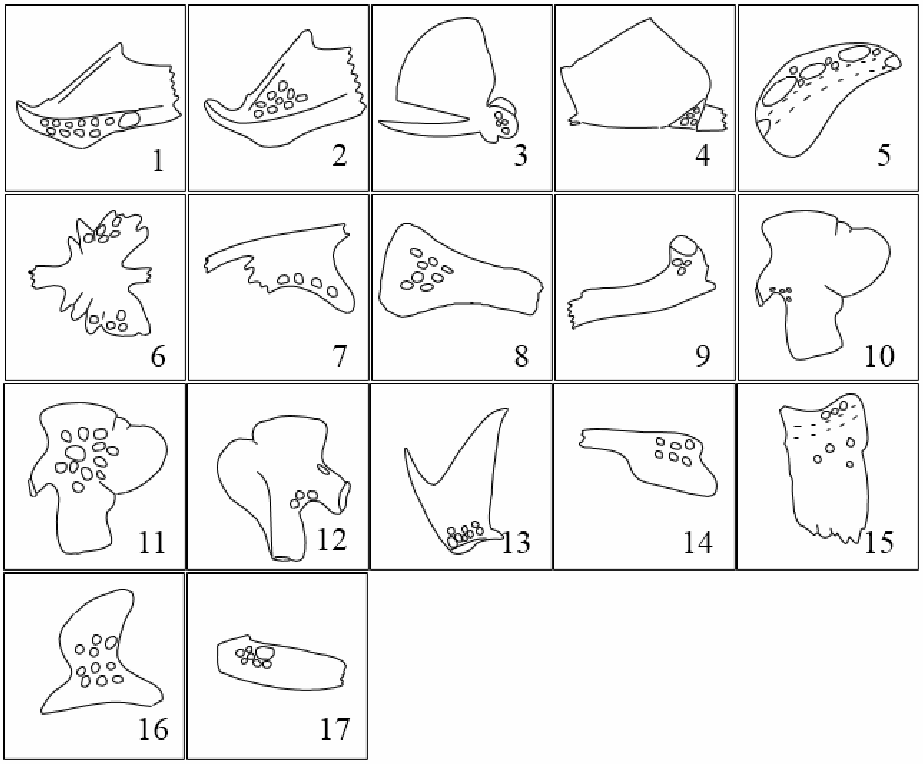


Fig. 4.4.1.1. Characters used on eelpout for analysis of fluctuating asymmetry. Only holes, which were analysed for particular character are indicated. All the holes from the indicated group indicated were counted independently on their size. Left bones are presented. 1, 2 - Articulare (holes); 3 - Quadratum (holes); 4 - Pteroticum (holes); 5 - Praeoperculum (holes, except seysmo-sensoric pores); 6, 7 - Parasphenoideum (holes); 8 - Ceratohyale (holes); 9 - Maxilare (holes); 10, 11, 12 - Hyomandibulare (holes); 13 - Urohyale (holes); 14 - Mesethmoideum (holes); 15 - Infraorbitale (holes); 16 - Coracoideum (holes); 17 - Interoperculum (holes). (based on Lajus et al 2003).

Fluctuating asymmetry represents one of three types of asymmetry (Van Valen, 1962). Characters that display fluctuating asymmetry have a mean of *R-L* equal to zero and variation normally distributed about that mean. The second type of asymmetry, directional asymmetry, occurs where one side is systematically larger than the other. The third type, antisymmetry, takes place when the distribution of *R-L* is about a mean of zero but the frequency distribution is platykurtic or bimodal (Palmer, 1994).

To assess fluctuating asymmetry (FA) the variance of fluctuating asymmetry was used (Leamy 1984; Palmer, 1994, Kozhara, 1994):

$$\sigma_S^2=\Sigma(R - L)^2/2n,$$

where *R* and *L* are right and left values of a character respectively.

The overall estimate of the magnitude of variation of a sample was measured using a sum of ranks after ranking the variation of each character across samples (Zakharov, 1989). For statistical comparison of samples, non-parametric statistics such as sign test and Wilcoxon matched pairs test was used (Lehmann, 1975).

For analysis of vertebrae abnormalities, the fishes of all sizes were fixed in alcohol and then X-rayed. The radiographs were checked for occurrence of defects under stereomicroscope. Only distinct abnormalities in the vertebral column were included into consideration. The visible spinal abnormalities resembling scoliosis, lordosis and kyphosis, were not registered. The observed vertebral defects differ morphologically and can be classified into following groups: 1) deformation of vertebrae (compression; distortion); 2) fusion of two or several vertebrae (fig. 4.4.1.2). Usually one type of the above-noted abnormalities was detected in particular individual.

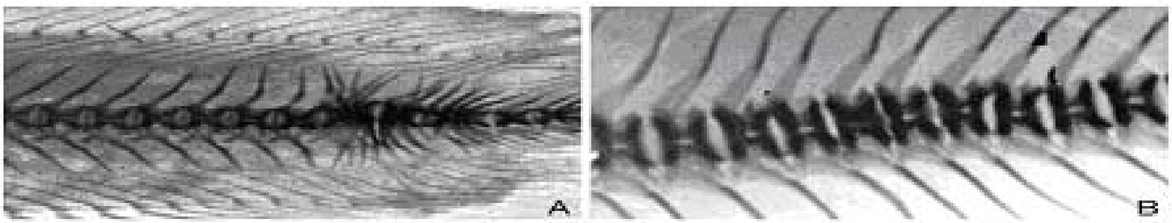


Fig. 4.4.1.2. The vertebral abnormalities in eelpout: A – fusion of several vertebrae; B – compression of vertebrae (from Yershov, 2008).

4.4.1.4. Available information on the status of the indicators in Russian part of the Gulf of Finland

Magnitude of fluctuating asymmetry of 17 characters of 18 eelpout from Gulf of Finland near St.Petersburg, collected in 1996is shown in Table 1. For comparison, values of fluctuating asymmetry from four other locations, collected in the 1995-1999,are provided (see Lajus et al 2003 for more details). Magnitude of fluctuating asymmetry of eelpout from the Gulf of Finland did not differ significantly from samples from Gulf of Gdansk and Wadden Sea, but was significantly lower that asymmetry from the White and Norwegian Seas.

Table 4.4.1.1. Stochastic component of total phenotypic variance (after partition out measurement error) of 17 characters of eelpout (see Fig. 2) from different locations: Kandalaksha Bay/White Sea (KB); Gulf of Finland/Baltic Sea (GF); Gulf of Gdansk/Baltic Sea (GG); Wadden Sea/North Sea (WS); Hafrsfjord/North Sea (HF).

Character	KB	**GF**	GG	WS	HF
1	.0157	**.0217**	.0059	.0140	.0222
2	.0236	**.0137**	.0227	.0223	.0274
3	.1128	**.0309**	.0074	.0316	.0408
4	.0395	**.0350**	.0549	.0224	.0382
5	.0303	**.0068**	.0073	.0224	.0181
6	.0459	**.0573**	.0345	.0376	.0380
7	.0717	**.3034**	.0762	.1671	.1168
8	.0499	**.0363**	.0410	.0032	.0492
9	.1212	**.0408**	.0749	.1178	.1738
10	.1264	**.5029**	.2656	.1279	.4392
11	.0214	**.0125**	.0181	.0174	.0453
12	.0341	**.0505**	.0412	.0730	.1037
13	.0394	**.0473**	.0110	.0633	.0286
14	.0498	**.0232**	.0229	.0295	.0400
15	.1209	**.0467**	.0756	.0714	.1161
16	.0254	**.0242**	.0203	.0177	.0382
17	.0650	**.0475**	.0333	.0319	.0376

Yershov (2008) analyzed 99 specimens of eelpout from Gulf of Finland and smaller number of fish from Wadden Sea and White Sea for vertebrae abnormalities. All fish were collected in 1995-1996.

The results of Yershov show that the vertebral abnormalities occur in eelpout from all localities where the samples were taken. The visible spinal abnormalities resembling scoliosis, lordosis and kyphosis, were not registered. Usually only one type of the above-noted abnormalities (deformation or fusion of vertebrae) was detected in a particular individual.

Malformations occurred in both truncaland caudal regions of the vertebral column of fishes. Deformed and normal vertebrae differed in size and shape. The type and degree of vertebral defects varied between fishes. Observed pathological changes in vertebrae usually were associated with deformations of the spines and arches.

The author found that vertebrae deformities occur in 7,1% of individuals from Gulf of Finland. It was higher than in the White Sea (4,5%), although the differences were not significant, and significantly lower ($p<0,05$) than in the Wadden Sea (24,1%).

It is worth noting that study of development of skeleton of eelpout, with including specimens from Gulf of Finland, did not report skeletal abnormalities (Voskoboinikova and Lajus, 2003).

4.4.1.5. Relevance and utility of application of the indicators in the Russian part of Gulf of Finland

I consider that analysis of developmental disorders in eelpout can bring useful information about status of environment in the Gulf of Finland. Relevance of these indicators for assessing population and ecosystem health has been already demonstrated in various organisms. Their studies on eelpout from the Gulf of Finland and comparison with fish from other parts of range showed that these indicators are variable, thus they may provide important information using techniques which have been already tested. It should be emphasizedhowever that interpretation of obtained results is not straightforward. In particularly, patterns of indicator variation in two available studies are not perfectly correlated. For instance, fluctuating asymmetry of eelpout from Gulf of Finland does not differ from that from the Wadden Sea whereas frequency of skeletal abnormalities in Gulf of Finland sample is significantly lower. This example shows that each indicator may have its own specifics. Evidently, magnitude of both fluctuating asymmetry and skeletal abnormalities is defined by numerous environmental factors, both natural and human-induced, and their interaction. This is a case however for all general stress indicators used under natural conditions. In combination with other ecosystem indicators, analysis of developmental disorders in eelpout can provide important information.

4.4.1.6. Sufficiency of current information for organization of environmental monitoring

In principle, available by now information is sufficient to conclude that proposed indicators are promising for use in environmental monitoring, although additional researches on fluctuating asymmetry may be needed. They are described in the Recommendation section.

4.4.1.7. What status of the indicators evidence about good environment status (GES)

Magnitude of fluctuating asymmetry and skeletal abnormalities is expected to increase when of environmental conditions are worsening. It should be kept in mind that departure of any environmental factors from optimum can cause such a response of the indicators. Thus, the evidence of good health of environment would be absence of growth of fluctuating asymmetry or skeletal abnormalities in time under normal range of variability of key environmental factors such as temperature, salinity and oxygen concentration.

Data available only for late 1990s, thus no information about long-term changes of the indicators exist.

4.4.1.8. Recommendations on application of the indicators for environmental monitoring for the Russian part of the Gulf of Finland

Frequency of skeletal (vertebral) abnormalities can be usedfor monitoring as it is. However, quite large sample size is needed for reliable assessment because only one character is used, and frequency of malformation is not high. Thus many individuals are needed to detect changes of environment. I would recommend sample size of 200-500 adult individuals. If using embryos, it should be taken into consideration that frequency of abnormalities can be partly determined genetically, and that embryos from one female can share a common environment. Because of that use of embryos will result in preudoreplication and hence needs increased sample size for reliable conclusions.

Selection of fluctuating asymmetry for monitoring will not require large sample sizes because multiple characters can be used.For this technique, I think that some additional research are needed to involve metric (measurable), but not only meristic (countable) as it is now, characters in the analysis. Metric characters are more simple to measure using modern techniques of image analysis and thus they can be measured in a more standard way which decrease variation among operators. If multiple (15-30) characters, both meristic and metric, are used, even comparatively small sample sizes (30-40 individuals) will provide reliable estimate of the indicator status.

For both fluctuating asymmetry and vertebrae disorder I would recommend sampling each 3-5 years from 2-5 stations in the Gulf of Finland.

4.4.2. MALFORMED AMPHIPOD EMBRYOS

4.4.2.1. Amphipods as indicators for hazardous substances

Amphipods have great potential for the sediment toxicity tests in estuarine and marine areas (Reynoldson & Day, 1993), because they are intimately associated with sediments either through their burrowing activity or by ingestion of sediment particles (Luoma, 1983; Bat & Raffaelli 1996; Bat, 1998). They are known as common members of the benthic community and as first taxon disappearing from the communities in contaminated areas or under hypoxia. By present, amphipods are widely used in 10-days laboratory survival tests of whole sediments in different countries (Nipper et al., 1989; Chapman et al., 1992, Matthiessen, 2000; Berezina et al., 2013).

In the Baltic Sea, where the bottom hypoxia and toxic pollution are among the major factors responsible for the declines in habitat quality, yet a little is known about the biological effects of environmental pollutants on different biological traits of crustaceans (Breitholtz et al., 2001). Linden (1976) studied the effect of oils on the amphipod *Gammarus oceanicus*. The *G. oceanicus* juveniles were found to be several hundred times more sensitive to the oils than the adults during acute exposure (Linden 1976). The research of hazardous substances effects on biological and physiological endpoints in the native Baltic amphipods *Monoporeia affinis* and *Pontoporeia femorata* were actively conducted in last decades (Bund et al. 2001; Sundelin & Eriksson 1998; Gorokhova et al., 2010). Adverse effects of various hazardous substances on the reproduction of the soft-bottom amphipod *M. affinis* are visible as malformed embryos in the Baltic Sea (Sundelin & Eriksson 1998; Sundelin et al. 2008). A strong relationship between the distance from the source of hazardous substances and malformation rate has been observed in the northern Baltic. For example, the high frequency of embryos malformations was recorded in females of *M. affinis* collected from the vicinity of an aluminum smelter and pulp mills in the northern Baltic Proper and the Bothnian Sea (Sundelin & Eriksson 1998). The proportion of malformed amphipod embryos in population was recommended recently as a valuable variable to be used for bioindication in various types of industrial recipient areas as part of effects monitoring (HELCOM, 2010b). The aim here is to develop this core indicator (malformed embryos in amphipods) for assessment of the biological effects and environmental status of the Baltic Sea subregions, the eastern Gulf of Finland case study.

4.4.2.2. DESCRIPTION OF MALFORMATION RATE AS A BIOINDICATOR

The malformation rates such as frequency of malformed, enlarged, undifferentiated and dead embryos per female were recommended to be a general bioindicator of contaminant effects (figs 4.4.2.1.- 4.4.3.3.).

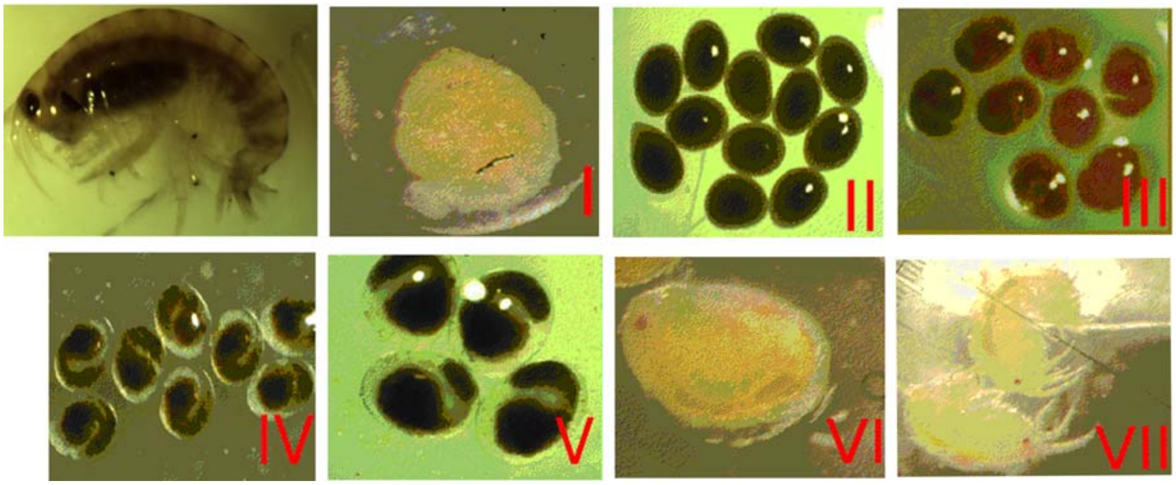


Fig. 4.4.2.1. Gravid female of the amphipod *Gmelinoides fasciatus* with eggs (dark color) in the marsupial camera and normally developed amphipod embryos (Stage I-VII).

The malformed amphipod embryos as a core indicator for biological effects cover response at the organism level and bridge the contamination status to the state of the biota. ‘High’ and ‘good’ classes indicate that areas are not disturbed by hazardous substances, while ‘moderate’, ‘poor’ and ‘bad’ indicate different degrees of disturbance by hazardous substances. The indication should be conducted with amphipods collected from contaminated and reference areas. The responses can be compared quantitatively to identify whether problems exist; and the levels of contaminants in environments can be related to the biological effect (proportion of malformed embryos in amphipods).

Possible confounding factors such as low food resourced and oxygen depletion may also affect the eggs development in amphipods reflecting in increasing number of undeveloped eggs, dead eggs or malformation rate. At the same time, it had been shown that the eutrophication or its effects do not directly increase amphipod embryo malformations. Oxygen deficiency was also shown in both laboratory microcosms and field studies to not correlate with the proportion of malformed embryos but, instead, increase the amount of dead broods (HELCOM, 2010b). Organic contents and oxygen in sediments or water near bottom should be controlled on sampling sites in order to distinguish effects of contaminants and confounding factors.

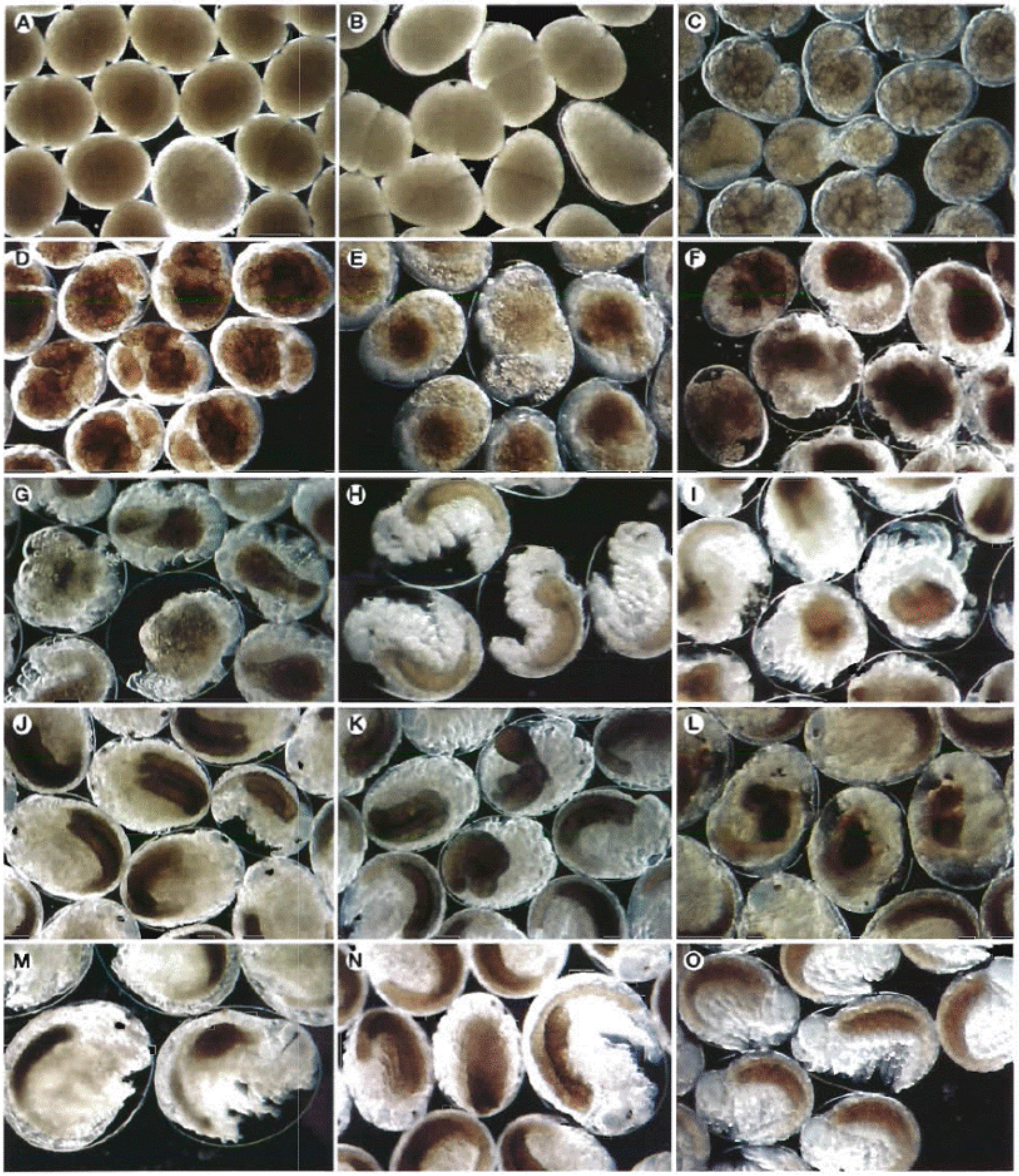


Fig. 4.4.2.2. Types of malformations in amphipod embryos of the amphipod *Monoporeia affinis* according to Sundelin and Eriksson 1998*:* (A-M) Malformed embryos of the amphipod at different developmental stages; (N, O*)* enlarged embryos with no other visible damage.

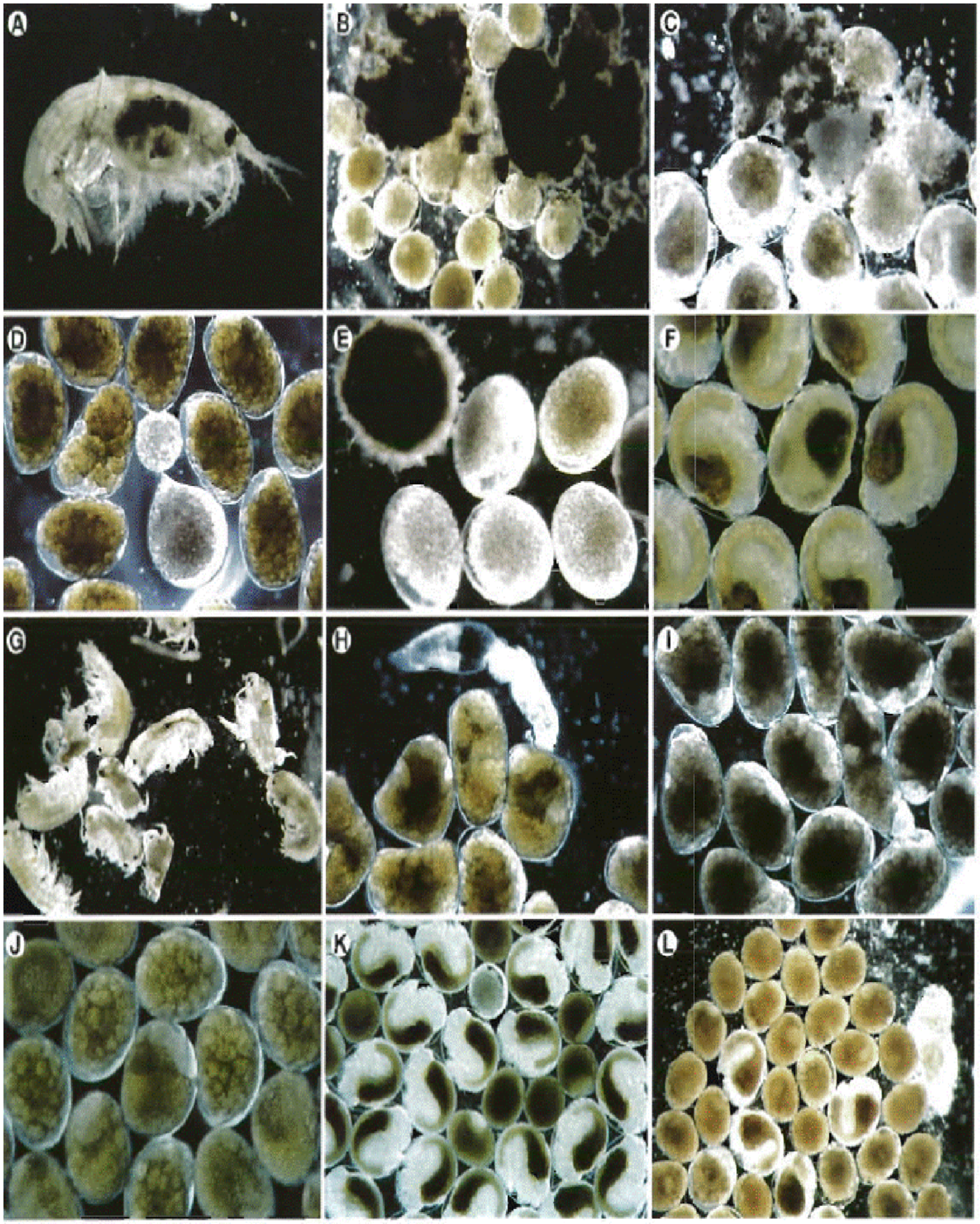


Fig. 4.4.2.3. Aberrant embryonic development of the amphipod *Monoporeia affinjs* according to Sundelin and Eriksson 1998. (A) Female with dead brood. (B, C) Unidentified dead eggs of a brood. (D-G) Single dead eggs and juveniles. (H-J) Embryos with aberrant cleavages in the early embryogenesis. (K, L) Undifferentiated embryos in which cells have degenerated.

Table 4.4.2.1. Assessment criteria for malformed embryos of *Monoporeia affinis*, according to HELCOM, 2010.

Status class	Malformed embryos, %
High	<2.9
Good	2.9<5.7
Moderate	5.7 <8.6
Poor	8.6 <11.4
Bad	>11.4

Assessment criteria have been developed for malformed embryos of *M. affinis* in the Baltic Sea by Sundelin et al., 2008, 2012 (Table 4.4.2.1). The background response was at malformed embryos rate < 5.7% at number of at least ten gravid females were put as minimum for classifying the status of the area. Method of malformation rate was included in the Swedish national monitoring Programme in 1994, with five stations in the Bothnian Sea and nine in the Baltic Proper. This method has also been used for other amphipod species in coastal waters outside Great Britain, Gulf of Riga, and Gulf of Gdansk and in the Belt Sea. The method is used in the BONUS BEAST Programme as a core biomarker.

The frequency of malformed embryos (malformation rate) has been demonstrated to be significantly at contaminated sediments in bioassays as well as in contaminated field studies when compared to control microcosm and reference areas (Eriksson et al. 2005) and also different years observations (Fig. 4.4.2.4). The BONUS BEAST project made ecotoxicological studies in several parts of

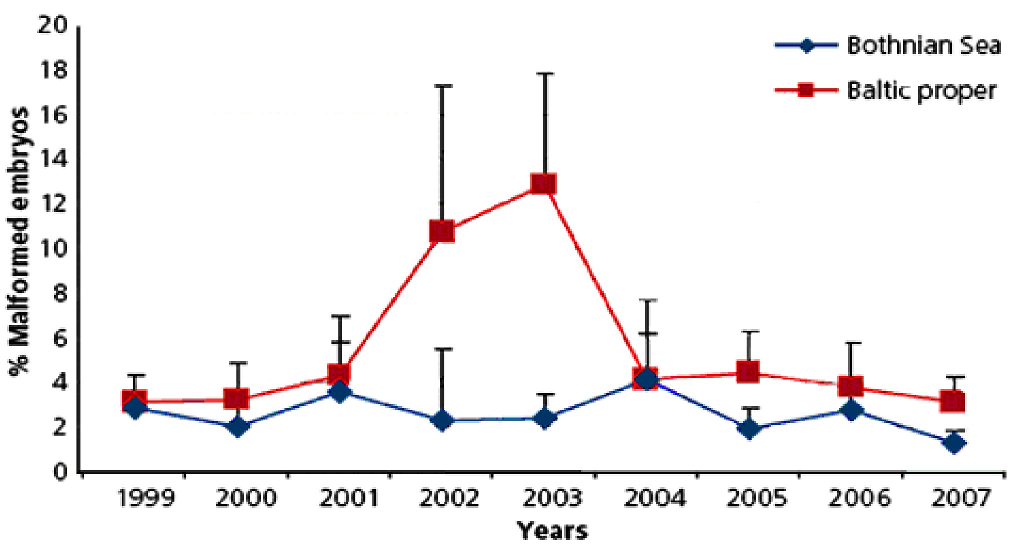


Fig. 4.4.2.4. Percentage of malformed embryos in the amphipod *Monoporeia affinis* collected from stations in the Bothnian Sea and the Baltic Proper. The malformation rate increased between 2001 and 2004 in the Baltic Proper for unknown reasons. Variance is given as upper 95% confidence intervals.

the Baltic Sea where were found a relationship between the malformations and contaminants in experiments and bioassay and in contaminant surveys (HELCOM, 2010b).

4.4.2.3. Methodical approach to Applying of the malformation rate as a core indicator in study area

The previous ecotoxicological studies in microcosms and field populations from different areas (contaminated and reference sites) of the Baltic sea have demonstrated toxicant-sensitive variables on embryonic development of amphipods *M. affinis* and *P. femorata* (Sundelin, 1983, 1998, Eriksson et al., 2005, Sundelin et al., 2008). These species distributed in areas deeper than 10 m in the northern parts of the Baltic Sea (Gulf of Bothnia). They need cold water and very sensitive to low oxygen (<4 mg/l, Goedkoop & Johnson, 2001). The loss of oxygen in the eastern Baltic Sea during last decades, including the Gulf of Finland, has reduced abruptly the abundance of *M. affinis* (Laine et al., 2007). This objective does this species as a difficult one to be used for bioassessment monitoring in the Gulf of Finland with wide-spread hypoxic events in the area near the bottom.

Similar biological effects of toxicants on embryonic development variables in amphipods were obtained for other amphipod species, including amphipods *Gammarus tigrinus*, *Pontogammarus robustoides, Gmelinoides fasciatus.* These species of amphipods may be also used for analysis of embryo aberrations and health status of the Gulf of Finland. The same protocol and method as in the case of *M. affinis* could be used for all of them. Guidelines are available in ICES Techniques in Marine Environmental Sciences (TIMES) # 41. Quality assurance declaration is updated regularly at website at Swedish EPA http://www.naturvardsverket.se/upload/02_tillstandet_i_miljon/ Miljoovervakning/programomraden/kust_och_hav/kvalitetsdeklaration_embryonal_vitmarla.pdf.

However, the assessment criteria have to be developed separately for used species because as it was shown in previous comparative studies the biological effect to contaminants may be varied between species and exposure conditions used, reflecting difference in sensitivity of species to toxicants. For example, the reference test to cadmium and other heavy metals indicates very high sensitivity of gammaridean amphipods *G. fasciatus, P. robustoides, G. tigrinus* (the 48 hours LC_{50} at 20°C) and low sensitivity of the haustorid amphipod *M. affinis* (Table 4.4.2.2).

Table 4.4.2.2. LC_{50} (mg/l) for cadmium (Cd), zinc (Zn), copper (Cu) for amphipod species at exposure time 48 hours according to Berezina et al. 2013, Strode, Balode, 2013.

Species	Temperature, ºC	Zn	Cu	Cd
Gmelinoides fasciatus	20	3.5	0.24	0.005
Pontogammarus robustoides	20	2.18	0.34	0.024
Gammarus tigrinus	20	0.31	0.08	0.068
Monoporeia affinis	5	28.6	10.7	12.6

4.4.2.4. Distribution of indicator species and relation to limiting factors

Three species of gammaridean amphipods *Gammarus tigrinus*, *Pontogammarus robustoides, Gmelinoides fasciatus* (fig. 4.4.2.5) were used as test species for applying and develop the study variable (malformed amphipod embryos) as a core indicator for biological effects of contaminants in the case of the Neva river estuary and the gulf of Finland. Distribution of these species in the Gulf of Finland is limited by different salinity; they are dominating taxa in the Neva river estuary (Fig. 4.4.2.6). All of them have a life span of 1.5 year and their mating begins in May; embryogenesis proceeds through 2-3 weeks, and juveniles are released several times in summer.

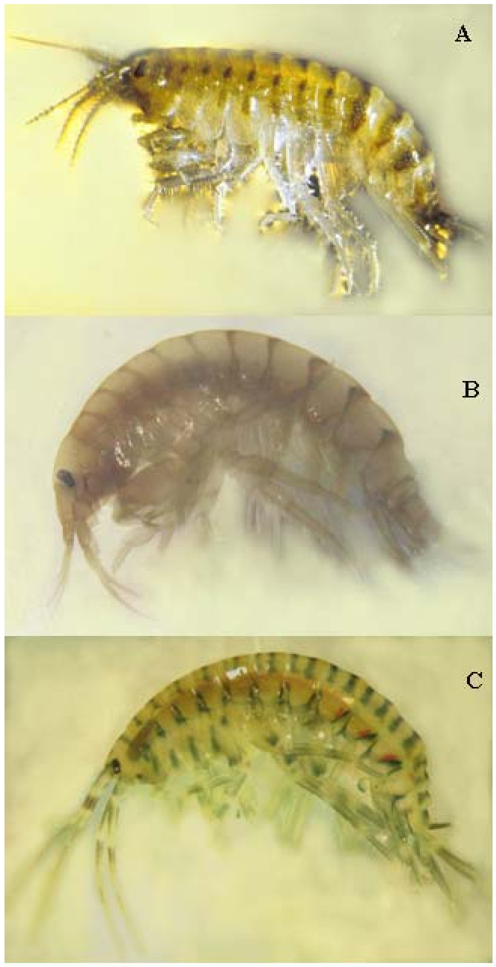


Fig. 4.4.2.5. General view of test species. A. *Gmelinoides fasciatus*, B. *Pontogammarus robustoides*, C. *Gammarus tigrinus* (photo by N. Berezina).

Gmelinoides fasciatus (fig. 4.4.2.5, A) was introduced from Lake Baikal intentionally to the Baltic region (Karelian Isthmus) in 1970s and its range extended to the eastern Gulf of Finland by 1990s (Berezina, 2007). Since the end of 1990s, it became the keynote species (above 40 % of the total benthic biomass) on different type of sediments in the open coasts of the Gulf of Finland and estuaries of the Neva, Luga, Narva rivers at the salinity from 0.005 to 3 ppt. Upper limit of the potential salinity tolerance in *G. fasciatus* was estimated as 5 ppt (Berezina et al. 2001, Berezina and Panov, 2004); this is corresponding to salinity in the most coastal waters of the Baltic Sea. At the same time, salinity below 2 ppt is needed for normal embryogenesis and high survival of released juveniles.

G. fasciatus is a middle-sized amphipod with a maximum of 12 mm in body length (Panov, Berezina, 2002). Sizes of ovigerous females range from 3.4 to 10 mm depending on habitat temperature, with smallest sizes found in Neva Bay during hot summer period at 27-31°C (Berezina, 2007). Clutch sizes vary from 3 to 45 eggs depending on the female body length. Embryogenesis of *G. fasciatus* lasts 180-220 degree-days, developmental time from hatched juveniles to maturation takes about 1000–1200 degree-days or 50–60 days at 18–20°C. Densities of *G. fasciatus* reach 4000 ind. m^{-2} in some locations of the Neva Estuary.

Pontogammarus robustoides (fig. 4.4.2.5, B) has been recorded in the southern Baltic Sea basin begins since 1963 this species has established in the oligohaline parts of southern Baltic Sea (Vistula, Szczecin and Curonian Lagoons) and dispersed in many coastal lakes/reservoirs and in the lower reaches or mouths of rivers emptying into the Baltic Sea. During the last few decades it was recorded in the eastern part of the Gulf of Finland, specifically in the estuary of the River Neva (Berezina & Panov 2003) and along Estonian coast in Narva Bay (Herkül et al. 2009). In the Neva estuary *P. robustoides* was abundant especially at southern location where adults (1500 ind.m^{-2}) and juveniles (3000 ind.m^{-2}) reached maximum in the middle of summer. *P. robustoides* is large-sized amphipod with a maximum of 22 mm in body length. In Neva Bay, it reaches 2700 ind. m^{-2}. Clutch sizes vary from 30 to 106 eggs per female in the body length range of 9–16 mm. Size-dependant individual fecundity was approximated by a power function ($E = 0.086L_b^{2.49}$) in the case of the Neva River estuary. This species is tolerant to water salinity from 0.1 up to 7.

Gammarus tigrinus (Fig. 4.4.2.5, C) is a species native to the Atlantic seaboard of the North America; it was first found in the Baltic Sea (Schlei Fjord) in 1975 (Bulnheim, 1976). In 1990-2000s, it spread along the entire Baltic Sea shore of northeastern Germany (Zettler 2001), north-western Poland (Gruszka 1999; Jażdżewski & Konopacka 2000) and reached Puck Bay (Szaniawska et al. 2003) and the Vistula Lagoon (Jażdżewski et al. 2002). In 2003 it was recorded in the Estonian coastal areas of the northern Gulf of Riga (Herkül et al., 2006) and off the Finnish coast in the Gulf of Finland (Pienimäki et al. 2004), in the Curonian Lagoon (Daunys, Zettler, 2006), and, later in 2005, it was recorded in the easternmost part of the Baltic Sea (Neva Estuary). *G. tigrinus* is adapted to wide range of the environmental conditions from freshwater to salinity of up to 25 PSU. The distribution of these three species in the Gulf of Finland is demonstrated on the map (fig. 4.4.2.6).

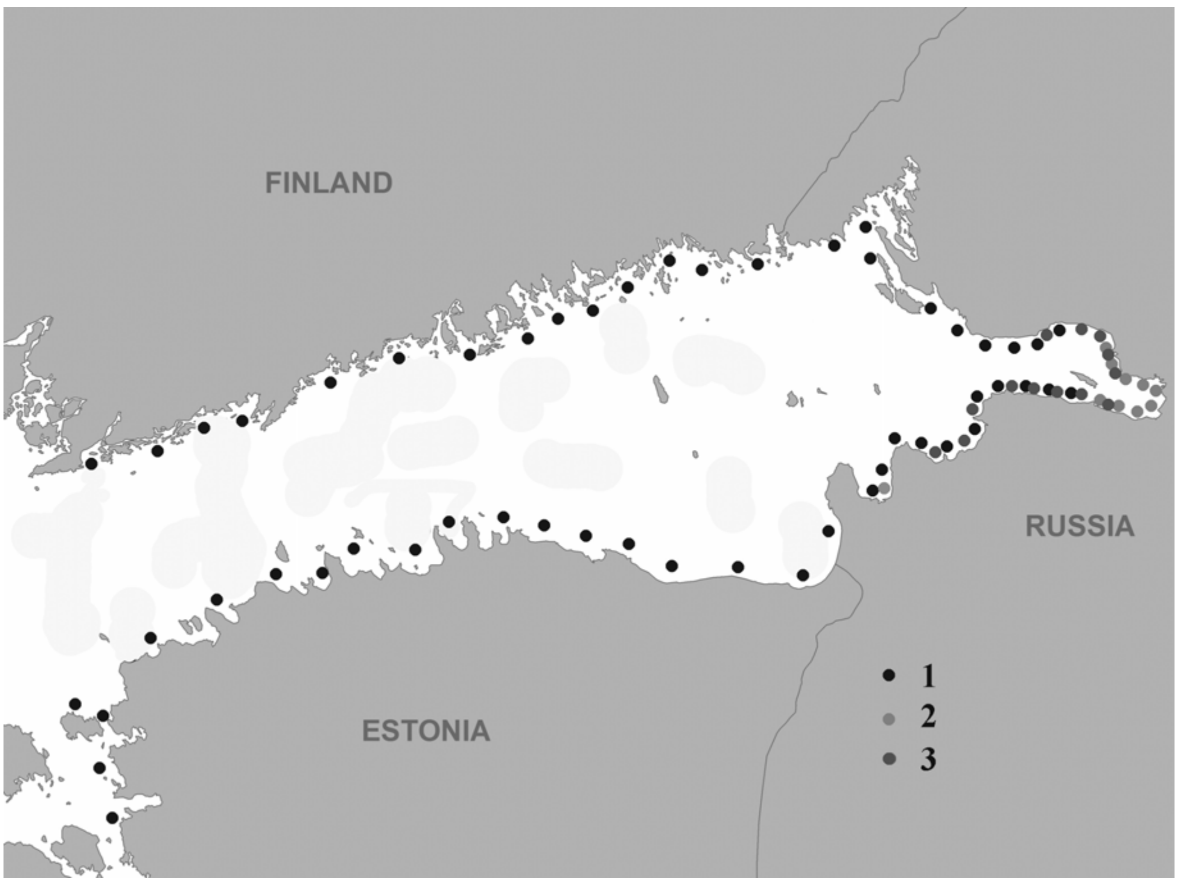


Fig. 4.4.2.6. Distribution of study amphipod species in the Gulf of Finland. 1- *Gammarus tigrinus*, 2- *Gmelinoides fasciatus*, 3- *Pontogammarus robustoides*.

4.4.2. 5. Sample collection and laboratory procedure

The samples of amphipods were collected from 10 to 12 a.m. in three replicates from study sites in summer 2012-2013 in the Neva Estuary. To collect quantitative samples of bottom animals including amphipods, a 0.7-m height plastic tube with the sampling area of 0.03 m^2 was used. All hard substrates (mainly pebbles and reed shoots) and a 3–5 cm layer of soft sediments (upper layer of sand with detritus) within the tube were gathered by hands and a hand-held net (mesh size 250 µm) during three-five minutes. The sample was preserved in 4 % formaldehyde before transportation to the laboratory.

In laboratory all amphipods with body sizes >2 mm were picked out by hand. Then amphipods were separated into four categories: juveniles, males, females I (without eggs in marsupium) and females II (gravid females, with eggs/embryos in marsupium). The determination of the reproductive status of the females was based on the presence and structure of brood plates (oostegites). The immature females have oostegites lacking setae.

The gravid females had eggs in the brood pouch /marsupium (fig. 4.4.2.1). The all gravid females were size-sorted in a 0.5 mm step and placed individually into Petri dishes; then the eggs were carefully teased out of the marsupium with pins or forceps. Only females carrying a closed marsupium were included in the analysis. The developmental stage of eggs (embryos) was identified according to Weygoldt (1924) and Scadsheim (1982), cited in Pöckl (1993). The seven stages were distinguished (fig. 4.4.2.1, Table 4.4.2.3).

Table 4.4.2.3. Identification of developmental stage of normal embryos in gammaridean amphipods

Stages	Description
Stage 1	Newly laid; two egg groups may be surrounded by a hyaline membrane; cleavage cells in each eggs not in excess of sixty-four
Stage 2	The hyaline membrane have disappeared; the egg is homogeneous internally and the egg membrane fits tightly around the cell mass
Stage 3	A ventral cleft is visible, extending into a horseshoe-shaped furrow and separating the future abdomen from the cephalothorax;
Stage 4	Appendage rudiments are visible and the dorsal organ attains its maximum size
Stage 5	Body appendages are jointed; gut system contains large yellow pigmented cell
Stage 6	Cephalothorax turns orange-red, later red pigmented eye spots appear; limbs biramous and segmentation clearly visible
Stage 7	Hatched and free juveniles (neonates)

4.4.2.6. Applying the malformation rate as a core indicator in study area

Previous experimental studies showed that the number of dead/undeveloped and malformed eggs/embryos in *G. fasciatus* increased already after one week (at Stage III) amphipods exposure in contaminated water (Cu^{2+} effect, fig. 4.4.2.7). Embryonic disorders reached a maximum to the end of embryogenesis. Rate of normally developed eggs/embryos (relative ratio of them to embryos at stage II) in *G. fasciatus* at control conditions reached 0.8-0.85, i.e. rate of natural mortality and aberrations of embryos reach 15-20%. When heavy metals affect on gravid females the number of malformed or partially undeveloped (dead eggs) rate in them have increased significantly reached 30-50 %.

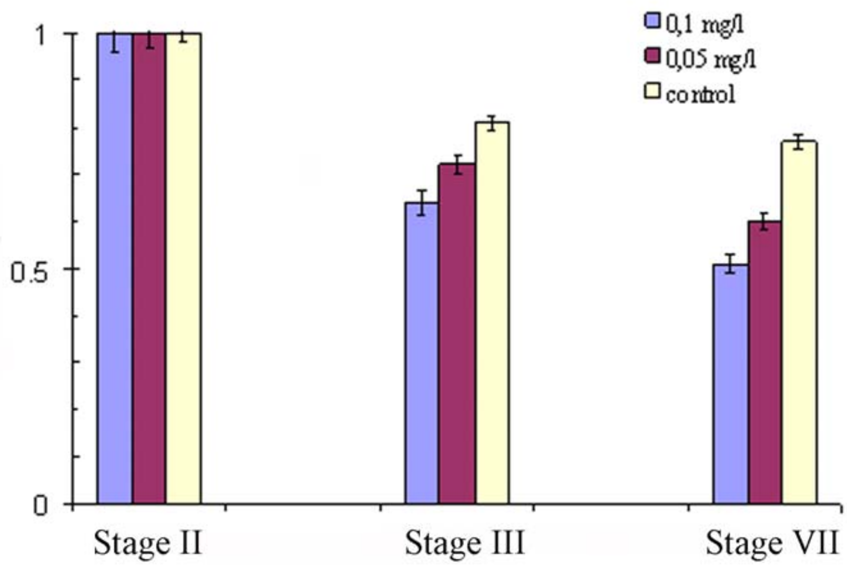


Fig. 4.4.2.7. Rate of normally developed eggs/embryos (relative ratio to embryos at stage II) in *Gmelinoides fasciatus* at different concentration of copper ($CuSO_4$). Contaminants can induce disorders in egg development leading to a significant increase of egg mortality and malformation.

The status of study amphipods (*G. fasciatus, P. robustoides* and *G. tigrinus*) reproductivity, measured as the proportion of malformed embryos. The good status is reached if <5-8 % of embryos are malformed and the bad status is given if >40% of embryos are malformed (Table 4).

Table 4.4.2.4. Assessment criteria for malformed embryos of gammaridean amphipods *Gmelinoides fasciatus, Pontogammarus robustoides* and *Gammarus tigrinus*

Status class	**Malformed embryos, %**
High	<5
Good	5<8
Moderate	8<20
Poor	20<40
Bad	>40

Note that the squares represent possibly contaminated assessment sites (cities, industries and other point sources) and circles reference areas (no point sources). The limit between good and moderate status was put at a value where all (> 99%) variation in the reference dataset is included.
Types of malformations and aberrations in gammaridean amphipods that were registered in the Gulf of Finland were separated into 8 types:

- Type 1. Oedema and impaired membranes where lipids had leaked outside the embryo.
- Type 2. Malformed eyespot;
- Type 3. Enlarged embryos with no other visible damage
- Type 4. Female with dead brood.
- Type 5. Unidentified Stage dead eggs/embryos of a brood.
- Type 6. Single dead eggs and juveniles.
- Type 7. Embryos with aberrant cleavages in the early embryogenesis.
- Type 8. Undifferentiated embryos in which cells have degenerated

The most frequent embryonic disorders such as embryos with aberrant cleavages in the early embryogenesis and single dead eggs and juveniles were found in the Koporskaya Bay and northern part Neva Bay in 2012-2013 (fig. 4.4.2.8). Percentage of malformed embryos in the amphipod *G. tigrinus, G. fasciatus* and *P. robustoides* collected from field sites in the eastern Gulf of Finland reached 30-60% testifying on poor state of environments in tested localities (fig. 4.4.2.8, Table 4.4.2.4). The status of coastal assessment units varied from good to poor. The coastal areas

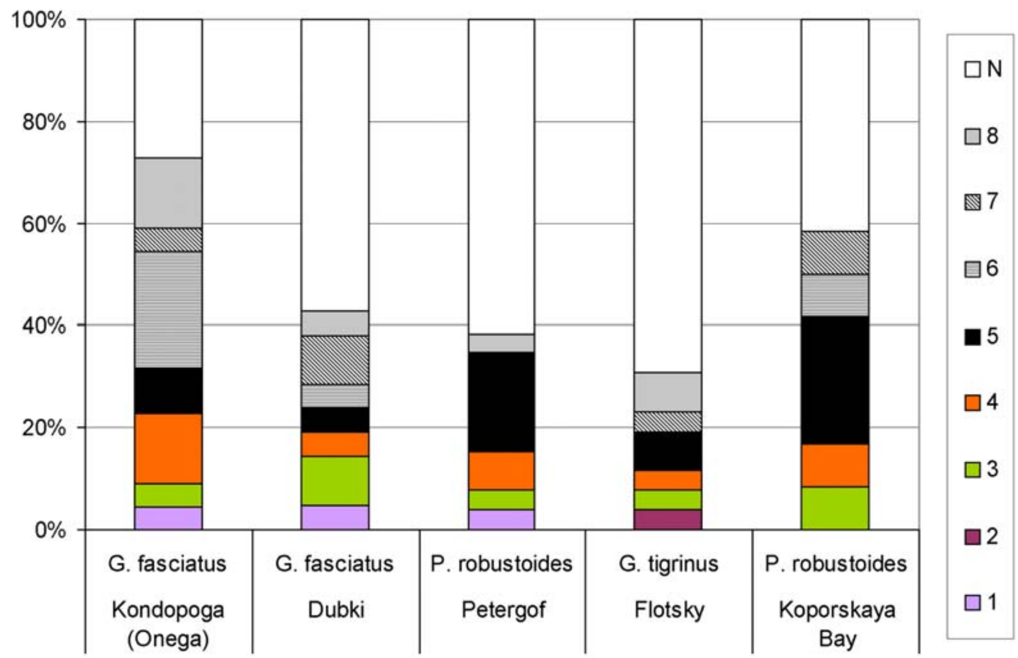


Fig. 4.4.2.8. Percentage of malformed and normal embryos in the amphipod *Gammarus tigrinus* (1), *Gmelinoides fasciatus* (2) and *Pontogammarus robustoides* (3) collected from field sites in the Gulf of Finland and its basin. Explanation of types is in text.

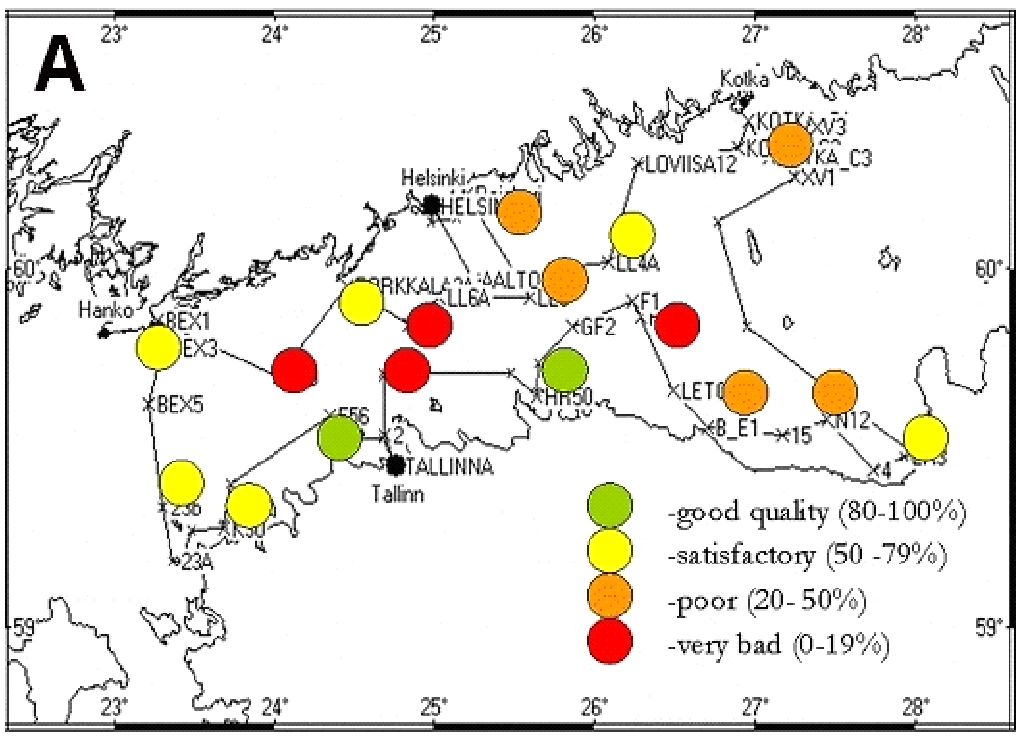
that received the highest status classifications (malformation rate <40 %) were located in the southern part of the Neva Bay (site Petergof) and in the northern coast of the inner estuary (site Flotsky). There was some tendency for the assessment units with the poorest status to be located either near point of wastewater discharges (Dubki-Olgino) and coastal sites of the Koporskaya Bay (near nuclear Power Plant). The waters near St. Petersburg area were generally classified as having a 'moderate' hazardous substances status.

Bioassay with amphipod *G. fasciatus* conducted previously in 2010-2012 for the eastern Gulf of Finland is also confirmed the presence of the problem zones with high sediment toxicity from the Gulf of Finland, open Finnish part and shallow Neva Estuary (Berezina et al. 2011, fig. 9 a, b). Following to indicated sediment quality estimation criteria in survival bioassay test: good quality at survival of test object from 80 to 100 %; satisfactory quality at survival of testobjects 50-79 %; poor quality at the survival of 20-50 % and very bad quality at the survival < 20 %. The significant differences in survival rates and reproductive variables of *G. fasciatus* were found between sites. Above 50% of the sites in central and north-eastern areas of the Gulf of Finland and 80% of the sites Neva Bay (2009) were assessed as contaminated areas. The survival rates obtained in the bioassay correlate significantly with Shannon index (macrozoobenthos) and weight loss-on-ignition (%) in sediments (Berezina et al. 2013).

4.4.2.7 Monitoring recommendations

The number of malformed embryos of benthic amphipods indicates that sampled areas of point-source pollution have impaired environmental status. Reference areas farther away from the point sources have considerably lower number of malformed embryos but also their status has declined in recent years. The results suggest that embryonic disorders variables in gammaridean amphipods *G. fasciatus, P. robustoides* and *G. fasciatus* are responsive and suitable tool that can be used as primarily indicator of sediment quality in different Baltic Sea regions but the most sensitive species should be found in further investigations. Our result suggest that *G. fasciatus* is good sensitive indicator of sediment quality in Baltic Sea region. We found malformation and death of amphipod embryos, and asynchronous maturation of males and females (change in sex ratio) collected in sites with distinct contamination rate that suggest reproductive variables of studied amphipod species as are responsive tools for assessment of sediment quality in Baltic Sea regions. Analysis of biomarker responses shows rate of malformed embryos in gammaridean amphipod is useful physiological variables for the assessment of pre-accident environmental status of local ecosystem.

The monitoring of the Gulf of Finland state concerning the inputs of pollutants should be strengthened. Embryonic disorders variables in gammaridean amphipods (*G. fasciatus, P. robustoides* and *G. fasciatus* and others) as a core indicator is convenient and appropriate method for assessing the quality of water and bottom sediments in the Gulf of Finland (including Russian regions) of the Baltic Sea, and in the future can be recommended to be used in the monitoring as a component of national environmental monitoring and assessment programmes, possibly together with other well-known methods such as 10-days mortality test, genotoxicity test, etc.



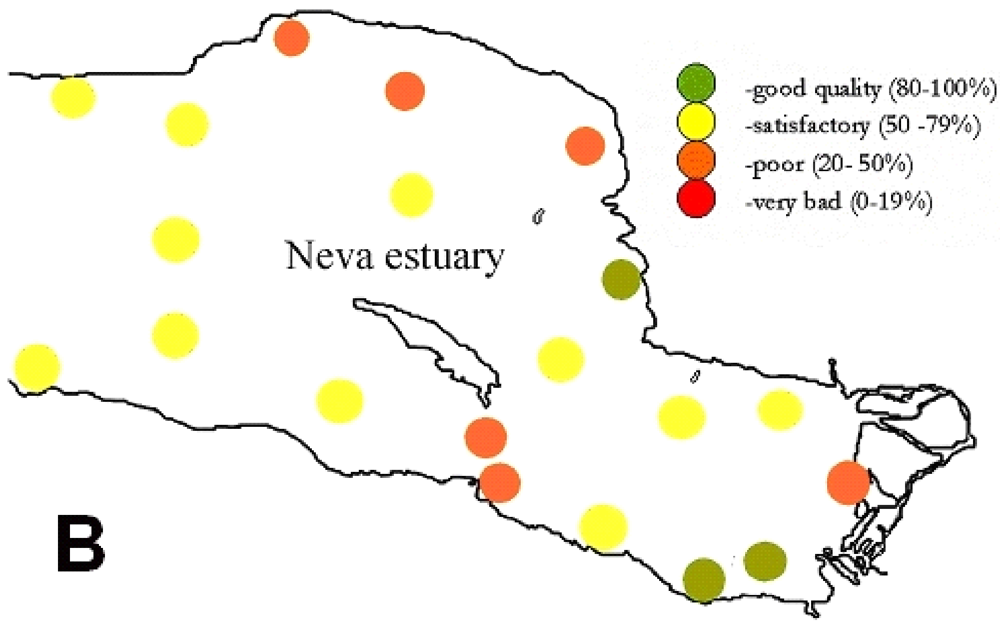


Fig. 4.4.2.9. Bioassay with *Gmelinoides fasciatus* showing unfavorable areas with contaminated sediments and station recommended to next monitoring with malformed embryos rate as a core variable (A, B – western and eastern parts of the Gulf of Finland).

The embryonic disorders variables should be monitored at least 20 stations in the Russian part of the Gulf of Finland (fig. 4.4.2.9 A, B) on a regular basis every year as a prolongation of the molnitoring network in the W part of the Gulf.

Monitored areas can include local points of polluted waters and other possible negative effects (port constructions, dredging) and reference areas in the Neva Bay, Luga Bay, Koporskaya Bay, Vyborg Bay and St.-Petersburg Resort District. A comparative number of sites are recommended to be in coastal and deep waters near point sources and in reference area. Data should include 30–50 individuals per amphipod species per site.

Also, control for state of large systems in the catchment areas of the Gulf of Finland on Russian territory. The River Neva, which discharges to the Gulf of Finland, has the largest river basin catchment area of the Baltic Sea (17% of the whole catchment). Therefore, observation area may include point sources of pollution in Chudskoe (Peipsi), Onega and Ladoga lakes and connected rivers basing on 2-3 years interval assessment (in mid-summer time).

4.5. POPULATION GROWTH RATES, ABUNDANCE AND DISTRIBUTION OF MARINE MAMMALS

4.5.1. General remarks on methodology

Abundance estimation and density distribution assessment of the ringed seal and grey seal in the Gulf of Finland has traditionally been implemented mainly by two methods – aerial surveying of seals hauled out on ice in spring and boat surveys of terrestrial or rockeries haul-out sites from late spring till autumn. Aerial surveys on spring ice method implies that snow has mostly melted, roofs of pupping lairs are gone, the largest part of the population tend to stay on remaining ice floes to complete their annual molt and is therefore available for registration from an aircraft.

For abundance estimation of the ringed seals on ice, strip transects method (Skalski *et al*., 2005) is typically used. The data are collected by observers from a fixed-wing aircraft flying along preliminary planned and randomly distributed linear transects covering certain portion of ice covered area. Flights take place in daytime under sunny or clear weather conditions, preferably with no wind. Observations are made from both sides of the aircraft. In Soviet time the seals observed on ice were recorded manually in a notebook or directly on map of the survey area. Modern survey techniques include use of digital cameras connected to hand held GPS units and voice recorders which allow precise registration of seals' positions and photo documentation for animals seen for further analysis. Currently the flight altitude and ground speed are controlled by board navigation system and maintained as consistent as possible in order to enable extrapolation of obtained data over the whole area of interest. Number and length of transects, survey duration and dates vary from year to year depending on ice and weather conditions, aircraft used and funds available. Estimation of number of seals hauled out on ice during the survey is used by the experts to predict the total population size taking into account various correction factors.

Several surveys have been conducted during the past decades but the differing methods used make it difficult to reveal the real population trend in the area. The methods of sampling the ice and calculating final results were either incomparable (Helle, 1980b; Härkönen and Lunnerid, 1992) or unclear (Zheglov and Chapskiy, 1971; Rezvov, 1975).

The earliest data on seals in the Gulf of Finland are found in Brandt (1856) and Smirnov (1908) who mentioned only the existence of seals in the area, while Gottberg (1925; reported in Härkönen *et al*., 2008) and Bergman (1956) presented detailed bounty statistics for the Finish sea area. Statistics for the Soviet part of the Baltic Sea showed that about 1400 seals were killed annually in 1940-1970s (Tormosov and Rezvov, 1978).

4.5.2. **Pusa hispida botnica** *abundance estimation results*

Systematic studies of ringed seal abundance in the Baltic waters of the Soviet Union were launched by Atlantic Scientific Research Institute of Fisheries and Oceanography (AtlantNIRO) in 1969. The first estimation of the population size based on counts in the Gulf of Finland was made in March 1970 when 5000 individuals were counted (Rezvov, 1975; Tormosov, 1977). Rezvov's (1975) estimate for both the Gulf of Finland and the Gulf of Riga was 9500 animals, but this figure becomes more uncertain taking into account Zheglov and Chapskiy's (1971) earlier estimation of 12500 seals for the same year obtained for the 9-11 March. The second survey conducted by them on 3-7 April gave lower number – 8000 seal after extrapolation and correction for haul-out probability. There's information available that the aircrafts LI-2 and IL-14 were used for seal censuses in 1970 and the survey was made along preliminary planned transects with fixed strip width (approx 150m). The authors noted that ringed seals disturbed by the engine sound went to water in 200-250 m before the approaching aircraft which might have caused additional bias in counts. Despite high level of data uncertainty, Zheglov and Chapsliy made a conclusion on considerable decline of seal abundance in the Baltic Sea.

In 1973 total seal number in the Gulf of Riga and the Gulf of Finland was reported to be 10 000 (8200 in the Gulf of Finland) individuals (Tormosov, Philatov, 1984). But this figure is probably too high given Tormosov's estimate of 2100 ringed seals in 1979 (Tormosov *et al*., 1980; Tormosov, Esipenko, 1989). The latter estimate is based on 65 animals detected on ice, while 8.8% of total ice area was surveyed. Other paper suggests that for the same year, 1979, the population size of the ringed seal in the Gulf was 3500 – 4000 (Tormosov, Philatov, 1984). A study in 1982 by Tormosov and Esipenko (1986) based on a survey fraction of about 3% gave an estimate of 3700-4000 individuals for the Soviet part of the Gulf. But in this case the extrapolation method used was questionable (Stenman, 1990). In the Gulf of Finland, in opinion of Tormosov and Esipenko (1990a), the ringed seal population was stable in 1970s and estimated to be approximately 4000 seals. In 1982 and 1985, ringed seal surveys conducted by AtlantNIRO in the Gulf of Finland yielded a roughly similar number – 4000 individuals (Tormosov and Esipenko, 1990a).

In 1992-1993 attempts were made by Russian and Finish researchers to count ringed seals using a helicopter MI-8. Unfortunately poor ice conditions in those years made it impossible to obtain a reliable estimate of the population in the Eastern part of the Gulf. The aerial counts of seals (89 in 1992 and 44 in 1993) provided only an indication of the number of seals in the area northeast of Seskar Island.

In 1994 strip transect technique was applied for the seal census. 61 seals were counted within the transects covering 36% of ice which gave an estimate of 173 animals. In 1995 AN-2 aircraft was used, 32% of ice was surveyed and total seal number was 169 (Härkönen *et al*., 1998). Important to note that in April, 1995 all ice concentrated in the Russian part of the Gulf of Finland and this figure represent an actual number of hauled-out seals in the area

Surveys over Russian territory were carried out in 1996. In total 22 ringed seals were observed and as the sampling fraction was 24% the estimate of the total hauled out population was 92. However due to military restrictions in the westernmost part of Russian waters only 60 % on ice suitable for seals could be covered by strips. Applying an average seal density in the area surveyed to the remaining area gave a total estimate of 149 seals (Härkönen *et al.,* 1998).

The authors noted that the most comprehensive survey was conducted in 1997, when due to western winds most of the ice concentrated in the Eastern part of the Gulf of Finland, which was fully accessible for an aircraft. In that spring there were 280 seals on ice which resulted in rough abundance estimation of 300 animals at the end of the XX century.

All in 1993-2002 seal counts in the Gulf of Finland showed quite similar results – from 150 to 170 animals were registered on ice while total abundance according to expert opinion was less than 300 (Verevkin, Sagitov, 2003).

On the 21st of April 2002 the Baltic Fund for Nature conducted a survey on the remaining ice floes with total area 200 sq km. And an estimated number of ringed seals was 164 individuals.

The next survey took place in 2004 and was supported by Finnish Game and Fisheries Research Institute. 179 sq km (12.4%) of ice was surveyed and only 3 ringed seals were found. Total number of seals on ice, thus, was 24. However, it should be noted that most of the ice that year remained on Finish side of the Gulf, and, combining Russian and Finish survey results, the researches came up with a total estimate of 100 ringed seals in the Gulf of Finland (Verevkin, Sagitov, 2004).

Due to financial limitations in early 2000s and a series of warm winters in 2007-2009 resulting in early ice melt and lack of ice in the areas typically used by the seals, no aerial surveys were conducted. Only in April 2004 a short flight was made along the coast line, but no data meaningful for number estimation were collected.

In April 2010 the Baltic Fund for Nature implemented another ringed survey within the project 'Straightening of marine and coastal protected areas' funded by UNDP, GEF and the Ministry of natural resources and ecology of Russian Federation. The ice area covered by strip transects was 1193.7 sq km (23.3%). 6 seals registered on ice allowed to estimate the total number of seals hauled out of 24 (95% CI: 8-44; Verevkin *et al*., 2012). Combining that survey results with the data collected by Estonian and Finish colleagues gave an estimate of 45 (95% CI: 12-77) seals in the Gulf of Finland.

In April 2012 the surveys were supported by UNDP. During two days of flights on 517 sq km (13,2%) of ice covered area 12 ringed seals were detected. Predicted seal abundance was 91 (95%C I: 44-139; Technical report, BFN, 2012).

Table 4.5.1. Baltic Ringed seal abundance estimated in the Russian part of the Gulf of Finland

Year	Abundance estimate	Authors
1970	5000-12500	Rezvov 1975, Zheglov and Chapski 1971
1973	8200	Tormosov, Rezvov, 1978
1979	793-1600	Härkönen et al., 1998, Tormosov et al., 1980
1982	2100-4000	Tormosov, Esipenko 1986
1985	3700-4000	Tormosov, Esipenko 1989
1992	89	Härkönen et al., 1998
1993	150	Härkönen et al., 1998
1994	173	Härkönen et al., 1998
1995	169	Härkönen et al., 1998
1996	149	Härkönen et al., 1998
1997	280	Verevkin, Sagitov, 1997
2004	100	Verevkin, Sagitov, 2004
2010	45	Verevkin et al., 2012
2012	91	Report UNDP 2012

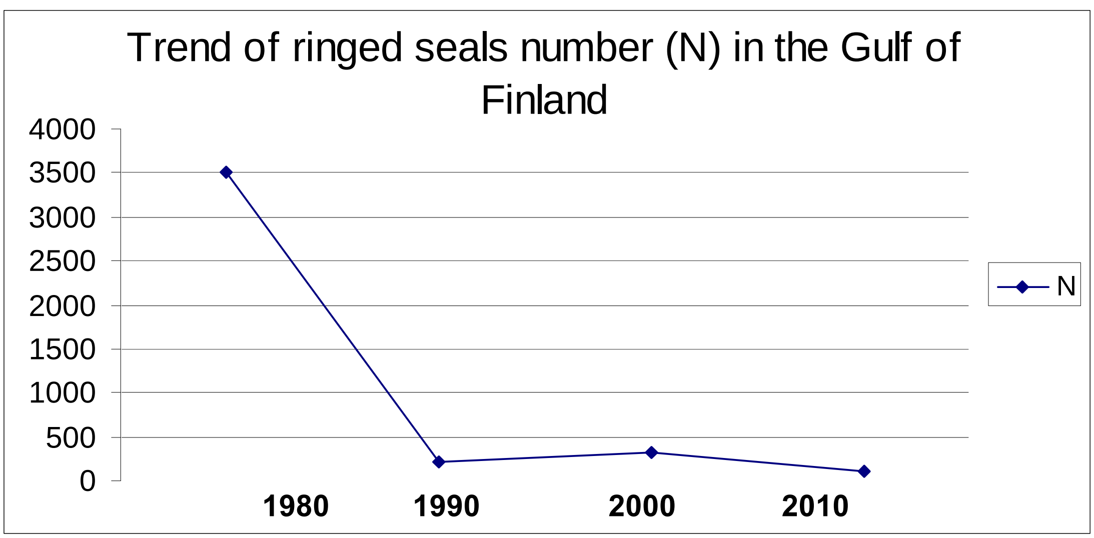


Fig. 4.5.1. Trend of ringed seals number (N) in the Gulf of Finland (after Tormosov, Esipenko, 1990; Harkonen et al., 1998; Verevkin, Sagitov, 2004; Verevkin et al., 2012)

The information available for population estimates in the Gulf of Finland from XX and XXI centuries (Table 4.5.1) is hard to compare and to evaluate in terms of results quality. This is mostly due to lack of information on location of transects and variances of estimates. Before 1980s the Soviet researches usually studied much larger area encompassing the Gulf of Riga and a large part of the Gulf of Finland including its western part and reported joint survey results for the area. Thus, the comparison with current surveys limited by Russian border with these historical data can't be made. Data quality for the ringed seal population number is insufficient to make any precise assessments of population trend including possible birth and mortality rates. Although it is possible to say that the population number has declined dramatically in 1970-1990s, probably due to intense harvest taking place until 1980, and then due to mortality events registered in the area in early 1990s when more than 150 dead seals drifted ashore in Russia and Finland (Stenman *et al*., 2005). O. Stenman (pers. comm.) suggested that either natural or man-made neurotoxins could be the reason for that.

4.5.3. **Pusa hispida botnica** ***distribution***

In winter ringed seal distribution is restricted by the availability of sea ice providing a platform for parturition and nursing the pups. Thus location of seals in ice season in a particular year is strictly related to weather condition and ice formation pattern. In mild winters when the ice forms only in easternmost part of the Gulf pupping occurs close to the city of St Petersburg making the breeding population more vulnerable to human caused disturbance, potential entanglement in fishing gears and poaching.

In severe winters, according to Rezvov (1975), the hauling out population density is much lower than in warm years when the ice availability becomes an issue. For instance in winter 1969-1970 an area of the ice occupied by the seals was 9328 sq km with average seal density 0.17-0.62 seals/sq km. In mild winter 1972-1973 the ice area occupied by the seals was only 2376 sq km while the density has increased up to 2.1.seal/sq km.

The map (fig. 4.5.2) schematically shows ringed seal sightings on ice in spring in early 2000 (Pogrebov, Sagitov, 2006). It should be noted that a considerable part of the population was detected in north-eastern part of Russian waters, surrounding Berezovie Island. Some animals were distributed to the north of Kurgalskiy Reef, close to the islands of the Gulf of Finland.

During the ice-free season, ringed seals mostly stay in the southern part of the Gulf. They haul-out on rocks in vicinity from one another. The largest haulouts are off Vigrund, Hitamatala, Remisaar islands and on Kiskolskiy Reef. In May, early June and in September-November, the ringed seal forms haulouts of up to several dozens of individuals. In summer the ringed seals leave the mainland coast to rest on the rocks off small islands or on reefs in the sea. The migration of ringed seals may be associated with increasing water temperature in the coastal zone and increased disturbance due to appearance of a large number of fishermen and tourists. At least where the visits by people of the haulouts are limited or banned, ringed seals haul out on the rocks during the entire summer. The main part of the population of the ringed seal breeds south and southwest of the Berzovie Islands in February-March. The size and the location of the haulouts are determined by the area and location of the suitable ice that is formed by late January, i.e. prior to pupping. A rookery has been always recorded in the region of the Berezovie Islands in 1969-1972 by Rezvov (1975) and by the Baltic Fund for Nature in 1997-2001.

Starting from 2010 annual seal counts during open water period have been conducted during the catamaran expeditions supported by NordStream AG company and the results were reflected in respective reports.

In spring-summer 2012 during the expedition to panned Ingermanlandskiy reserve islands seal censuses were implemented at two key seal sites – at Maliy Island and at small archipelago of islets Hallikarti – Ityakivi. During the second stage of the expedition, which was less favorable for seal censuses, Rodsher Island was also visited. Unfortunately because of time deficiency such important seal sites as islands Vigrund and Hitamatola, Ostrovnoy Reef were not explores as well as less important Maliy Tyuters and Halli Islands and Reef Tiskolsky.

The ringed seals were recorded only at first stage of the expedition, in June. Two animals were found on the reefs at Maliy Iisland, another one lied on big stone in 2 km northward from Bolshoy Fiskar Archipelago. Remains of dead body of ringed seal (died in winter or early spring) were found on Maliy Fiskar Island.

Figure 4.5.3 reflects main known patterns of the Baltic ringed seal seasonal movements (Pogrebov, Sagitov, 2006). Although it is unclear how reliable this information is as no particular methodology to determine this pattern was used and on-land observations suggest that the seals might be seen practically in all parts of the Gulf in open-water season with no strong attachment to any particular area in any given time. Possibly the individuals tend to use the same sites for hauling out and foraging from year to year, but those sites for sure differ for different animals.

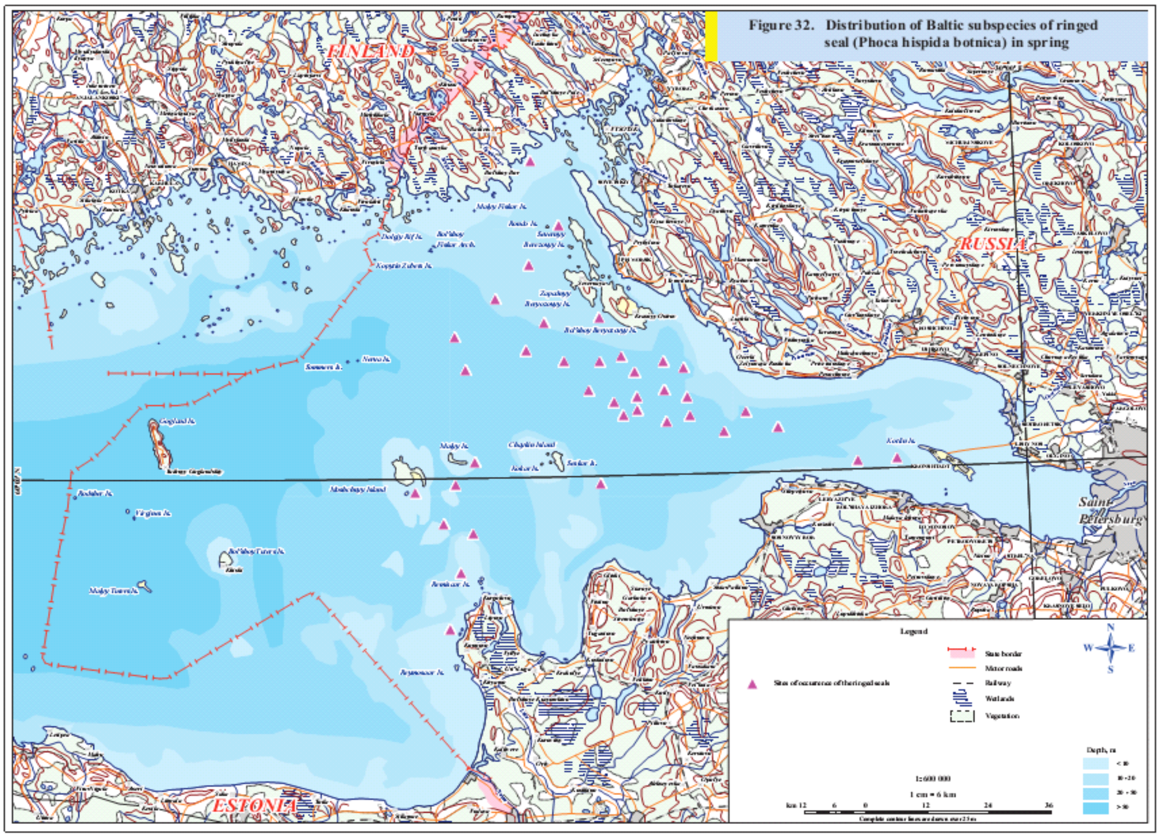


Fig. 4.5.2. Sightings (triangulars) of the Baltic ringed seal on spring ice (Pogrebov, Sagitov, 2006)

Based on telemetry study the western limit point of distribution in Russian Federation is Maliy Tyuters Island and the eastern point locates near Tolbukhin lighthouse. The eastern part of Nevskaya Bay is probably not available for the seals because of the Flood Prevention Facility Complex (Dam) which delimits this part from the rest of the Gulf. Ringed seal is not restricted in the movements during open-water period as the locations of tagged individuals covered almost whole area within its range (Härkönen *et al*., 2008). The ringed seal uses haul-out sites after the ice break-up during annual molt and in other time of an open water period for resting. The seals exclusively use moraine ridges (rockeries) for hauling out. Ringed seal from population of the Gulf of Finland hauls out alone or gathers in groups up to 80 individuals. Seal individuals mainly use terrestrial haul-out sites in May-June and September-October (Verevkin, Sagitov, 1997; 2004).

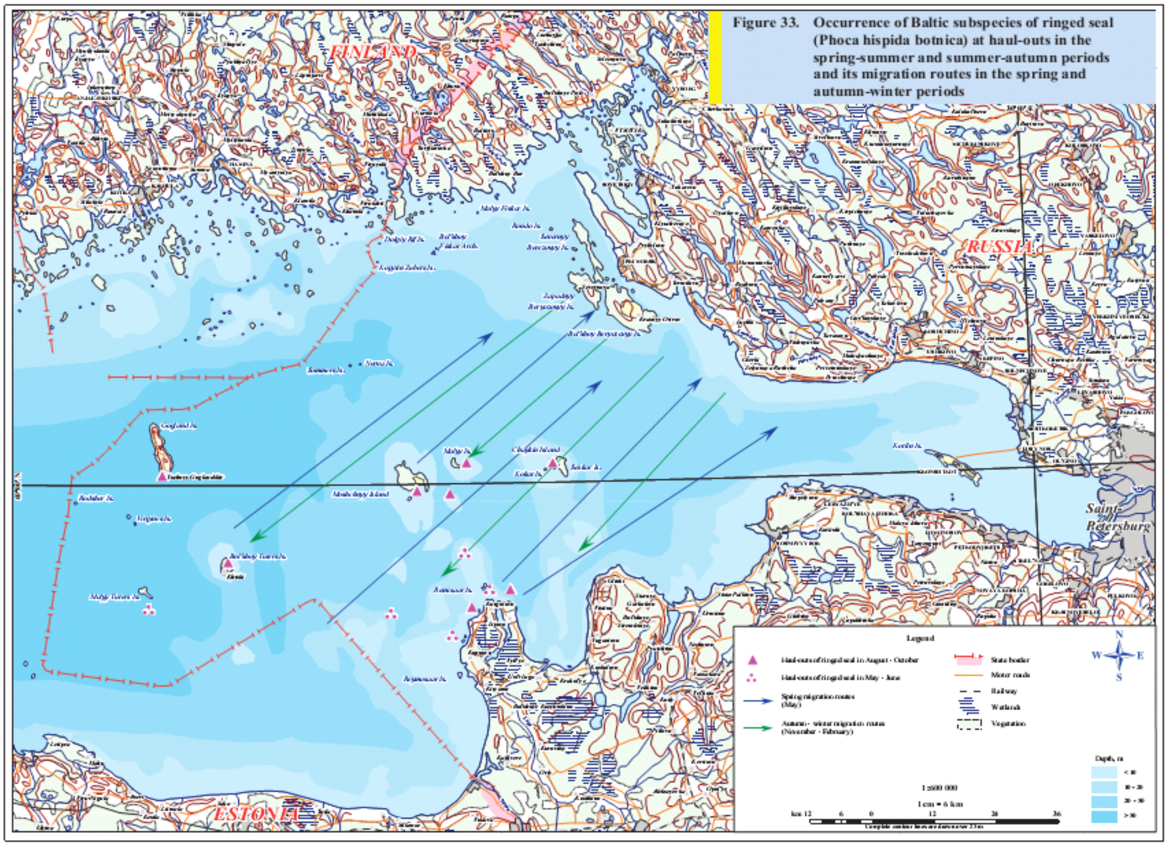


Fig. 4.5.3. Ringed seal seasonal movements – spring – blue arrows, autumn – green (Pogrebov, Sagitov, 2006)

Vessel observations of 1978-1983 implemented by AtlantNIRO revealed that the main area of haul-out site concentration was Kurgalskiy Peninsula (Kurgalskiy and Kiskolskiy (Tiskolskiy) Reefs). The seal abundance on Kurgalsky Reef was 100-250 individuals, on Kiskolskiy Reef and Bolshoy Tyuters Island - 100-200 individuals, on Moshniy Island - 70-100 individuals. About 50 animals used to be observed at Virginy Islands and about 30 animals regularly hauled out around Maliy and Seskar Islands. Hauling out groups of less than 10 individuals existed on Berezoviy Archipelago and around Kiperort Peninsula (Tormosov, Esipenko, 1986). Thus, southern part of the Gulf was playing a crucial role for the ringed seal in term of haul-out sites.

In 1990s haul-outs of ringed seal were also observed on the islands of southern part of the Gulf of Finland and Kurgalskiy Peninsula during vessel survey but seal abundance was not comparable with previous data due to mass morality taken place at the beginning of 1990s (Stenman *et al*., 2005). Haul-outs of several dozens of seals were registered on Kurgalskiy and Kiskolskiy reefs, Hitamatala Bank and Vigrund Reef. Groups of 5-15 individuals were common at Maliy and Maliy Tyuters Islands and single individuals occurred on Bolshoi Tyuters Island, Moshniy Island and Seskar Island (Verevkin, Sagitov, 1997; 2004; Fig.4). Several stationary counts have been carried out on Kurgalskiy Peninsula in May-June and September-November during the last fifteen years and showed maximum seal number equal to 40-50 individuals per season with a spike of 96 individuals in 2007 (Loseva, Verevkin, 2012).

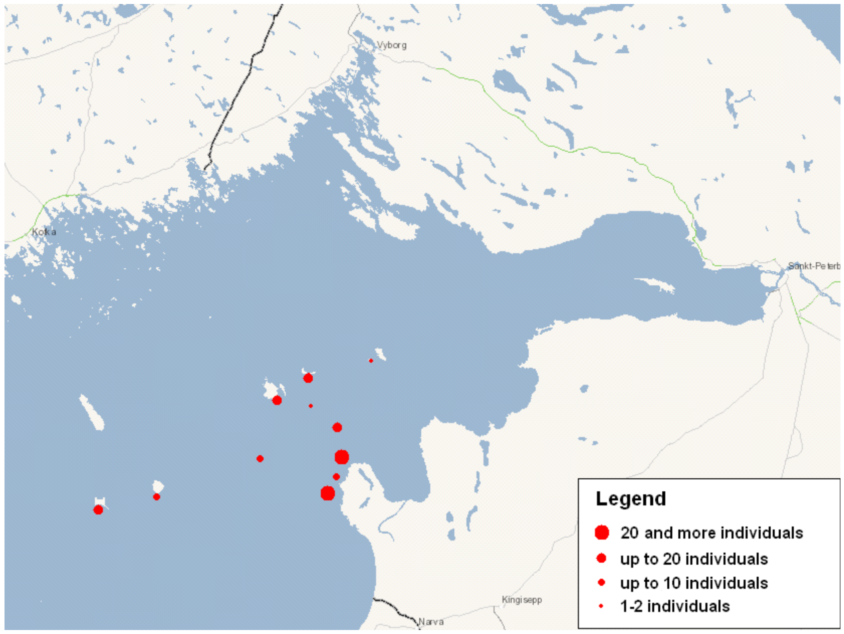


Fig. 4.5.4. Haul-out site distribution in the Russian part of the Gulf of Finland (Verevkin, Sagitov, 1997; 2004)

Study of haul-out site distribution in 2012

In 2012 a dedicated study was implemented by A. Loseva in the frames of UNDP/GEF project which had a purpose to determine a presence of haul-out sites in the regions that had not been in focus of observations in the last decades. In order to study haul-out site distribution of ringed seal a questionnaire method was used. The group of responders included commercial fishermen, amateur fishermen, inspectors of fisheries control service, inspectors of State Inspectorate for Small Vessel, staff of Hydrographic Service. About 100 people took part in the survey. A questionnaire form included questions on haul-out site location, seal number, day of year, year of sighting, seal species and sighting frequency. To make the determination of seal species easier some photos with the most typical external features of both seal species, grey seal and ringed seal, were demonstrated to the responders. The project was implemented in September-December 2012. The area of the Gulf of Finland was divided into 10 regions for futher analysis: the northern coast of Nevskaya Bay, Berezoviy Archipelago, Vyborg Bay, boarder region of the northern coast, the southern coast of Nevskaya Bay, Koporye Bay, Soikinskiy Peninsula, Luga Bay, Kurgalskiy Peninsula, islands of open sea. The results were combined with the latest literature data (Verevkin, Sagitov 1997; 2004).

During the project, locations of 40 permanent haul-out sites (11 sites are known from literature), 6 disappeared haul-out sites and 11 sites of single sighting were determined (fig. 5). 22 of 40 permanent haul-out sites are used by the ringed seals with a high level of probability, 13 are possibly used by the ringed seals and for 5 sites seal species observed was not identified. For questionnaire data the greatest number of the sites was found in the region of Berezoviy Archipelago while the largest ones are known at Kurgalskiy Peninsula. Considerable number of the sites locates on the islands in the open sea (Maliy, Maliy Tyuters, Boloshoy Tyuters, Moshniy and Seskar Islands) but some permanent sites were also revealed in Vyborg Bay, Luga Bay and a border zone of the northern coast. Coastal zones of Nevskaya and Koporye Bays seem to have lost their importance for ringed seal haul-outs since only occasional sightings of hauling out seals registered there but some permanent sites still remain in the central part of the Nevskaya Bay (Verevkin, pers. comm.). Time of haul-out site disappearance coincides with the period of seal mass mortality (beginning of 1990s). There are no reports on existence of haul-out sites around Soikinskiy Peninsula at present or in the past. According to the responds to the questionnaires, one new site was started to be used by the seals in 2005 and it is confined to the northern continental coast near Berezoviy Archipelago. The results of questioning confirmed clear seasonal dynamic of haul-out site use (Report …, 2012).

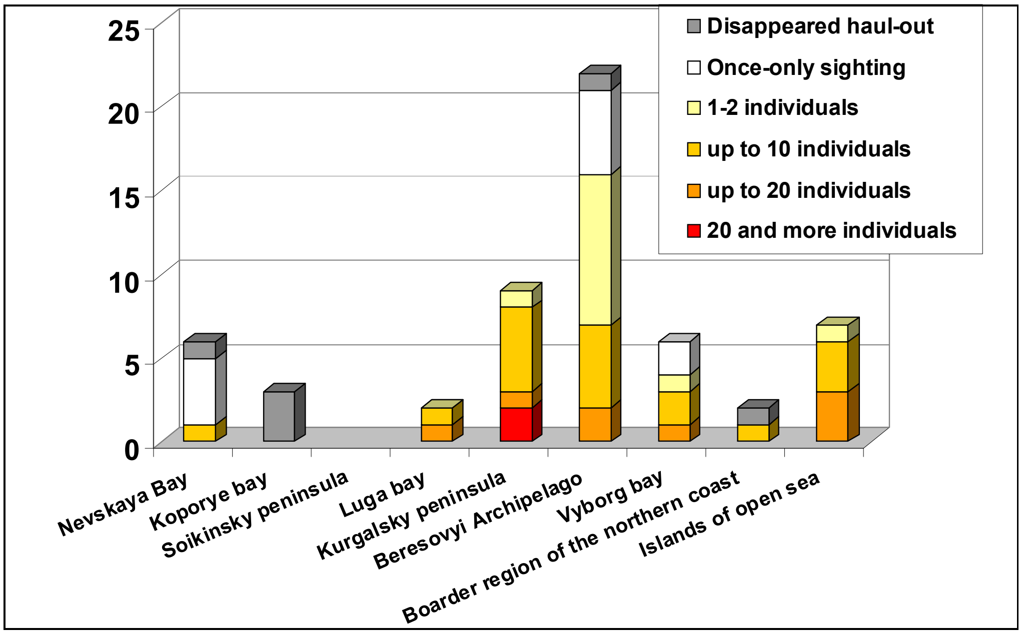


Fig. 4.5.5. Number of permanent haul-out sites, disappeared haul-out sites and sites of single sighting in different regions of the Russian part of the Gulf of Finland.

Three approaches have been used for monitoring the haul-out sites: a questionnaire method, a stationary observation and a route survey. For continuous monitoring it is important to keep in mind that presence of ringed seal on haul-out sites is unstable and a number of individuals undergoes considerable fluctuation during short period of time. Therefore choice of appropriate methodology depends on a purpose of the study. The main characteristics are 1) number and distribution of haul-out sites in a region 2) abundance and frequency of seal presence on haul-out sites 3) seasonal dynamic of haul-out site use. In the ideal case abundance of the seals on haul-out sites is a maximum number of seals counted during the season.

A questionnaire method may actually be considered as a basis for further observation since the information on seal species, seal number and frequency of haul-out site use is scarce or even lacking. The method gives an opportunity to determine general tendency of haul-out distribution and long-term dynamic. This principally serves the purpose (1) but repeated using of this method for revealing any changes in haul-out site distributions is possible only after a few years or a decade. The purposes (2) and (3) might be difficult to achieve.

Stationary observations are needed to monitor the status of a certain haul-out site particularly in terms of abundance, frequency of use and seasonal dynamic which serves the purposes (2) and (3). But it is unsuitable to determine the total abundance of hauled out seals in a region Route survey is a subsidiary method since it is quite difficult to determine any characteristics of a haul-out because of the fluctuations in ringed seal presence as noted above. It is appropriate for confirmation the questionnaire data which also serves the purpose (1) and it is often the only way to monitor some haul-out sites which are difficult to access.

So for monitoring of ringed seal haul-out sites a complex approach is necessary. The best way is a series of route surveys in key regions determined by previous surveys and questionnaires combined with stationary observations on the sites which are presumably characterized by the greatest number of individuals and/or highest frequency of occurrence based on previous observations, questionnaires and rout surveys. It is significant to take into account factors affecting ringed seal haul out probability (precipitations, wave altitude, time of a day).

Most of ringed seal haul-out sites actually observed by experts are situated in the southern part of the area and Kurgalskiy Peninsula seems to be the key region for the haul-outs in open water period. The recent research based on questionnaire method showed that there is a great number of sightings of hauling out seals in northern part of the Russian waters of the Gulf (Berezoviy Archipelago and Vyborg Bay) that may indicate that there are two separate systems of haul-out sites in the Gulf of Finland. However, strong evidence obtained by route and stationary observations is needed to verify this suggestion.

There is a number of complexities in comparing the data of ringed seal haul-out site use between decades due to differences in methodology and total population abundance. Based on questionnaire materials it is suggested that haul-out number decreased slightly in the last 10-15 years. The disappeared sites are mostly confined to continental coast. The main reasons for disappearance seem to be the population decline and increasing of anthropogenic disturbance factor magnitude. Coastal sites are usually characterized by increased level of human disturbance so they are suboptimal for the seals. Probably, the importance of northern part of the Russian area of the Gulf has increased for ringed seal but it is quite difficult to trace the changes as no special long-term observations have been carried out in the northern part of the Gulf of Finland.

Can the haul-out site use by the ringed seal be considered as an indicator of an environmental status of the region? During the implementation of the project it was noticed that location of permanent and disappeared haul-out sites in many cases coincides with a) Important Bird Areas (IBAs; Pogrebov, Sagitov, 2006) and, in particular, the most important migratory sites of marine bird species in the Gulf of Finland (Noskov, Rymkevich, 2012) b) territories which were recommended as a strict protection zone of Berezovie Islands regional complex reserve according to biodiversity study (Technical report…, 2008). So haul-out sites of ringed seal are probably may be used as an indicator of valuable coastal biotope complexes status.

As ringed seal hauling out on land as well as many bird species is very sensitive to presence of people, dogs, boats, motorboats, helicopters and other sources of disturbance (Esipenko, 1989; Dmitrieva, 2000) existence of haul-out sites can be a qualitative indicator of territories with low level of human impact. However, further research of seal behaviour is needed since there are some unusual examples of ringed seals using the banks which are located near to inhabited localities and even towns of Leningrad Region. Perhaps haul-out site selection depends on certain conditions (e.g. day of a year). Ringed seal haul out sites are mostly confined to vast shallow zones with great amount of rocks and moraine ridges which have significance for many species and the ecosystem of the Gulf of Finland as a whole but also special research of habitat characteristics is needed. Besides, haul-out sites may show seasonal trends of ringed seal abundance in different regions.

There are no evidences that haul-out sites of ringed seal can indicate state of the food webs since a foraging area may be in dozens kilometers away from a haul-out site for some seal species. Nevertheless it should take into consideration that fluctuations of ringed seal number on land may reflect local movements of fish stocks. There are also no evidences that interannual changes in seal abundance on haul-out site indicates population dynamic as annual percentage of the population occupying the site may be variable from year to year.

4.5.4. **Halichoerus grypus macrorynchus** ***abundance estimate results***

The Baltic grey seal is common though not abundant in the Gulf of Finland. In mid-XX century its population was depressed, and there were no more than 1000 individuals in the Baltic Sea. The main reason for the subspecies abundance rapid decline was assumed to be lowering reproduction rate due to accumulation of high concentrations of toxic substances such as DDT, PCB and heavy metals in seals tissues (Tormosov *et al*., 1990). Today the numbers of this species have been to some extent increasing. According to annual surveys, the abundance of this seal increased from 9700 individuals in 2000 to 17640 in 2004 (Halkka *et al.,* 2005). The bulk of the population dwells in the central Baltic Sea, and only a small portion, in the Gulf of Finland.

Grey seal population in the Baltic Sea waters of former Soviet Union in the Gulf of Riga in 1970s was 100-150 individuals (Tormosov, Rezvov, 1978), whereas in the Gulf of Finland only single animals were detected (Tormosov, Rezvov, 1978; Zheglov, Chapskiy, 1971). According to expert opinion the population number in that period was about 50-70 grey seals in the Gulf of Finland (Tormosov, 1977). Paper published by Tormosov and Rezvov in 1978 stated that the overall grey seal number in the Soviet Union waters was 500-1000 animals. In 1980s the survey conducted in the Gulf of Finland gave another result – 200-300 seals (Tormosov, Esipenko, 1986; Soderberg, 1991), and a larger estimation was reported in 1990s – 600 animals (Halkka, 1992). The monitoring of grey seals in the region was launched in 1993 thanks to WWF support. The coast line and islands were investigated, and locations of seal sightings were registered. It was found out that in winter time the grey seal is rare, occasional sightings are associated with ice floes brought to the Gulf of Finland by western winds. The aerial surveys typically reported sightings of single animals or small groups. The largest group was detected in April 2002 (Verevkin, Sagitov, 2004).

The numbers of the grey seal has been increasing in the Gulf of Finland not so rapidly as in the Baltic Sea as whole. According to surveys' results, over the same period from 2000 till 2004 the stock of grey seals in the Russian water area has increased from 400-500 to 600-700 (Verevkin, Sagitov, 2004). In the Russian part of the Gulf of Finland, grey seals appear in spring through summer forming haulouts up to 300 individuals in the region of Kurgalskiy Peninsula. In winter it is possible to observe only small groups of seals on drifting ice which is brought over by western winds.

The latest available estimate of grey seal population number in the whole Gulf of Finland suggests that there are 1400 individuals in the area. Trend of grey seals number in the Gulf of Finland (the whole gulf and Russian part separately is represented on a graph (fig. 4.5.6).

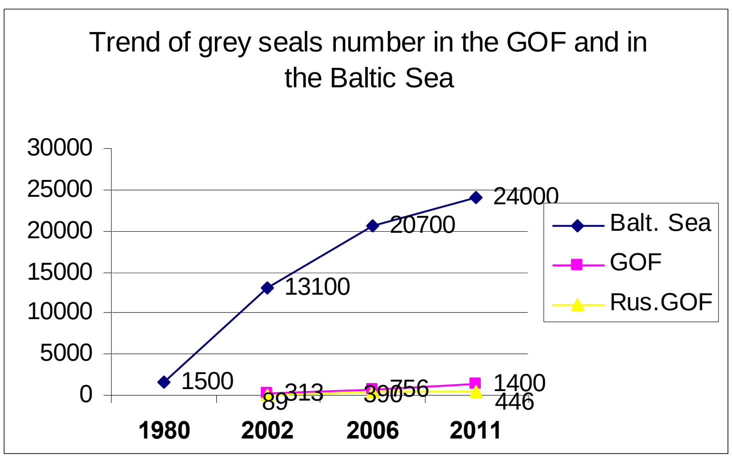


Fig. 4.5.6. Trend of grey seals number (after Verevkin, 2013; 1980 – Helle 1983; 2002 – Hallka et. al; 2006-2011 – HELCOM seals experts; Verevkin).

4.5.5. Halichoerus grypus macrorynchus *distribution*

In the summer the grey seals usually concentrate near the southern coast of the Gulf. On Maliy Tuters Island the seals haul-out on the rocks near the northernmost and south-western part of the island. A large haul-out site was observed in Vigrund Island area. Two dense groups were detected there and in a quiet weather it was possible to count up to 150 seals (Verevkin, Sagitov, 2003). Similar situation was on Hitamatula Island sand bar and along the reef to north-west of it where a group of 200-250 grey seals was registered. To the south of Moschniy Island the same authors reported a group of 50-100 seals. Along the northern coast of the Gulf only single animals were seen although there were plenty of suitable haul-out sites there.

In spring-summer 2012 during the Baltic Fund for Nature expedition, supported by NordStream AG company, to panned Ingermanlandskiy reserve islands, the rookery of 70-90 grey seals was found on the 10th of June on the reefs near Halikarti Island. Some animals swam around, including 2-3 juveniles. One adult grey seal recorded on Halikarti Island. At second stage of the expedition (on the 7th of July) 27-30 grey seals were counted at the same place near Halikarti. Another 15-25 seals were observed in water within the area of 1-1.5 km from the rookery. One juvinile animal was found on Halikarti Island.
Remains of two dead grey seals were recorded South Virgin and Maliy Islands. The old scull of grey seal was also found on Maliy Island.

The pupping grounds of the gray seal are not closer than 180 km away from the city and largely west of Gogland in the frontier area of three states: Russia, Estonia and Finland. Due to that, in the course of aerial surveys during the first half of April, in the Russian water area of the Gulf of Finland, gray seals occurred only rarely.

Figure 4.5.7 reflects main known patterns of the Baltic grey seal seasonal movements (Pogrebov, Sagitov, 2006). Although it is unclear how reliable this information is as no particular methodology to determine this pattern was used and on-land observations suggest that the seals might be seen practically in all parts of the Gulf in open-water season with no strong attachment to any particular area in any given time. Besides, telemetry studies demonstrated that grey seals migrate very actively and even can mix up with subpopulations in other Gulfs of the Baltic Sea.

Grey seal in the Baltic Sea is considered as a single population. In the Gulf of Finland the seals start to use haul-out sites after ice break-up for molting and later for resting. The seal number on haul-out sites increases during the summer as individuals come from western part of the Gulf. Grey seal demonstrates flexibility in habitat use and hauls out on sandy banks, moraine ridges and bedrock cliffs. Grey seals are gregarious and gather together in compact groups.

Within the area of USSR grey seal used haul-out sites in south-eastern part of the Gulf of Finland. The main sites located at Põhja-Uhtju Island (at present - Estonian area) and Kurgalskiy Reef (Hitamatala bank), Vigrund Reef and Vestrgrund Reef (Zheglov, 1973; Tormosov, 1978; 1990). Since total abundance of grey seal population was extremely low (2000 individuals in 1970s; Boedeker *et al*., 2002) the number of seals on haul-out sites were not more than 50 individuals (Tormosov, Esipenko, 1990b).

The most abundant haul-outs are known on Hitamatala Bank (Kurgalsky Reef), where seal number achieves 250 individuals. Other important haul-out sites in the southern and central parts of the Gulf of Finland are Vigrund Reef (up to 150 individuals) and Rosovaya Bank (50-100 individuals) next to Moshniy Island. Single individuals are also observed around Maliy Tyuters Island. In the northern parts of the Gulf the main sites are Halikarti, Rapakivi and Virginy Islands. Single individuals use reefs and bounds around Bolshoy Fiskar, Maliy Fiskar, Kopytin and Smolistye Islands, and also on Halli Cliff (Verevkin, Sagitov, 1997). The easternmost known haul-out site is regularly observed near Kotlin Island in vicinity from Kronshtadt (fig. 4.5.7).

Fig. 4.5.7. Grey seal few miles to the west from Kronshtadt (photo by O. Zyryanov, Oct., 2012)

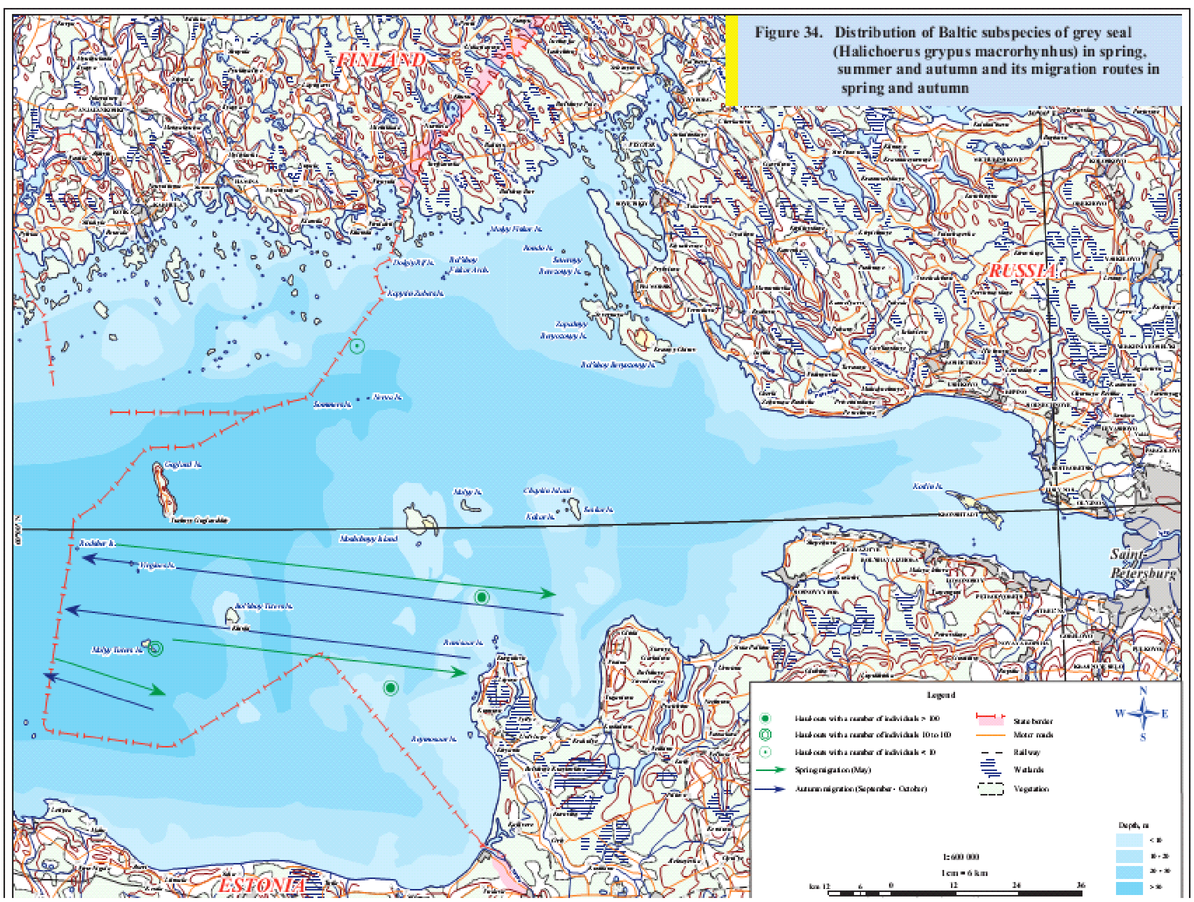


Fig. 4.5.8. Grey seal seasonal movements - spring – blue arrows, autumn – green (Pogrebov, Sagitov, 2006)

To count grey seal on haul-outs a boat survey is used. The seals are counted in late May-early June while they are molting and tend to stay on land. The main distribution area is surveyed 2-3 times during the 2-week period and the maximum daily sum of those repeated counts is included in the estimates. As counts on haul-out sites are a primary method of grey seal population survey in the Baltic Sea, number of animals hauling out on land can serve as one of the indicators of grey seal abundance in the Russian part of the Gulf of Finland, the Gulf of Finland and the Baltic Sea as a whole. Haul-out sites may show seasonal trends of grey seal abundance in different regions of the Gulf of Finland (fig. 4.5.8).

4.5.6. **Phocoena phocoena phocoena *distribution***

In early XX century harbour porpoises were abundant in the Baltic Sea with their range extended into the easternmost part of the Gulf of Finland (Koschinski, 2002). According to rather poor data available some individuals reached the Eastern part of the Gulf, were observed in the Neva River and even in Lake Ladoga (Tomilin, 1957). It's not known whether it was a part of regular movements or the visits were occasional. There are reasons to think that the distribution range of harbour porpoises has been decreasing starting from the beginning of XX century. Today its eastern limit is believed to be in Polish and Swedish territorial waters to the West from Gotland Island. To the West from the line regular occurrence of low number of animals is suggested. In 1906 in Baltijsk area (today – Polish territory) a case of by-catch of 5 pregnant females was registered (Braun, 1906) which means that at that time porpoises used the area for long-term stays. Later, between 1922 and 1933, quite a lot of individuals were seen in that region (Skora *et al.,* 1988). In Lithuanian territorial waters the latest record of *P.p. phocaena* dates back to 1938, in Estonian waters – to 1961 (Timm *et al*., 1998). Taurins (1982) and Pilats (1994) reported by-catch cases in Latvia, in the Gulf of Riga in 1964 and 1974. The easternmost sightings in Finland were reported by Mattsson (Koschinski, 2002) in 1990-1991 when about a dozen of porpoises were seen near the town of Kotka.

No reliable data on harbour porpoise sightings in Russian territorial water in recent decades were found in literature. According to Red Data Book of the Russian Federation (Red Data Book, 2000) North Atlanic Subspecies of *P.phocaena* (both the Barents and the Baltic Sea populations) is categorized as subspecies with indefinite status, low in number or poorly studied (Category 4).

In 2011 harbour porpoise dedicated project in Russian waters was supported by ASCOBANS secretariat. Assessment of dolphin distribution and occurrence in the 26^{th} and 32^{nd} subregions of the Baltic Sea (economic zone and territorial water of the Russian Federation, Kaliningrad and Leningrad regions) was made based on questionnaire survey results obtained from local people whose life style and work are closely related to the sea. Fishing brigades were visited (by car or by motor boat) and interviewed anonymously. Zoological collections of two museums – AtlantNIRO (Atlantic Scientific and Research Institute of Fisheries and Oceanography) in Kaliningrad region and the museum of Zoological institute of Russian Academy of Sciences (St Petersburg) were studied in order to get data on available dolphin findings from the Baltic Sea.

From 01.07.2011 till 07.07.2011 several islands located in the Russian part of the Gulf of Finland were investigated with an aim to find remains of harbour porpoise *Phocaena phocaena phocaena*. The expedition was conducted on board of catamaran Centaurus II in the frames of larger project devoted to inventory of the biodiversity of the islands to be included in planned nature reserve Ingermanlandskiy (financed by Nord Stream AG). The coastlines of Seskar, Severniy Berezoviy, Bol'shoy Feskar, Kurgal'skiy Reef islands were carefully studied but no porpoise remains were found.

The survey included 62 responders in Kaliningrad region and 32 in Leningrad region and revealed 3 reliable cases of dolphin observations (2 cases – *D. delphis*, 1 – *P. phocaena*) in Russian territorial waters of the 26th sub region of the Baltic Sea. 4 harbour porpoise skulls found in XX century in the studying area are currently stored in the museums of Zoological Institute RAS and 'AtlantNIRO'. Information on precise place and time of finding are unavailable. Additionally there are 4 records dated back to the beginning of XX century in the Zoological Institute museum's catalogue. Questionnaire survey allowed to cover time period of about 20 years, which regarding very few dolphin sightings gives evidence on animals' very occasional visits to South-Eastern Baltic (Trukhanova *et al.,* 2012).

No harbour porpoise by-catch cases were reported in the region presumably due to low number of the species.

4.5.7. Population growth rate and GES

According to indicator description, a depleted population can evaluated as obtaining good environmental status (GES), when observed rate of its increase doesn't deviate significantly from its intrinsic rate of increase (10% for grey and ringed seals). When populations are close to their carrying capacities, populations obtain GES if the rate of decrease is less than 10% over a period of 10 years as stated in the OSPAR convention. For the total Baltic seal population of the ringed seal 4.5 average growth rate was reported for the period 1988-2011 (Härkönen, unpublished). Baltic grey sea population number has been increasing more rapidly – 8.5% per year for the period 1990-2002 (Halkka *et al.,* 2005, Stenman *et al*., 2005). Following HELCOM guidelines, we estimated mean population growth rate for ringed seal for each 5 years starting from the first census conducted in 1970 and for grey seal – annual growth rate since 2001.

For an indication of good environmental status we set 0.1 growth rate (figs. 4.5.9 and 4.5.10). For the years when more than one population estimate was available (as in the case with the ringed seal earlier counts) we used the largest value in order to achieve smoother trend.

The Baltic ringed seal population has been declining during the last 42 years with an average decline rate 7% per year though the data suggests that there were periods of rapid growth (up to 88% difference in the counts conduced in consecutive years) as well as years of catastrophic decline of population number (in late 1980s-early 1990s the population was declining approx. 42% per year). The latter might be well explained by the registered high seal mortality and collapse in pup production in the Baltic Sea related to contamination of the environment by highly toxic substances including PCB and DDT. Additionally epizootic events might have taken place in that period in the populations of marine mammals in the region. However the significant fluctuation in overall seal abundance and growth rate trends seem to be unlikely and can be related to survey data uncertainty. In the light of up-coming revision of Red Data book of the Russian Federation we proposed to change the current conservation status of Baltic ringed seal from EN (endangered) to CR (critically endangered) due to low numbers and high sensitivity level to poor environmental conditions and disturbance.

For the grey seal population estimations were quite rare and based primarily on the results of the counts on the islands and summer haulout sites. For the calculation of population growth rate we used only figures obtained in 2000s and reported in Verevkin, 2012.

It should be noted that growth rate calculated for the grey seal based on number of animals detected on terrestrial haul-out sites does not accurately reflect the population status since probability and frequency of haul out site use might depend on disturbance level and weather condition. Hence this parameter might vary from year to year without strong correlation with accrual population size.

In the light of up-coming revision of Red Data book of the Russian Federation we proposed to change the current conservation status of Baltic grey seal from EN (endangered) to NT (near threatened).

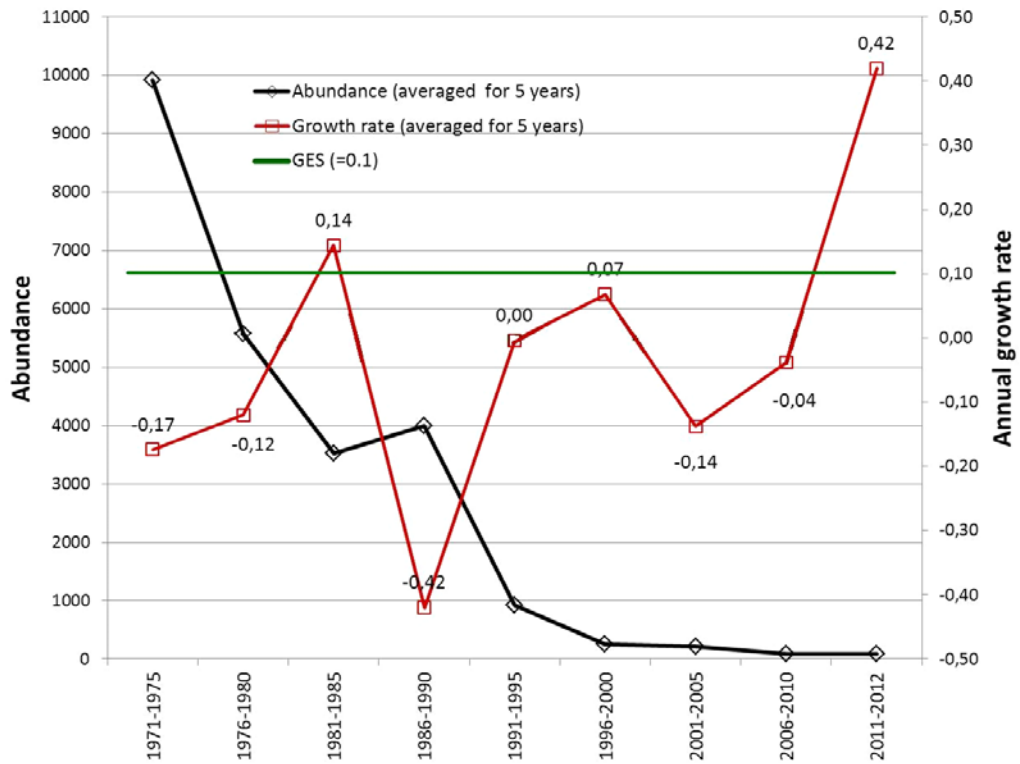


Fig. 4.5.9. Changes in the population growth rates (squares) and abundance (diamonds) of ringed seal in the Gulf of Finland. Both parameters are shown as a moving average of 5 years. The green line denotes the GES boundary for the population growth. Note that before 1990s the counts results refer to the Soviet Union waters.

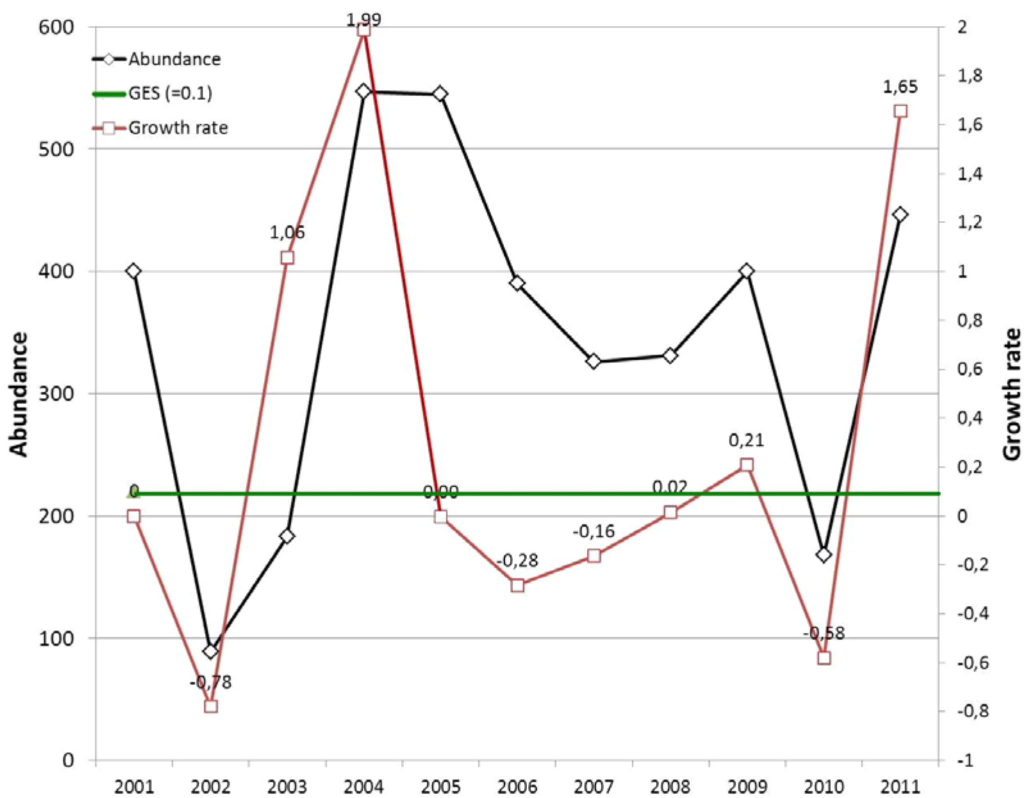


Fig. 4.5.10. Changes in the population growth rates (squares) and abundance (diamonds) of grey seal in the Gulf of Finland. The green line denotes the GES boundary for the population growth.

The grey seals are known to be less sensitive to disturbance than, for example, the ringed seals, and the commercial fisheries are not currently a major threat for these animals as due to large body size they can easily tear the nets rather than get entangled. In mild winters with poor ice conditions grey seals can breed on land although the pup mortality rate is really high (Jüssi *et al*., 2008). All these facts suggest that the sub-population of grey seals in the Russian waters of the Baltic Sea is currently in a quite good condition even taking into account growing anthropogenic pressure on their environment. The subspecies might be used as an indicator of GES.

Harbour porpoise visits to the Russian waters are occasional and very rear. An attempt to estimate the abundance of this species in Kaliningrad waters of the Baltic Sea will be made in 2013-early 2014 in the frames of RUMBAH project which is a continuation of pan-Baltic SAMBAH project being implemented by the Baltic Fund for Nature in cooperation with Shirshov's Oceanology Institute and supported by Swedish Institute. However, due to low numbers and related difficulties in population monitoring the abundance and distribution of harbour porpoise in Russian waters is very unlikely to become a useful indicator of environmental status assessment.

4.5.8. Updates on ringed seal population abundance and distribution from 2013 aerial survey

The Baltic ringed seal aerial survey was conducted on 15th and 18th April 2013, encompassing ice covered areas of the Gulf of Finland close to peak of seal annual molt using standard line transect methodology (see, e.g. Skalski *et al*., 2005) assuming random distribution of the animals in the survey area. The survey was supported by NordStream company.

The data were collected from a fixed-wing low noise aircraft Cessna-210 'Centurion' with upper wing flying along linear transects (mainly South-North oriented) which position was planned beforehand using satellite ice imagery of the Gulf of Finland so that the transects ensured systematic coverage of the ice surface with random starting point. Observations were made by two observers from both sides of the aircraft to 450 m distance on either side, i.e. strip width was 900 m. A consistent strip width was maintained by having each observer align markers placed on the windows and the wing struts of the aircraft. This is a standard approach for seal surveying used in the Baltic Sea (Härkönen, Lunneryd, 1992; Verevkin *et al*., 2012). The flight altitude and ground speed were controlled by board navigation system and maintained as consistent as possible at 90 m and 210 km/h respectively. Each animal, detected on ice, was photographed with a high resolution digital camera Nikon equipped with a long focal length lens (70-200, f2.8 and 18-200, f3.5-5.6).

The geographical coordinates (lat/lon) for each picture were determined using hand-held Garmin cs62 and Etrex GPS units attached to the cameras. Observations were also recorded by the observers by digital voice recorders which made further data analysis easier.

For the purpose of the analysis, we used a set of way points, each of which marked individual animals seen within transects. Seal population number estimation was conducted using standard extrapolation methodology for the ringed seal (as grey seal number was too low for any estimates). With a purpose of the analysis we subdivided the Gulf of Finland into a grid of equal blocks of 1 sq km each, which were further used as sampling units. As an estimate accuracy measure the coefficient of variation was used (CV). All means are provided with corresponding standard deviations (SD). All analysis was performed in R programming environment (R 3.0.0; R Development Core Team, 2008).

Ice covered area of the Gulf of Finland included in the survey was 3499 and 3797 sq km on the 15th and 18th April respectively. By the time when survey started the ice cover was represented by two discrete ice concentrations in the South and North of the Gulf separated by a vast water area in the central part. Along the southern and northern coast there was stable fast ice up to 40 cm thick. In 5-10 km from the shore the broken drifting ice zone consisted of large ice floes characterized by high level of cohesion started. On the 18th April after the continuous southern winds a large zone of brash ice appeared along the northern fast ice edge and it was not suitable for seal haul out.

The survey coverage was 340 sq km (9.72%) and 368 sq km (9.7%) of ice on the 1st and 2nd survey date respectively. The results of the first flight were used mainly as reconnaissance data. The flight was implemented after a few cloudy days with no satellite images of the region available beforehand. That it why it was necessary to visually assess the distribution of different ice types, their suitability for the seals and delimit the survey area. For seal population number estimation the results of the second flight (on the 18th April) were used as that flight provided the most complete coverage of the ice covered area of the Gulf and was close to the peak molting season in seals when the largest part of the population stays out of water ensuring upper skin layers insolation.

Based on visual observation results on the 15th of April (Table 4.5.2) 6 individuals of the Baltic ringed seal and 2 grey seals were registered. The animals were either on large ice floes or next to water access holes and cracks in ice. Mean observed ringed seal density in the survey area was 0.018 (SD=0.152) animals per sq km (ranged from 0 to 2 seals per 1 sq km). Having extrapolated estimated mean density to non-surveyed area we got a total number estimation for the ringed seal on ice on the 15th April 2013 equal to 62 (CI 95% 11-112, CV=40.82%). Three days later, on the 18th April (Table 4.5.2) ringed seal density increased significantly and was 0.063 (SD=0.332) seals per sq km (ranged from 0 to 3 animals per sq km). 23 ringed seals were visually detected on ice. Number of grey seal registered remained the same – 2 individuals. Total seal density (for both species) on ice on the 18th April was thus estimated as 0.071 (SD=0.353) seals per sq km. Having extrapolated estimated mean density to non surveyed area we got a total number estimation for the ringed seal on ice on that date equal to 237 (CI 95% 138-336, CV=20.85%).

Table 4.5.2. The results of seal aerial survey in the Gulf of Finland

Date	*P. hispida*	*H.grypus*	NA	Total	Number estimation
15.04.2013	6	2	1	9	83 (CI 95% 28-139, CV=33.3%)
18.04.2013	23	2	4	29	269 (CI 95% 169-369, CV=18.57%).

Discussion

In the second day of the aerial survey (18th April) the abundance of ringed seals on the ice has increased 3.54 times compared with the first day (15th April). This may be due to the series of warm, sunny days when the seals started to haul out on ice to facilitate the processes of annual molting. Interestingly, on 18th April significant number of animals (48%) was observed in pairs in close proximity to each other. In some cases it was possible to assume that such pairs were a female and her molted pup (seal were hauling our next to the same water access hole), but in most cases both animals were adults, and the distance between them was up to several tens of meters. All animals were registered at a considerable distance from the coast, the minimum registered distance from the shoreline was 3 km.

Comparing with the results of the surveys conducted in 2010 and 2012, the estimate of the size of the Baltic ringed seal population made in spring 2013 is much higher. According to Verevkin *et al*. (2012) the number of seals in 2010 was estimated at 45 seals with a large 95% confidence interval from 12 to 77 animals. In the Finnish part of the Gulf 100% of ice were surveyed and only 3 seals were found.

In 2012, aerial surveys conducted on 11-12th April showed a higher number of animals - 91 individual with a 95% confidence interval from 44 to 139 individuals (Technical report, BFN, 2012). It should be noted that in 2010 and 2012, the mean density of seals on ice was nearly identical - 0.022 and 0.023 individuals per sq km respectively (Verevkin *et al.*, 2012; Technical report, BFN, 2012), the small sample size did not provide the possibility to identify statistically significant differences in the number and density of the population. ‘

The population estimate obtained in 2013 assuming the size of the Baltic ringed seal population of 237 (CI 95% 138-336) individuals is 2.6 times higher than the result of the previous year, with the confidence intervals overlapping only slightly, which indicates a significant increase of hauling out population size. The mean seal density per 1 sq km has also increased in 2.74 times. And the number of seal recorded within transects has increased from 12 in 2012 to 23 in 2013, though the area covered during the survey has been reduced by 27%.

It can be assumed that the recent years have been characterized by favorable ice conditions from the point of view of seal reproductive success and pup survival rate. On the other hand, the aerial survey in 2012 was held a week earlier than in 2013, and, obviously, a smaller proportion of the population entered annual molt stage and was available for registration. In addition, the weather conditions might have affected the results of observations.

In 2013, the results of aerial surveys have not revealed any particularly restricted seal wintering and breeding areas in the Gulf of Finland. During the surveys there were still fast ice areas remained along the northern and southern shores, which have not changed their position over the winter period. Animals, as well as signs of their presence (e.g. water access holes), were found in both northern and southern parts of the area, while the easternmost point of seal detection was E28.467°, and the westernmost – E27.633°.

However, it is possible to mark out two broad areas where the seal sightings were the most numerous – they are the water area to the West of the reserve 'Berezovie Islands' in the square between N60.4433°, E28.75° and N60.31833° E28.39333°, and water area to the North of the Kurgalsky Peninsula in the square between N60.03833° E27.90333° and N59.77667° E28.165°.

Low number of the Baltic ringed seal population in the Gulf of Finland makes it difficult to obtain accurate estimates of its size, since at low abundance and uneven distribution of the animals on ice the probability of accidentally getting 'failure' of the sample is high. In other words, when the number of animals on ice is small the randomly positioned transects may be outside the areas where seals are concentrated which may result in underestimation.

Therefore, given the low number of the seal population in the Gulf and its high degree of vulnerability and high protection status, it is important to implement a series of aerial surveys on annual basis throughout the period of seal annual molt, which will provide more accurate and detailed data on the number and distribution of the population.

Updates on seal strandings on the shore of the Gulf of Finland

In 2013 late spring - early summer 11 cases of seal stranded dead on shore of the Gulf of Finland were registered. 9 bodies were found within the borders of St Petersburg (in Kurortniy district) and 3 - outside the city. All the seals stranded were grey seals, juvenile or adults, and most of the bodies were not fresh which means that apparently the animals died during the winter and were brought onshore when the water in the Gulf became warmer. There were no evidence of violent death found but there is still a possibility that some of the seal died in fishing gears.

Most of the information on strandings was received either from local people and people spending weekends on shore or from the City Beach Cleaning Service.

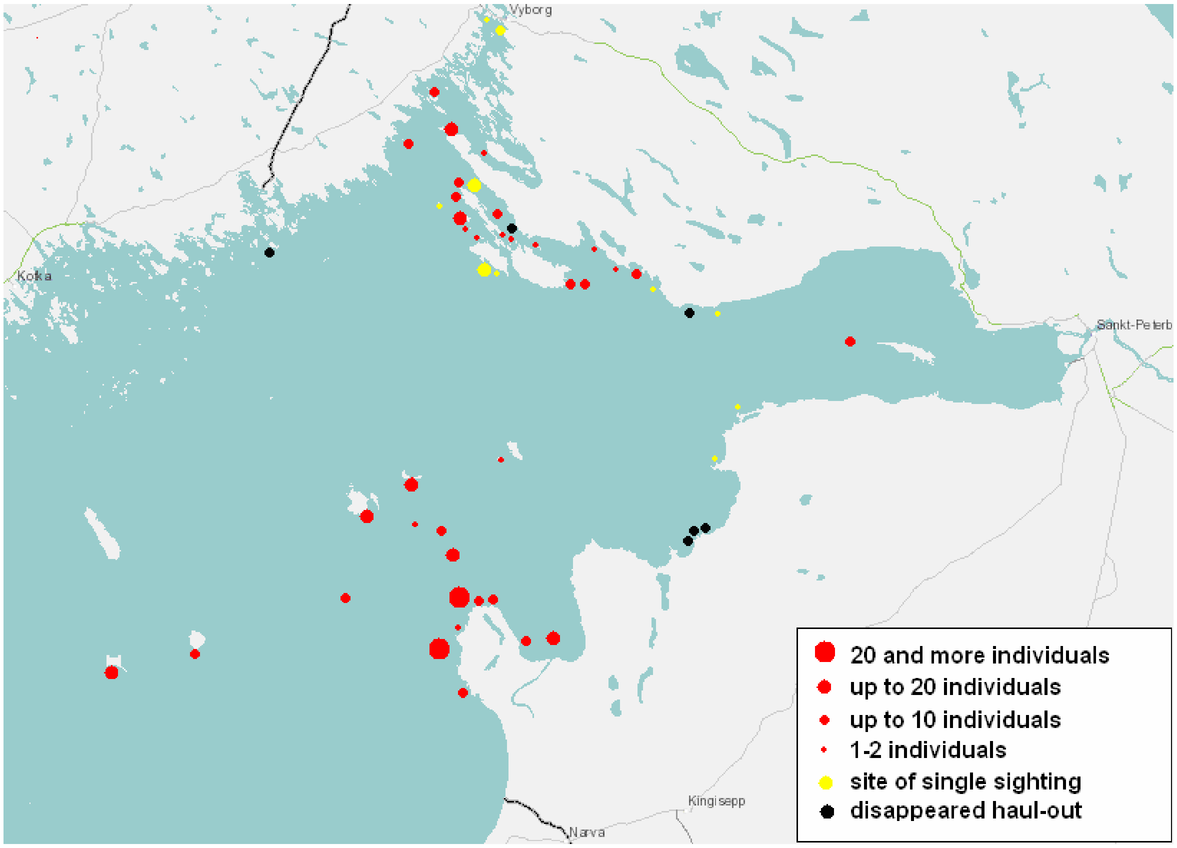


Fig. 4.5.11. Distribution of haul-out sites of the Baltic ringed seal in open water period in the Russian part of the Gulf of Finland in 2012 (updated map, based on questionnaire and published materials) (Loseva*, in prep*.)

4.5.9. Recommendations on monitoring of population growth rates, abundance and distribution of marine mammals in the Gulf of Finland.

It is important to note that there are two seal species inhabiting permanently Russian part of the Gulf of Finland but their population statuses differ. The Baltic ringed seal population is still critically low in numbers and requires permanent monitoring, in-depth threat analysis and applied conservation actions. The grey seal population seems to be increasing during the last decade and is therefore not under special concern in terms of immediate conservation measures implementation.

Taking into account the current status of seal populations in the Russian part of the Gulf of Finland and existing gaps in our knowledge we recommend the following:

1. To conduct regular aerial surveys (on annual or biannual basis) of Baltic ringed seal on spring ice to collect an up-to-date data on number and distribution of these animals. We recommend using instrumental methods of surveying (digital photography, IR imagery) in order to improve seal detection rate and cover a 'blind zone' under an aircraft. We also consider appropriate to conduct a series of aerial surveys throughout a molting season in order to avoid large biases in number estimation related to low population number and uneven distribution of seals.
2. To conduct biotelemetry studies including seal satellite tagging with tags equipped with temperature and pressure sensors, accelerometer and dry/wet switch. This will allow to get a comprehensive data on physical parameters of seal environment, to get diving profiles of animals of different sex and age groups which will become a basis for understanding of foraging behavior and association of seal feeding ground with major fishing areas on the Gulf of Finland.
3. To study diet of different sex and age groups of seals by getting stomach content samples from by-caught of drowned animals and by running analysis of otholiths in excrements.

4. Organization of pilot studies of acoustic deterrent devices effect on seals. A combined data from telemetry studies and fishermen visual observations and gear inspections will allow to conclude on the efficiency of ADD use from keeping the seals away from fishing gear and decreasing of by-catch rate. It is also important to find out if ADDs might prevent seals from using particular water areas which are critical habitats for these animals. Based on such study result it will be possible to develop regulations for ADD use and introduce seasonal and regional restrictions for these devices.
5. To conduct regular questionnaire surveys of seal by-catch rate in the Gulf of Finland. It is possible to work with a limited number of reliable fishermen and then extrapolate the data collected over the total number of fishermen in the area taking into account differences in fishing effort in different parts of the Gulf.
6. To implement regional restrictions for ice leisure fishermen based on ice formation pattern in a given year and a predicted ringed seal lair distribution. Certain areas of fast ice should be closed for vehicle traffic (in particular further than 5 km from the shoreline) in order to exclude disturbance factor for breeding seals. To increase control on small boats traffic in major seal haul-out sites in late spring and early autumn to minimize disturbance factor.
7. To introduce strict control measures for large capacity vessel traffic during the ice-bound season to ensure vessel passage only within specifically designated vessel routes and to avoid seal disturbance on pupping ground and ice habitat fragmentation.
8. To conduct detailed boat-based survey of terrestrial seal haul-out sites in the Gulf of Finland in order to get comprehensive data on seal distribution and key habitats. Clearly there are still a lot of site which were reported to be used by the seals in different seasons of a year but for some of them no reliably documented seal sightings are available.
9. To monitor on regular basis seal haul-out sites in order to timely track changes in seal distribution during different seasons and be able take proper conservation actions and, in particular, to establish temporal protected zones for the seals.

4.6. PREGNANCY RATES OF MARINE MAMMALS

To the best of our knowledge no dedicated pregnancy rate studies were recently conducted on seals in the Russian part of the Gulf of Finland. In 1970s morphological parameters of the Baltic ringed seals were studied by Philatov and Tormosov (1978) including assessment of genitals state. However, no specific conclusions were made.

In 1976 a paper was published by V.A. Zheglov reporting the results of a study devoted to grey seal maturing and prenatal development. 106 females were studied and it was found out that the maturing process is rather extended: first ovulation occurs at the age of 4-7 years, whereas the first pregnancy was in average observed in older females – from 5 to 8 years old. Females capable to breed were also found among the seals older than 20 years. Although at this age the sexual processes are going down and pregnancy occurs rarer (Zheglov, 1976). Hence the age group of seals making the major input into population reproduction is from 8 till 20 years. The same author demonstrated that there's an implantation delay taking place in the Baltic grey seal after mating and lasts about 3.5-4 months - until mid- late July.

In 1991-1992 due to mass mortality of ringed seals 150 seal bodies were found on both Finish and Russian territories. About 50% of them were adults, i.e. individuals in reproductive age. About half of them were females. The reason that caused observed mortality was not reliably identified but according to expert opinion it could be related to some neurotoxin affecting the seals (O.Stenman, pers. comm.). This event obviously had a severe impact on the population reproductive potential. Approximately at the same period of time decline of ringed seal pregnancy rate associated with prevalence of uterine occlusions and possibly cause by some contaminants in the water was reported by Finish researches (Helle *et al*., 1976).

Currently, regarding ban of seal harvest, the only possibility to study pregnancy rate of the seals in the Russian part of the Gulf of Finland is to conduct post mortem of stranded or by-caught animals. But any conclusions which could potentially be made on such data would be biased due to specifics of group sampled. Another possible way to study birth rate of the seals is to count a number of pups born per year.

For the ringed seal it is problematic because the pups are hidden in snow lairs sometimes until weaning and, in most cases, until molt. Aerial surveys provide an opportunity to count pups on ice after snow melt although sometimes pups are almost of the same size as adults by the time when survey is conducted and are difficult to be classified. Low number of pups found during aerial surveys might be also related to sensitivity of the pups to disturbance by an aircraft - they might go to water well before being approached. Another option is to study location of lairs but this is a subject of future work.

Therefore under the current conditions and regarding high conservation status of Baltic ringed seal and grey seal we don't consider this particular indicator to be applicable in the Russian part of the Gulf of Finland at the moment.

4.7. NUTRITIONAL STATUS OF SEALS

To the best of our knowledge no dedicated nutrition status (blubber thickness) studies were conducted on seals in the Russian part of the Gulf of Finland. In 1970s morphological parameters of the Baltic ringed seals were studied by Philatov and Tormosov (1978) in order to reveal differences between this subspecies and Ladoga ringed seal. 150 bodies were examined; body length and weight of main internal organs were measured. The authors concluded that allometric growth rate of organs of Baltic ringed seal is higher than one of the relative subspecies. Low current population number and high conservation status make it impossible to conduct any systematic studies of seal nutrition status. By-catch cases are rare enough and are typically not reported by the fishermen to provide a reasonable sample size for such kind of assessment.

Possibly, depletion of fish stocks in the Russian part of the Gulf of Finland caused by overfishing and extensive industrial development of the region might have affected seal nutrition status but this still has to be studied. Further studies of seal diet and related fish stocks status might help to make conclusions on the availability of foraging resources for the seals in the region and indirectly demonstrate their nutrition status.

Therefore under the current conditions we don’t consider this particular indicator to be applicable in the Russian part of the Gulf of Finland at present.

4.8. NUMBER OF DROWNED MAMMALS AND WATERBIRDS IN FISHING GEARS

4.8.1. Number of drowned mammals in fishing gears

By-catch is considered as a major threat for pinnipeds worldwide. However, this is one of the most difficult factors for direct assessment. Mitigation measures require consolidated efforts to be made at different levels – from local individual fishermen to the state agencies and fisheries controlling authorities. In Russian Federation by-catch of red listed marine species is illegal and the penalty for accidental catching a seal in fishing gears (if reported) was 10000 Rub (about 250 Euro) in 2012 (Order…, 2008). Deliberate killing of a seal (which might be the case if the animals gather in fishing areas) implies a penalty equal to 120 times minimum salary rate (which will be about 14 000 Euro for 2012; Order…, 1994).

In the Gulf of Finland no direct measures are taken in order to minimize seal population losses due to death in nets. There were a few attempts made to assess the number of animals get caught every year in the area. The first questionnaire survey among the commercial fishermen working in the Gulf of Finland was planned in 2003. The anonymous questionnaires were distributed in main fishing areas although no feedback was received. The authors concluded that the by-catch was very rare and there was not enough information to report (Verevkin *et al.,* 2008). Four years later the same approach was used and some data were collected. Unfortunately the fishermen do not make records of seals by-caught and typically can't distinguish the species. That is why all the data received concerning both grey and ringed seals together without any reliable division of the species.

In the area of Vyborg Bay fishermen noted dramatic increasing of the number of grey seals in autumn 2007 in comparison with the previous years. According to the fishermen the seals damaged not only the gill nets but also the fyke-nets. By-catch cases in these gears were very rare because grey seals could tear them off easily. There were some changes in animal behavior. Seals became more courageous, curious; they accompanied fishing boats and fishermen while they were setting their nets. Seals could come very closely to the nets set in the shallow water on the depth less than 1,5 meters (Table 4.8.1). Fishermen in the Nevskaya and Luzhskaya Bays had positive or neutral attitude to marine mammals. Usually they did not use any methods to prevent stealing of the fish or damages of the fishing gears. Only in the area of Lisiy Nos commercial fishermen hanged on the small bells ('bryacelo') on the stakes to frighten animals. In 2007 there were 11 cases of seals' death in the fishing gears in Russian part of the Gulf of Finland.

As we mentioned above, in 2003 in the same area there were very few cases of stealing fish or damaging gears and no by-catch cases were reported at all. In 2007-2008 the situation became different. In spite of lack of a critical conflict between marine mammals and commercial fisheries in the Gulf of Finland there was an increasing of frequency of occurrence of the seals in the close proximity from the fishing gears. Animals caused harm to the fishing gears and to the caught fish also more often. Some cases of by-catch of the seals were shown, first of all for the stake-nets, less for the fyke-nets and trammel nets.

Therefore, the intensification of the conflict became obvious. This conflict appears in the competition for the fish stocks. It leads to more frequent death of the seals in the fishing gears on the one hand and to significant harm to the fishing industry on the other hand. In the areas of the most critical seal-fisheries conflict situation it is essential to take measures to diminish harm caused by the seals to the commercial fisheries, and also to decrease mortality of marine mammals in the fishing gears. It may be achieved by taking out catch from the nets before the dawn, patrolling the gears, setting the gears in the remote areas, far from the seal concentration places. It is recommended to lead further investigations of this problem with the aim to reveal the dynamic of the conflict, changes in animal behavior and changes in fishermen attitude to marine mammals.

Table 4.8.1. Fishing gears, damaged by the seals in the Gulf of Finland in 2007

Fishing area	Fishing gears	Depth of setting, m	Number of damaged gears per season (per 1 fisherman)
Vyborg	gill nets, trawls	2- 35	10-30
Nevskaya Bay	gill nets	15-20	8-10
		2-5 (within the city area)	2-3
Luzhskaya Bay	gill nets	2-20	12-15

Between 2006 and 2009, 48 carcasses were found on the shore (fig. 9) and about 50% of them had signs of violent death. There's a possibility that some of the seals found died in fishing gears and were thrown away by the fishermen. Some of the bodies had stones or bricks tighten to their flippers to drawn the body and hide the fact of incidental catch (Trukhanova *et al*., 2010).

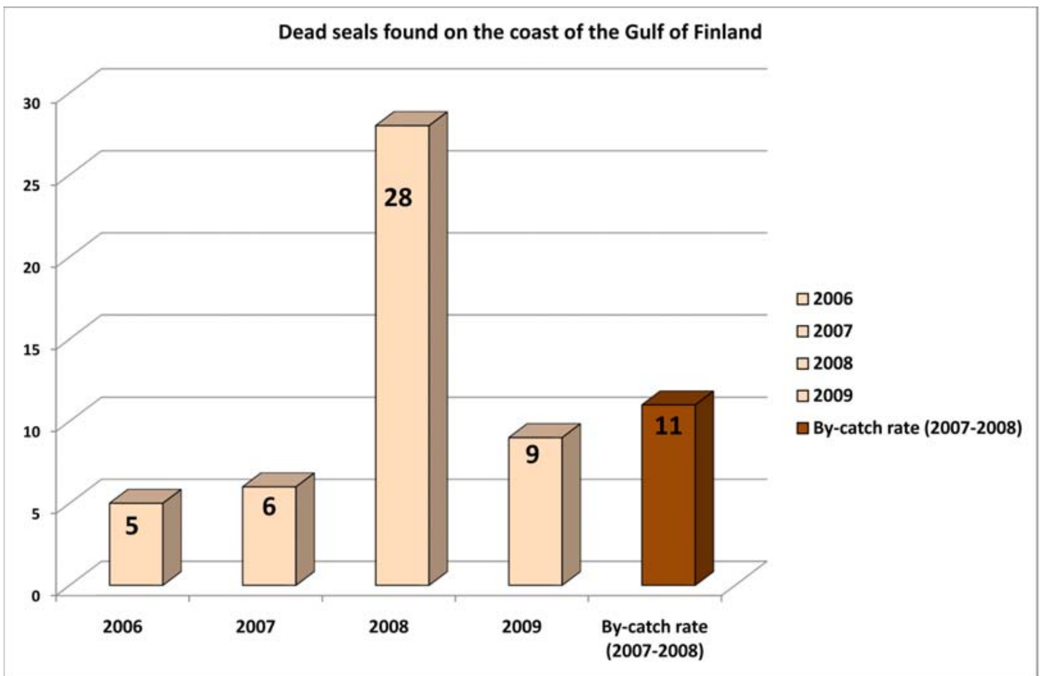


Fig. 4.8.1. Strandings of both seal species in the Gulf of Finland and by-catch rate in 2007-2008 (Trukhanova *et al*., 2010)

The most numerous cases of seal strandings occurred in late spring 2008 when 23 dead seals were found in Kurortniy district of St.- Petersburg (Verevkin *et al*., 2008). The experts related this event to mild winter and poor ice conditions which forced the population to breed within the city. High level of anthropogenic activity in the area including coastal fisheries might cause the observed mortality event. Out of 23 bodies, 4 ringed seals and 12 grey seals were examined. All ringed seals were older than 3 years, 3 of them apparently drowned in nets and one was shouted. 2 of the grey seals were adults and 10 juveniles, 9 of which probably died in fishing nets (Verevkin *et al*., 2012).

Currently the data on by-catch and strandings are not collected regularly. Interviews with fishing brigades are conducted by individual biologists on volunteer basis and more coordinated efforts are required to make any significant progress. Regular monitoring of the coast line should be implemented (even on volunteered basis) and it is critically important to disseminate information among local citizens and authorities on people and organizations to be contacted in a case of seal findings on shore. This approach might help to increase sample size and enhance our knowledge on seal mortality sources and seasonality. Besides it seems to be necessary to establish a mechanism of by-catch reporting. This mechanism should be developed at high administrative level in order to obliged commercial fishermen to submit data on the number of seals incidentally caught in their nets and to ensure that no penalty is applied in cases when seal death was accidental.

The by-catch problem and seal-fisheries conflict in general can be resolved only in a case of spatial or temporal separation of the conflicting parties which is incredibly difficult to achieve within a semi land locked water basin. Currently world used methods to mitigate the conflict can be divided into three general approaches (Brothers *et al*., 1999; Cox *et al*., 2007): development and application of specifically modified gear types, use of deterrent devices including acoustic deterrence, and establishment of seasonal and/or regional fishing restrictions.

Under the circumstances of intense industrial development of the area of the Gulf of Finland and decreasing of the number of areas available for fishing the latter approach seem to be unrealistic. Relatively small scale of commercial fishing in the Gulf it is commercially inefficient for the brigades to buy and use rather expensive seal-proof modifications of fishing gears. This leaves us with the only possible way to keep the seals away from the nets saving both animals' life and fishermen catch – use of acoustic deterrent devices (ADDs). Thus we consider important to look for the possibilities to supply local fishing brigades with ADDs and conduct a pilot project to study their impact on seals and potential benefits for the fishermen.

By-catch rate as a direct measure of threat to marine mammals and level of anthropogenic impact on the water basin should become one of the key indicators of the Gulf of Finland ecosystem status.

4.8.2. Number of drowned waterbirds in fishing gears

There are no data on the list of species and number of waterbirds drowned in the fishing gear in the Russian part of the Gulf of Finland. There is only one reference (Podkovirkin, 1977), where mass by-catch of Long-tailed Ducks (*Clangula hyemalis*) into whitefish nets during autumn migration was documented. According to our accidental observations during 20 years of work with waterbirds (V. Buzun), single Long-tailed Ducks (*Clangula hyemalis*), Black-throated Diver (*Gavia arct*ica), Tufted Ducks (*Aythia fuligula*) and Herring Gulls (*Larus argentatus*) were recorded drowned in fishing nets and fixed gill nets in different seasons and in different parts of the gulf. So, diving birds is a 'group of risk' to be drowned in fishing gears.

The study of the issue in the Leningrad region nowadays is rather complicated. During 90s and 2000s the management of fishery has changed radically. The commercial trawling and using fixed gill nets have been stopped. At present time the fishery is conducted by small teams and individual fishermen by fishing nets (mostly made in China) with 40-50 mm cells. More then one thousand of such teams and individual fishermen are working along the coast of the gulf.

Fig. 4.8.2. Juvenile Great Crested Grebe (*Podiceps cristatus*) drowned in fishing net **(**photo by V. Buzun).

Moreover, a lot of fishermen are doing illegally and their catch is not recorded. Most of fishing nets are used on small depths. The total length of nets per team exceeds several hundred meters. The cases of disposal of cheap gear at sea in case of storm or clogging with seaweeds became more often during the last ten years and this is significant threat to marine mammals and birds.

We can make the following conclusions:

- The indicator 'Drowned waterbirds in fishing gear' is important for monitoring the Russian part of the Gulf of Finland. However, it is rather difficult to control the work of fishery teams, including bycatch of seals and waterbirds. Using questionnaires in such conditions is not effective. Reliable data on bycatch can be obtained only in selected personal contacts with fishermen under the guarantee of not applying punitive sanctions in case of revealed violation of environment protection law.
- The data on the indicator are not available.
- The data on the indicator should be collected during the periods i) of intensive migration (May and September-October) in the areas where stopovers of waterbirds were recorded; ii) during the second part of the breeding season (July – August). Selected areas for monitoring the indicator should be organized in deep waters during the migration season, and in shallow waters - during breeding season to monitor the by-catch of yearlings.

4.9. WHITE-TAILED EAGLE PRODUCTIVITY

4.9.1. Description of proposed indicator

The productivity of white-tailed eagle in the coastal zone (15 km zone landwards) of the Baltic Sea is an indicator describing not only biomagnification of contaminants but also persecution, disturbance of nest sites, food availability and availability of suitable nesting sites. Thus, it describes in reproductive terms the growth rate and condition of the population and indirectly indicates the potential for increased abundance. White-tailed eagle productivity reflects the health status of the population and is based on the brood size (number of eggs per breeding pair) and the breeding success (% successful reproduction of all pairs). Productivity is measured as the mean number of nestlings out of all occupied nests. (HELCOM, 2012a;b).

4.9.2. State of the indicator in the Russian part of the Gulf of Finland

White-tailed eagle as a bird of prey takes the top position in the food pyramid. The status of various population characteristics of this species may be an indicator of the state of coastal ecosystems. The eagle population state in coastal ecosystems may be assessed using the following criteria: indicators of breeding success of this species and its breeding distribution of seats in coastal ecosystems. These parameters of the population state characterize not only the degree of contamination of feeding grounds, but also the degree of anthropogenic disturbance, breeding sites disturbance and loss', the availability of suitable nesting sites and food.

At least 6 pairs of white-tailed eagle nest in the coastal areas of the Leningrad region (at a distance of 15 km from the coast of Gulf of Finland). More than half of the pairs hunt and collect food exclusively in marine and coastal habitats. These birds feed on fish from the Gulf of Finland, wetland and water birds, and the remains of marine mammals, especially different species of seals.

Within the territory of the city St.-Petersburg white-tailed eagle annually was observed during seasonal movements in the coastal zone of the Neva Bay and above this area of water. Several observations in the city itself and even in the central part of St.-Petersburg were documented by ornithologists: 29.10.1999 (district Avtovo, SW of SPb), 10.01.2001 (Neva River near the Palace Bridge), 14.03.2004 (SPb sea-port area), 10.10.2005 (N part of SPb flood defencive barrier), 9.03.2010 (Neva River, near Winter Palace, Hermitage) and also in suburbans of St.-Petersburg (Hrabry, 2001a; Hrabry, personal comm.). It is impossible to estimate the birds number, evidently the same bird(s) were observed several times.

Reproductive performance of some eagle pairs nesting in the coastal areas have been annually monitored during the last 15 years. Some of these data was published (Ptschelinzev, 2003; 2006).

Nonlinear regression model of productivity (number of juveniles per couple) of the White-tailed Eagle population in coastal areas is shown in Figure 4.9.1.

Data from the last five years do not suggest a slight increase in productivity after the decline of productivity in the first years of the 21st century.
Information on reproductive success of a population are a convenient and revealing indicator of the coastal ecosystems' state because they allow to control the quality of many other characteristics.

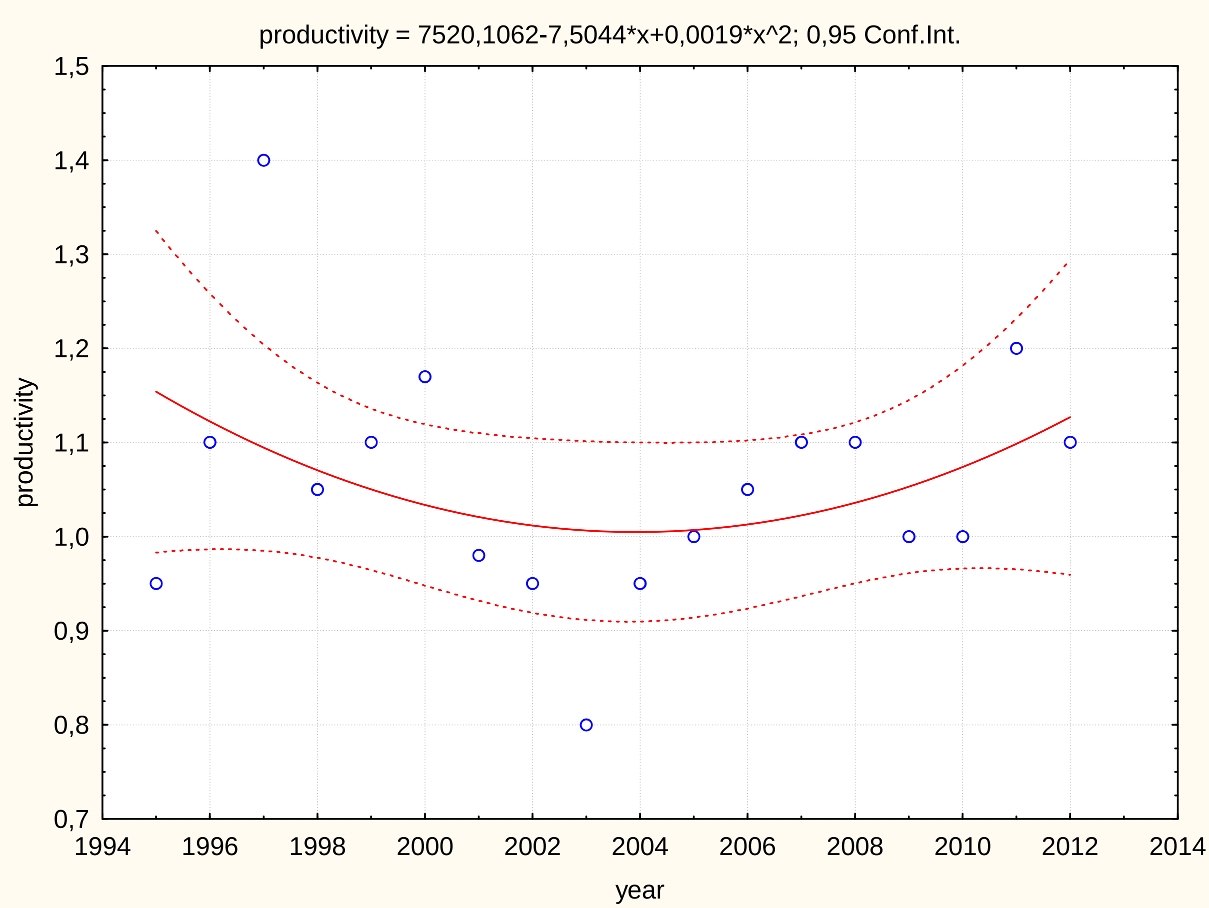


Fig. 4.9.1. Productivity (number of juveniles per pair) of the White-tailed Eagle population in coastal areas (nonlinear regression model, by Pchelintsev).

4.9.3. GES boundaries

The proposed GES boundary is based on pre-1950s data from Sweden, i.e. based on a time period when the impacts of hazardous substances on the population are perceived as being low. The GES boundary is set at the lower 95% confidence level of the pre-1950s data. The proposed GES boundary for breeding success is 60%, for brood size 1.64 nestlings, and for productivity >1.0 nestlings; the parameters are monitored in all the Baltic Sea countries. The assessment units of the core indicator are the coastal strips (15 km inland) of the Baltic Sea's sub-basins (HELCOM, BSEP, N 129A, 2012).

4.9.4. Monitoring of white-tailed eagle populations should include the estimation of breeding success and control of nest sites of this species. To receive complete information on the status of the eagle population the research on all known eagle's nests in the coastal area should be conducted. This monitoring should be carried out every year, or at least once every two years.

White-tailed eagle is the least abundant species among all of animals of the Gulf of Finland! That is why we propose to include its abundancy as a core indicator as well. These indicator reflects both ecosystem health and several human pressures.

4.10. ABUNDANCE OF WATERBIRDS IN THE WINTERING SEASON

4.10.1. History of the study of wintering water birds in the city of St.-Petersburg

The first observation of the wintering mallards (*Anas platyrhynchos*) appearing on unfrozen patches of water in the Neva river belongs to E.A.Bihner (1884). Later, the winter encounters of birds were described by V.L.Bianki (1907). There is also a work by B.Yu.Falkenshteyn (1932) which mentions wintering of the common (*Larus canus*) and herring (*Larus argentatus*) gulls. The most important is the review of avifauna, including wintering species, made by A.S.Malchevsky and Yu.B. Pukinsky (1983) using the data of Leningrad ornithologists obtained from 1940 to 1980. In 1991, the survey of V.M.Hrabry was published where the occurrences of wintering birds were also mentioned. The book 'Birds of the cities of Russia' (2012) also briefly describes them. The greatest number of published works on monitorings in the last 30 years were focused on the mallard, because it is the most abundant wintering waterbird in St.-Petersburg. The distribution and the number of wintering birds of this species is the most affordable indicator of the conditions of the reservoirs. It should be noted that some of the peripheral urban reservoirs such as lakes Krasnoselskie, the non-freezing in mild winter areas of the Gulf of Finland near the river mouths, and the rivers themselves, are a part of a natural landscape, and are also useful for monitoring. In parallel with the mallard, all kinds of other waterbirds were surveyed (gulls, grebes, diving ducks). The following publications are the most informative of the papers on mallards: O.P.Smirnov (1984), V.M.Hrabry (1986, 2006), S.A.Kouzov (1993), U.A.Birina (2002a, 2006) .The most important publications on the other species of water- and shorebirds are the following: U.A.Birina (2002 b, 2002 c, 2006), A.A.Aleksandrov (1996, 1997 a, b, c, 2001, 2002, 2005 a, b), C.L.Zanin (2007.2010), S.G.Lobanov (2001), I.Yu.Yanovsky (2009).

4.10.2. Methods and participants of the previous phase of monitoring of wintering water- and shorebirds of St.-Petersburg region

A.S.Malchevsky and Yu.B.Pukinsky (1983) collected data by polling their peers and reviewed their own observations and publications. B.A.Podkovyrkin, in winter of 1979-80, was the first to map all the mallards wintering in the unfrozen patches of water in St.-Petersburg. In 1984-1986, V.M.Hrabry (1986) toured the wintering patches of water by car and during the day also had time to register the majority of wintering waterbirds. In addition, he used the data of birdwatchers, including school children, to determine the limits of the number of birds in the unfrozen patches during winter. He used the same methods to obtain the data in autumn to compare with winter counts. The number of mallards increased. No more one person could cope with their counting. It was necessary to assess out not only the winter, but also the pre-winter abundance (autumn maximum).

In November 2, 1986, the complete census of waterbirds was organized for the first time in urban areas, with the participation of volunteers, biologists and students (Birina, 2005). The reservoirs in 99 sites were surveyed simultaneously at 14 pm and 10000 mallards were counted. Later, another 29 sites were found where the number of mallards was extrapolated to be 4050. Total population of mallards in early November was estimated as 14050 individuals. Later, these pre-winter population surveys were conducted in 1987, and 2012, at intervals of 2-3 years, with the participation of experts and students of St.-Petersburg State University. Autumn survey was always carried out in late October and early November between the first freezing of inland waters and the final freeze-up. At this time, the number of mallards and other waterbirds reached a maximum in autumn (the birds from the nearby areas and passing birds were present), then the numbers decreased, because part of waterbirds left to warmer wintering grounds.

Subsequently, the winter mallard population ranged from 51.6% (winter 1995-96) to 71.7% (in 1989-90) of pre-winter (autumn) maximum.

Since the autumn of 1986 to 1990, the first surveys were conducted at two fixed routes - average length of each 5 kilometers - on the most of the possible types of reservoirs (ponds, and areas of small, medium and large rivers). At the 1st route - at 2-day intervals, at the second - every 7-10 days. We studied the population dynamics, movement of mallards and common species of gulls, and the species composition of avifauna (Birina, 2002a).

In February 1996, a total survey of winter abundance of waterbirds was conducted, similar to autumn survey. Based on data on the seasonal population dynamics in 2 fixed routes the winter abundance in the city was extrapolated for 1986-1990 (Birina, 2005). The results coincided with the data of S.A.Kouzov (1993), which with 3 assistants in 1989 and 1990 also explored the city, conducting surveys 1 every 2 weeks for 11-routes in all the districts of St.-Petersburg. After 2000 the need for such an extrapolation disappeared because of the full census in winter, organized by V.M.Hrabry with the participation of members of the Ornithological Society of the St.-Petersburg Society of Naturalists (Hrabry, 2005).

Thus, at present, the monitoring is carried out by means of routing and total counts of water- and shorebirds. It must be emphasized that the winter total registration is carried out at -8-12 degrees when the ice conditions and distribution of birds are most stable.

4.10.3. Main changes in the winter avifauna of the water- and shorebirds of St.-Petersburg in the 20th - early 21st century

1. In the 1960s, the group of city mallards began to form and has reached 500-600 individuals by winter 1979-80 (Smirnov, 1984, Podkovyrkin, 1985). In winters of 1984-1986, there were already 4000 mallards (Hrabry, 1986).

2. Maximum abundance of wintering mallards was observed in winter 1987-88 years - 9722 birds after the corresponding maximum of pre-winter (autumn) population (14271 individuals). In winter of 1989 -90, the number of birds was almost the same - 9629 individuals, and then in winter 1995-1996 there was a 3-4-fold decline to 2551 individuals (January 28 1996). The declines of autumn and winter bird abundance paralleled: the 1996 was also the year of the minimum autumn abundance (2818 mallards).Then the number of mallards slowly increased; by autumn 2003 and 2004 it exceeded four thousand (4047 and 4017) reaching the level of 1984 -1986 (Birina, 2005). Winter abundance, according to the total registration by V.M. Hrabry, continued to decline steadily: in the winter of 1999-2000 - 1897 birds, 2000-2001, -1765, 2002-2003 - 1679, 2003-2004 - 1573 , 2004-2005 - 1357 Mallards (Hrabry, 2005). Unfortunately, the data of V.M.Hrabry for the last 8 years have not been published, although in the book ‘Birds of Russian Cities’ (2012) he argues that ‘a strong tendency for decrease in abundance of wintering mallards continues to the present time’. However, according to our own data, total registration at the end of February 2013, during a prolonged winter with persistent negative air temperatures (-8 -20 degrees during the day) showed an increase of winter mallards (fig. 1).

3. Already in the late 80s of the 20th century (1986-1990) the terms of departure of last individuals for most species of shore- and waterbirds shifted later, and the time of the first birds arrival shifted earlier, compared to 40-70s' (Malchevsky, Pukinsky, 1983). Accordingly, the wintering time shortened for the wintering birds, because mild and late winters became more common, when the ice cover formation on the Neva river is delayed until the second half of January (Birina, 2002b). Thus, six of the 10 species rare in the city or its' center for which A.S.Malchevsky and Y.B.Pukinsky (1983) noted the dates of flight, either were delayed longer than usual during autumn migration (1 to 20 days, Great Crested Grebe, Eurasian Widgeon - for a decade, Northern Shoveler for 2 weeks, Red-breasted Merganser - for a month and 40 days), or were observed by a certain period before the spring (Common Teal - a month earlier, Northern Pintail - 10 days earlier). Later the similar analysis will be held for the other species common an abundant in the city. Thus, the arrival of the first black-headed gulls in 1986-1990s' were offset earlier by 24 - 39 days, and even in the most late spring of 1987 - by 4 days. Such timing of the first significant increase of the spring abundance that had been considered as early in the 50's - early 70s', later became common in the second half of the 80's. These dates often coincide with the end of wintering in mallard (Birina, 2006).

Fig. 4.10.1. Mallards wintering in Saint Petersburg (photo by U.Birina)

4. Since the end of December 1987, after several decades of interruption in mild winters flocks of european herring gulls and mew gulls (*Larus argentatus, Larus canus*) began to re-emerge. Their number varied from a few dozen to a few hundred birds. Among them there was glaucous gull (*Larus hyperboreus*): 1 – 2 birds were met by U.A.Birina on January 28 1989 (Birina, 2002a), then there were 2 winter encounters: on February 12 1991 by V.A. Buzun (in personal communication to Hrabry, 1991), and on January 10 2001 by A.A.Aleksandrov (1997). Before these three, encounters of the Glaucous Gull were reported only for the beginning of the 20th century – 'since the last meeting on the Neva River in the winter of 1907 (Bianki, 1997), it had not been met' (Malchevsky, Pukinsky, 1983). In beginning of the 20th century, such mild winters were known like 1928 when 'a large number of mew gulls wintered in Leningrad port' (Falkenshtein, 1932). By 1996, the wintering flocks of european herring gulls and mew gulls have become common (Aleksandrov, 1997).

5. Since January 4 1989 and January 10 1990 1-2 birds of such distant migrant, as the lesser black-backed gull began to occur (*Larus fuscus*) (Birina, 2002b).

6. Since the winter of 1988-89, wintering tufted duck became usual *(Aythya fuligula),* (Birina, 2002a), since 2005-06, including 2012-13 long-tailed ducks have been wintering regularly (*Clangula hyemalis*) - in 2006-07, even small groups of up to 4 birds were met (Birina, 2010). A.S.Malchevsky and Y.B.Pukinsky (1983) mentioned only one single bird wintering in 1970.

7. The most important change is the change in the status of the black-headed gull (*Larus ridibundus)* and the great black-backed gull (*Larus marinus*): since the winter of 2006-07, black-headed gulls began to occur in groups from 7 (in 2013) to 30-70 birds - 6 winters of the last 8.(Birina, 2010). Up to this time black-headed gull was strictly migratory species (2 encounters of single wintering birds in earlier years) - Birina, 2006. Since the winter of 1994-95, the Great Black-backed Gull began to appear - (Aleksandrov, 1996, 1997). In 1996-97, Aleksandrov counted 42 birds, and then extrapolated to the '100 -150 animals at least'. In the winter of 2005-06, this previously rare in the Leningrad region species became common for the winter: it was not encountered only in 2 out of

the last 8 years. Over the years, along the route U.A. Birina registered from 1 (2009-10) to 42 (2005-06), birds (Birina, 2010).

8. Since the winter of 1995-1996, the frequency of encounters of rare wintering bird species increased in St.-Petersburg:
9. The black-necked grebe (Podiceps nigricollis) – was encountered for the first time on February 3 1996 (Birina, 2002).

10. The common scoter (Melanitta nigra) – was met for the first time in the winter 1994-95 (Aleksandrov, 1996).
    The greater scaup (Aythya marila) – in January 2007 (Birina, 2010).
    The velvet scoter (Melanitta fusca) – in winters of 1996-97, and 2004-05 (Aleksandrov, 1996).
    The common pochard (Aythia ferina) – was encountered for the first time on January 31 1996 (Birina, 2002a, 2002b).
    The red-breasted merganser (Mergus serrator) – in the winter of 2005-2006 (Birina, 2002 b).
    The smew (Mergus albellus) – single birds were encountered from the winter of 2001-2002(Aleksandrov, 2005) untill the winter of 2005-06 up to 3 birds at once (Birina, 2010).
    The common eider (Somateria mollissima) – 2 birds were met in the winter 2001-02 (Aleksandrov, 2005) (earlier, in 1969 and 1970, several birds were also encountered - Malchevsky, Pukinsky, 1983)
    The great crested grebe (Podiceps cristatus) – Aleksandrov, 2002.
    Since 2006-07 sporadic winterings were reported for rare species:
    The mute swan (Cygnus olor) (Zanina in personal communication to Hrabry, 2007)
    The whooper swan (Cygnus cygnus) (as above)
    The bean goose (Anser fabalis) – a young bird in 2006-07 (Birina, 2010)

The greater white-fronted goose (Anser albifrons) – a pair of adults (1 overwintered) in 2008-09 (Janovsky, 2009).

The eurasian bittern (Botaurus stellaris) – Zanin, 2007.
The grey heron (Ardea cinerea) – Zanin, 2010.
The common moorhen (Gallinula chloropus) – (Zanina personal communication, 2012).
Since the winter of 1994-95, the three species often wintering in the city began to occur more frequently and had even became regular:

The eurasian coot (Fulica atra) wintered in 1978-80 in Leningrad (Hrabry, 1991) – since 1994 it was met several times (Birina, 2010)

The common goldeneye (Bucephala clangula) wintered in the region and in the city in 1970-79 (Malchevsky, Pukinsky, 1983) – since 1994-95 it winters almost every year (Aleksandrov, 1996, 2005, Birina, 2002b, 2010).

Goosander (Mergus merganser) – up to 30 birds were known wintering in the region (Malchevsky, Pukinsky, 1983) – since 1995-96, from 14 to 42 birds are encountered almost every year (Birina, 2010, 2002, Aleksandrov, 1997, 2005).

Since the winter of 1987-1988, the wintering single whistle (*Anas crecca*) did not became more frequent and occurred at the constant level (Birina, 2002a, 2010). The reported frequency of wintering increased because of the same wintering male. A.S.Malchevsky and Yu.B.Pukinsky (1983) reported its' wintering in the Leningrad region. In 1979, 1980 and 1985, 2-3 birds of this species were also observed wintering in Leningrad (Hrabry, 1991).

Regular estimations of waterbirds in St.-Petersburg area have beed done by Vladimir Hrabry during winter periods of January-February of several years (2000-2005). (Note: Saint-Petersburg administrative region – is large area, including all area of water of the Neva Bay and some adjacent parts and shoreline of the eastern Gulf of Finland). Lately such investigations were cancelled because of stop of financing. These results are summarized in the Table (tab. 3.1), presented by Dr. Vladimir Hrabry (Zool. Inst. RAS).

During last decades seasonal dynamics of Mallards had changed substantially, the seasonal difference in population abundance was very much smoothed (fig. 4.10.2).

Table. 4.10.1. Results of winter (January-February) calculations of waterbirds in St.-Petersburg area

Species/Year	2000	2001	2002	2003	2004	2005
Mallard (*Anas platyrhynchos*)	1897	1765	1679	1573	1511	1357
Whistle (*Anas crecca*)		1				
Wigeon (*Anas penelope*)			1			1
Tufted duck (*Aythya fuligula*)	2	3		4	4	6
Greater scaup (*Aythya marila)*	8		6			7
Common eider (*Somateria mollissima*)		3				
Long-tailed Duck (*Clangula hyemalis)*		3		5		8
Goosander (*Mergus merganser*)		12		16		18
Great black-backed gull (*Larus marinus)*			3		2	6
Common Gull (*Larus canus*)		>4			>18	3
European Herring Gull *(Larus argentatus)*	>453	>345	>654	>632	>790	>1200
Black-headed Gull *(Larus ridibundus)*	2		2			2
Pallas's Gull (*Larus ichthyaetus*)		1				
Lesser Black-backed Gull (*Larus fuscus*)		2			6	
Common Pochard (*Aythya ferina*)	1				1	1
Whooper Swan (*Cygnus cygnus*)		1				1
Eurasian Coot (*Fulica atra*)		1	1			

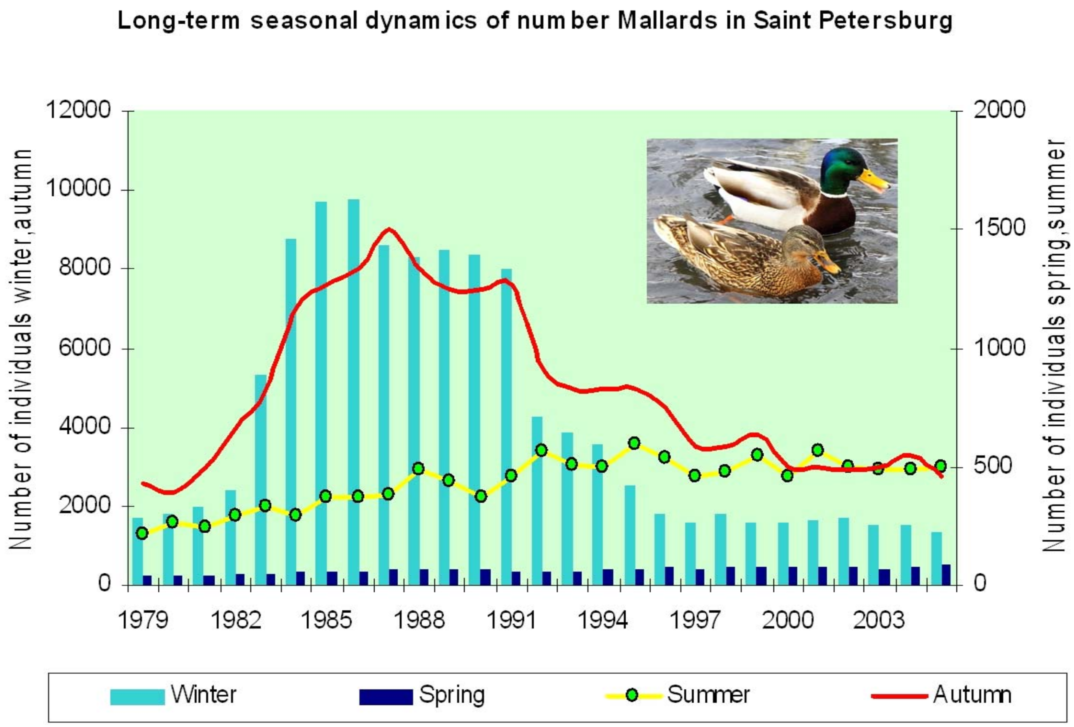


Fig. 4.10.2. Long-term seasonal dynamics of abundance of Mallards in St.-Petersburg area (after Hrabry, 2011).

4.10.4. Reasons for changes in winter avifauna of water- and shorebirds

Virtually all of the changes were associated with increased frequency of mild winters since 1987-88, when large areas of open water on the Neva River and the small and medium-sized rivers remained non-freezing even during strong (up to-26 degrees), but short-term (no more than 7-10 days) frosts. In such years, the ice formation can be late along most of the Neva River up to the 20th of January; some birds that occur in autumn, including during migration, delay their departure and stay for winter. When the patches of open water shrink in short periods of frost, the birds relocate to the remaining patches.

The decrease in the number of wintering mallards 4 times after flourishing of urban population in late '80s (1986-1990) could be partly related to the economic crisis in '90s and the associated decrease of number of patches of open water due to decline in industrial production (thanks to reduction of warm waste water discharges from factories) and as well as reduced feeding of birds by humans (Hrabry, pers. comm.).

However, objectively important factors can be estimated as follows:

- the reduction of the number of mallards in winter corresponded to the autumn decline, which depends directly on reproductive success in breeding and migrating birds;
- the feeding of mallards did not decline;
- the area of open water did not decrease due to mild winters compared to the level before the crisis;
- in the '90s (1990-2000) there was a pan-European decline of many species of birds, including other than waterbirds, that was not associated with less favorable conditions of reproduction.

The emergence of other water birds in small numbers wintering in St.-Petersburg was due, as a rule, not to increase of their total number (the possible exceptions are the smew, that wintered only 3 years in a row, the Great Black-backed Gull, and the Eurasian coot), but with the advent of suitable winter conditions. The increasing numbers of wintering herring gulls and the appearance of geese can also be due to the general increase in their numbers, and to the favorable conditions, such as the presence of places to stay, feeding, including natural sources of food, the low level of pollution hunting, and predators. One exception is the white-tailed eagle *(Haliaetus albicilla),* which from time to time flies in with flocks of gulls (Hrabry, 2001b). A necessary condition is also a tolerance of birds (some or many individuals of a certain species) to human presence and water transport.

4.10.5. Suggestions for monitoring of wintering waterbirds in area of St.-Petersburg

Total registration of wintering birds requires a large number of observers, that makes such surveys difficult to carry out every year.

1. Continued inventory along the established rout.
2. Full census of birds in late October and early November 2013 to determine the maximum autumn (pre-winter) number of waterbirds and to compare it with the winter numbers.
3. Full winter census of waterbirds during relatively stable ice conditions at -10 -12 degrees.
4. A comparison of winter bird numbers with autumn (pre-winter) to find out how many birds remain for the winter in the last 15 years.
5. The same analysis for the years 2006-2012 after the database for these years will be processed.
6. Compiling an annotated list of species found in St.-Petersburg in the winter since 1986 with the specification of their numbers and a more detailed status: tried unsuccessfully to winter, winters, probably wintered; winters annually, only mild (favorable) winters, winters occasionally with interruptions unrelated to favorable winters and the presence of other species of gulls and waterbirds, winter single or up to 5, 10, 20, 30, 50, 100 birds, or several hundreds or thousands of individuals.

Full census of wintering birds requires a large number of observers, making such surveys difficult to maintain every year, and requires a dedicated funding.

4.11. ABUNDANCE OF WATERBIRDS IN THE BREEDING SEASON

4.11.1. Introduction

The majority of coastal and island territories in the Russian part of the Gulf of Finland were closed for public access during the period of the Soviet Union because of the strict boundary regime. Since the survey of two islands (Maly and Moshny) by Finnish ornithologists (Suomalainen, 1937; Putkonen, 1938) there was a huge gap in survey researches on the islands in the Eastern part of the Gulf of Finland. First works were started in 1988 on the Kurgalsky Reef (Buzun, Mierauskas, 1993), followed by surveys of several islands (Gogland, Virgini, Bolshoy Tuters, Maly Tuters, Moshny, Sescar, Sommers and Kozliny) during June, 18-22 in 1991 and June, 13-19 in 1992 (Noskov et al., 1993) and surveys of the majority of islands of the Gulf during May, 1 - June, 15 in 1994 and June, 19-29 in 1995 (Iovchebko et al., 2004) (figs. 4.11.1- 4.11.3).

During this period the ornithological studies on the islands situated in the central part of the gulf (Fig. 2-3) may be characterized as rather irregular. Intensive population studies of the Herring Gull (*Larus argentatus*) during several years (1988-1992) were conducted on the islands of the Kurgalsky Reef by Valery Buzun, Mierauskas Pranas & Greimas Edmundas (Mierauskas et all., 1991; Buzun, Greimas, 1997; ***SPbU, Institute of Ecology*** of Nature Research Center, Lithuania). The breeding of the Mute Swan was studied at the same site during 1995-1997 by Dmirtry Leoke (Leoke, 1998, SpbU). The breeding of the Mute Swan (*Cygnus olor*), Tufted Duck (*Aythya fuligula*), Great Cormorant (*Phalacrocorax carbo)*, Little tern (*Sterna albifrons*), Greylag Goose (*Anser anser*) and some other species breeding on the Kurgalsky Reef was studied by Sergey Kousov (Zoological Institute RAS, SpbU) in 1993-1999 and 2005-2012 (e.g. Kousov, 2007; Kousov, Kravchuk, 2011, 2012, 2013). Some data on breeding were obtained during the running of the programme 'Study of the status and trends of migratory birds populations in Russia» (SpbU), started in 1996 in cooperation with OMPO, France ('Migratory birds of the Western Palearctic'). The regular surveys of breeding birds on the islands of the Gulf of Finland have been started since 2010 thanks to the financial support of the Company «Nord Stream AG».

Fig. 4.11.1. Seskar Island is the nesting area of Cormorant, Common Eider, Black-Headed Gull, Common Gull, Lesser Black-backed Gull and migration stopover place for ducks (photo by E. Zaynagutdinova).

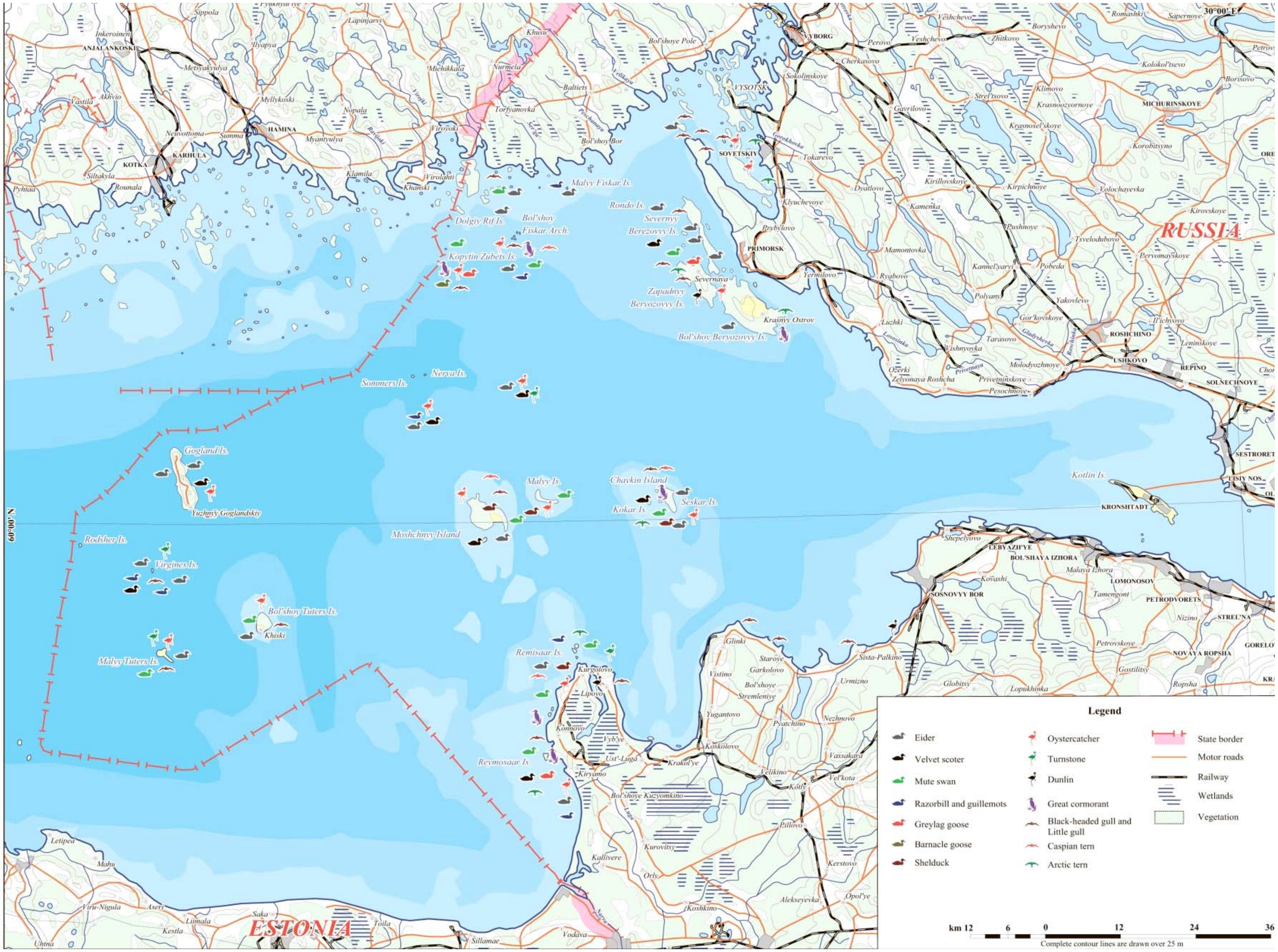


Fig. 4.11.2. Distribution of the Baltic Sea bird fauna in the spring and summer (nesting) period (Environmental Protection Atlas …, 2006)

Fig. 4.11.3. Sommers Island is the nesting area of Turnstone and Common Gull (photo by V. Buzun).

4.11.2. State of the indicator (the characteristics of the available data)

The comparable data on numbers during breeding for the islands of the Eastern part of the Gulf of Finland are available for 2010-2012. The method of survey is similar to the method used by Finnish ornithologists for the survey of waterbirds (Koskimies, Väisänen, 1991). The complete registration of nests was executed on small islands following the method of sweeping: three participants were arranged in a line at 5 m intervals; so they passed practically all island territory. This method makes possible to register all nests situated in the open and to scare up practically all birds sitting on eggs from the nests sheltered by plants. Only some stone surfaces ('mutton foreheads') and steep rocks were not covered by the inspection. The surveys were conducted on the islands of archipelagos (Bolshoy Fiskar, Seskar, Berezoviye, Kurgalsky Reef) and some single islands (Gogland, Kopytin, Maly Fiskar, Riyabinnik, Dolgy Reef, Maly Tuters, Nerva, Sommers, South and North Virgins, Rodsher, Maly, Remisaar, Rondo, Galochiy, Zubets, Tuman, Soglasny).

The data on numbers during breeding were also obtained for some islands of the gulf for 1999, 2000, 2005-2009 during the expeditions of the researches of SpbU, but the majority of them remain unpublished. The data on the breeding success in waterbirds are absent for the studied region, except for the data on the Herring and Lesser Black-backed Gull obtained for 1989-1992 for the Kurgalsky Reef (V. Buzun, SpbU). Some population indexes such as the average number of eggs per nest and the average brood size are available for several species from the same place but the data have been published only in part (S. Kousov, SpbU).

For the Russian coast of the Gulf of Finland only fragmentary data on the abundance of breeding waterbirds are available (Malchevsky, Pukinsky, 1983; Buzun, Khrabry, 1990; Leoke, 1998; Iovchenko, 2003; Rychkova, 2010).

Below the general review of the abundance and distribution of species selected by HELCOM CORESET is presented. The data on numbers are based mostly on the results of the surveys conducted in 2010-2012.

Great Cormorant (*Phalacrocorax carbo*)

Several colonies of the Great cormorant were recorded in the Russian part of the Gulf of Finland for the first time in 1994 on the archipelago Bolshoy Fiskar (Gaginskaya, 1995; Osipov, Gaginskaya, 1994; Gaginskaya, Rychkova, 2011). The species came from the adjoining territories of Finland. So far, it moved to the east to the Berezoviye islands. Small breeding population was also recorded on the islands of White Sea (Zimin et al., 1993). In 2012 the total number of breeding pairs for the archipelagos Bolshoy Fiskar, Dolgy Reef, Seskar, Kurgalsky Reef, islands Soglasny and Rondo is about 4600 (surveys of the researches of SpbU, June 2012, the data were combined by A.R.Gaginskaya for the programme 'CorMan'(coordinator - the University of Aarhus, Denmark)). In one local breeding colony situated near the coast (Kurgalsky Reef) the number of breeding pairs increased dramatically from 66 pairs in 2005 up to 1250 in 2012 (Kouzov, Kravchuk, 2012). The variation of numbers on the islands North Virgin, Dolgy Reef, archipelagos Bolshoy Fiscar and Sesrar is presented in Table 1 (after Sagitov et al., 2012).

Common Eider (*Somateria mollissima*)
Breeds on the islands of the Gulf of Finland to the east, up to the mouth of the Viborg Bay (along Vihrevoy – Igrivy) (fig. 4.11.4).

Fig. 4.11.4. Nesting colony of Lesser Black-backed Gull andnest of Common Eider in vicinities of Lukoil terminal in the Gulf of Vyborg (photo by V. Fedorov).

According to data of 2010-2012 the total number of pairs on the islands where the surveys were conducted varies from 124 to 194 pairs (Table 4.11.1). A small breeding population (30-40 pairs) is known for Lake Ladoga.

Velvet Scoter (*Melanitta fusca*)
Breeds on the islands of the Gulf of Finland to the east up to Berezoviey islands (Rondo). Very few breeding pairs were recorded during the surveys of 2010-2012 (Table 4.11.1).

Sandwich Tern (*Sterna sandvicensis*)
The species does not breed in the Russian part of the Gulf of Finland.

Caspian tern (*Sterna caspia*)
The breeding of the species is known for archipelago Bolshoy Fiskar (up to 2007) and archipelago Kurgalsky Reef (2-3 pairs, up to 1996). The maximum number of breeding pairs at the archipelago Bolshoy Fiskar was recorded in 2005 (46 pairs). Small isolated colony was known for Lake Ladoga (Birina, 1994, no modern confirmation for this fact).

Little tern (*Sterna albifrons*)

The Little tern breeds mainly along the southern coast of the Gulf of Finland, from Kurgalsky Reef up to Saint-Petersburg and Zelenogorsk. Its numbers vary in all places from several tens to 100-150 pairs (Buzun, personal comment). The breeding number of the species depends on the availability of suitable open biotopes for breeding (the increase of numbers was recorded when additional areas transformed during large-scaled constructions were available) and foraging (broad area of shallow waters).

Black-headed Gulls (*Larus ridibundus)*

The most numerous species of gulls in the Russian part of the Gulf of Finland. Most colonies are located on the shore (natural and artificial waterbasins). The total number of breeding pairs is unknown. About 2000 pairs breed in colonies situated on archipelagoes Seskar, Berezovieye, Kurgalsky (Buzun, personal comment). During the expeditions of 2010-2012 the colonies of the species were recorded on the islands of the Sescar archipelago (Table 4.11.1).

Common Gull (*Larus canus*)

The total numbers of the species in the Russian part of the Gulf of Finland is unknown. The number of pairs breeding on the islands surveyed by the expedition of 2010-2012 does not exceed several tens pairs (Table 4.11.1).

Lesser Black-backed Gull (*Larus fuscus fuscus*)

The species decreases in numbers as in other parts of the Baltic region. However, rather large monospecific colonies (up to 200 pairs) survive in the most eastern part of the Gulf of Finland (Bereziviye islands, the Viborg Bay), serving as a refuge for the species (Buzun, personal comment). According to data of 2010-2012 the total number of pairs on the islands where the surveys were conducted varies from 85 to 177 pairs (Table 4.11.1).

Herring Gulls *(Larus argentatus)*

This species along with Common gull is the main species forming the colonies of waterbirds on the islands in the Eastern part of the Gulf of Finland. The numbers increased until the mid 90s, nowadays they have stabilized. Some data suggested that the numbers even are decreasing. In 2010-2012 number of this species on the islands varied from 1000 to 2800 nests (Table 4.11.1).

Razorbill (*Alca torda*)

Breeds mainly on central islands of the Russian part of the Gulf of Finland. The estimated number of pairs on studied islands in 2010-2012 varied from several tens up to hundred and a half in different years (Table 4.11.1). The breeding success of the species is affected by the numbers of foxes and American minks, which come to islands during winter time.

Guillemot (*Uria aalge)*

First breeding colony was recorded in 2010 on the island Severny Virgin with the total number minimum 9 nests (Vysotsky et al., 2011). The number of breeding pairs increased three times in 2011-2012 (Table 4.11.1).

Black Guillemot (*Ceppus grille*)

Presumably, the number of breeding pairs is decreasing. For example, two small colonies disappeared from coastal islands (Buzun, personal comment). Very few breeding pairs were recorded during the surveys of 2010-2012 (Table 4.11.1).

Turnstone (*Arenaria interpres*)

Breeds sparsely on the islands of the Russian part of the Gulf of Finland. The number of pairs does not exceed 10 pairs (Buzun, personal comment).

4.11.3. Conclusions

After preliminary analysis of the data available the following conclusions can be made:

- The indicator 'Abundance of waterbirds in the breeding season' measured in the number of breeding pairs is very important and useful for the Russian part of the Gulf of Finland. Since the islands of the gulf have not been much affected by human activity yet, they can serve as a model of increasing anthropogenic impact on waterbirds. The constructions of harbors including large oil loading and chemical terminals, the intensification of vessels traffic, water, air and noise pollution are affecting the marine fauna.
- The available data are not sufficient yet to make conclusions because up to 2010 the data were collected irregularly, except for the Kurgalsky Reef for the Great Cormorant (the numbers of breeding pairs are available for 1993-1999, 2005-2012).
- The proposed core indicator 'Abundance of waterbirds in the breeding season' has two parameters: abundance and breeding success. To elaborate 'Good Environmental Status' for the parameter 'Abundance' for our region some additional analysis of the available data should be conducted to reveal the baseline. The data on parameter 'breeding success' are fragmentary.

4.11.4. Indicator monitoring recommendations

- To monitor the indicator 'Abundance of waterbirds in the breeding season' it is necessary to provide surveys of the islands of the Gulf of Finland twice a breeding season (for parameter 'abundance' – number of breeding pairs).
- To monitor the parameter 'abundance' (number of breeding pairs) we recommend the following sites: the Sescar island, Berezoviye islands, Kurgalsky Reef , Bolshoy Fiskar, Rodsher, Virgini, Sestroretzky Rasliv, cape Chernaya Lahta, Plavni Krondshtatskoy Kolonii, skerries of the northern coast of the Viborg Bay.
- In future the breeding success could be monitored in selected coastal and island locations using locally representative species, such as Lesser Black-backed Gull, Common Gull, Little tern, Common Eider and Great Cormorant. The survey of such locations should be done not less than three times during breeding season. As estimated parameter we could use the average number of fledgling per nest.

Table 4.11.1. Number of breeding pairs of rare and some common species of birds on the islands of the Eastern part of the Gulf of Finland (by the data of expeditions of 2010-2012). After Sagitov et al., 2012

Island or archipelago	**North Virgin**	**South Virgin**	**Rodsher**	**Dolgy Reef**	**Arch.Bolshoy Fiskar**	**Maly Fiskar**	**Arch. Seskar**	**Ryabinnik**	**Nerva**	**Sommers**
Species (English, Russian and scientific name)	**Years:** 2010 2011 **2012**									
Cormorant	225	-	-	471	1172	-	2000	?	?	?
Phalacrocorax carbo (Linnaeus, 1758)	198	-	?	375	1220	-	3720	-	?	?
	181	-	-	**431**	**1143**	-	**2740**	-	-	-
Eider	35	13	29	11	100	6	-	?	?	?
Somateria mollissima (Linnaeus, 1758)	23	11	?	4	80	3	1	2	?	?
	5	-	-	**3**	**109**	-	**3**	**8**	**12**	**1**
Velvet scoter	-	-	-	-	1	-	-	?	?	?
Melanitta fusca (Linnaeus, 1758)	-	-	?	-	-	-	-	-	?	?
	-	-	-	-	**3**	-	-	-	-	-
Black-headed Gull	-	-	-	-	-	-	85	?	?	?
Larus ridibundus (L.)	-	-	?	-	-	-	-	-	?	?
	-	-	-	-	-	-	**250**	-	-	-
Common gull	-	-	3	-	-	-	-	?	?	?
Larus canus (Linnaeus, 1758)	-	-	?	1	1	-	17	-	?	?
	-	-	-	-	-	-	-	-	-	**30**
Herring gull	270	188	48	213	573	475	-	?	?	?
Larus argentatus (Pontoppidan, 1763)	40	60	?	40	300	102	270	225	?	?
		-	-	**224**	**852**	**481**	**467**	**≥250***	**522**	**3**
Lesser black-backed gull	26	33	5	8	26	52	2	?	?	?
Larus fuscus (Linnaeus, 1758)	3	5	?	5	20	7	20	25	?	?
	-	-	-	**18**	**41**	**54**	**8**	**≥25***	**31**	-
Razorbill	56	25	54	-	20	1	-	?	?	?
Alca torda (Linnaeus, 1758)	46	10	?	-	24	3	-	-	?	?
	50	-	-	-	**68**	**4**	-	-	**1-2?**	-
Guillemot	9	-	-	-	-	-	-	?	?	?
Uria aalge (Pontoppidan, 1763)	27	-	?	-	-	-	-	-	?	?
	22	-	-	-	-	-	-	-	-	-
Black Guillemot	1	2	2	-	5	-	-	?	?	?
Cepphus grylle (Linnaeus, 1758)	-	1	?	-	2	-	-	-	?	?
	-	-	-	-	**2**	-	-	-	-	-

'?' – no survey of the island were conducted during this year.

'-' - no birds were found

'*' - because of late time of visiting island, only rough estimation of the breeding pairs number is done, based on counting of fledglings

4.12. NUMBER OF WATERBIRDS BEING OILED ANNUALLY

4.12.1. Description of the indicator

Indicator ‘Proportion of seabirds being oiled’ is targeted at different species of water birds. For each species, the percentage of birds with visible traces of oil is estimated.
The main component of this indicator is a share of oiled individuals calculated for each bird species wintering or breeding in a certain area. The summarized data are then compared with the total abundance of aquatic birds, separately for winter and summer. The calculation of this index is based on the results of the winter, summer and nesting surveys of water birds.
A share of oiled birds found dead or killed on the coast (beaches) can be used as an additional component of the indicator.

4.12.2. Applicability of this indicator to the Russian waters of the Gulf of Finland

Only partial usage of the main indicator is possible for the Russian part of the Gulf of Finland (for nesting birds and summer surveys). Assessment of winter birds oil pollution should be excluded on several reasons: first, in the Russian waters of the Gulf of Finland the populations of wintering birds of different species are unstable. As a rule, the eastern part of the bay is covered with ice, and temporary wintering flocks of birds are formed only in mild winters. Second, the total number of wintering birds is very low, within a few thousand individuals in total for all species in a favorable winter. Third, the winter counts of waterbirds in the Russian part of the Gulf of Finland have not ever been carried out before, and conducting of such surveys is not expected in the future. Summer counts of aquatic birds are carried out only in the central part of the islands in the central area of the Russian part of the Gulf of Finland, and they include only nesting birds. Total abundance of water birds in summer has not been evaluated and is not intended to be evaluated.
However, assessment of the additional component of the indicator in the Russian part of the Gulf is possible.

4.12.3. The possibility of oil contamination of birds in the Russian part of the Gulf of Finland (based on expert's personal data)

No special case studies and the degree of contamination of aquatic birds with oil have ever been conducted in the Leningrad region. We can base our estimates only on probabilistic models and indirect observations. Fig. 4.12.1 shows the main ports and oil terminals in the Russian part of the Gulf of Finland, and the risk areas descried in federal and regional Oil Spill Response Plan (LARN), as well as the areas with high risk of accidents of tankers, when bunkering and pumping oil on water (Sutyagin, 2009). Oil Spill Response Plan (LARN) is a plan for the prevention and elimination of oil spills and oil products, developed for each individual oil-related facility on the basis of regulatory documents.

Fig. 4.12.2 shows large breeding populations and migratory aggregations of marine water birds (Buzun, Rezvyj, 2006). The comparison of these figures reveals that nesting sites, and aggregation areas overlap with areas of high oil contamination risk in many areas of the Gulf waters. Previous studies revealed the greatest degree of contamination of birds with oil near port areas (Zydelis et al, 2006). According to data of the regional center ‘Monitoring of the Arctic’ the small amounts of oil and oil products frequently spill into the Gulf of Finland. For example, in the port of St.-Petersburg it happens up to several times during the day, mostly from ship discharges and spillages during bunkering (Sutyagin, 2007).

In 1988-1992, the breeding colonies of herring gulls were surveyed on the islands north and west of the Kurgalsky peninsula (59°36’-59° 50’; 27° 58’-28° 10’) (Mierauskas et al, 1991). There, random samples of birds were used to estimate the number of oiled seagulls, as well as individuals with any anthropogenic damage. The share of birds with oiled feathers, partially entangled in net fragments, fishing line, plastic waste and ropes was calculated for the total bird abundance in the colony. The proportion of oiled gulls ranged from 3.3 to 7.2%. The proportion of birds with objects on the feet and beak varied from 0.4 to 1.3% (unpublished data).

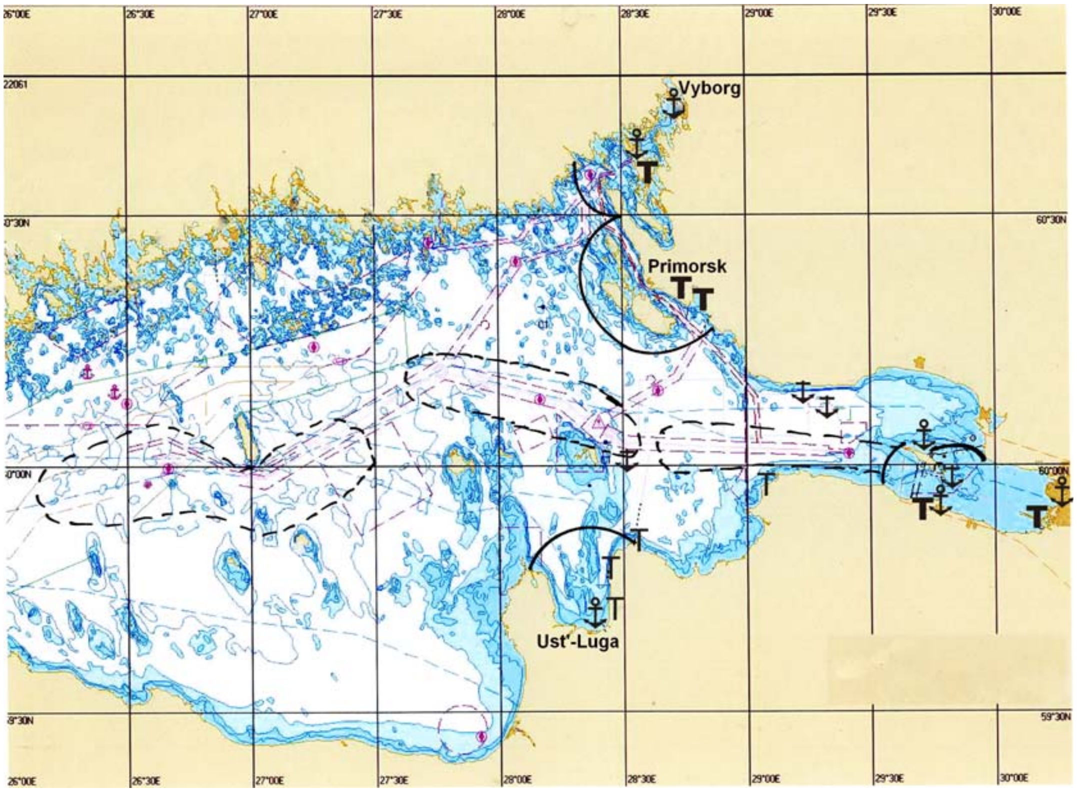


Fig. 4.12.1. Ports (anchor icon) acting (bold letter ‘T’) or under construction (regular letter ‘T’) terminals transferring oil and petroleum products; roadsheds, bunkering and transfer sites of oil and oil products on the water (icon without anchor at the top of the circle); risk zones of accidents, defined for the whole year according to the federal and regional Oil Spill Response Plans (thick solid line), the area of accident risk, defined on the basis of HELCOM statistics and open publications in the press (thin dashed line).

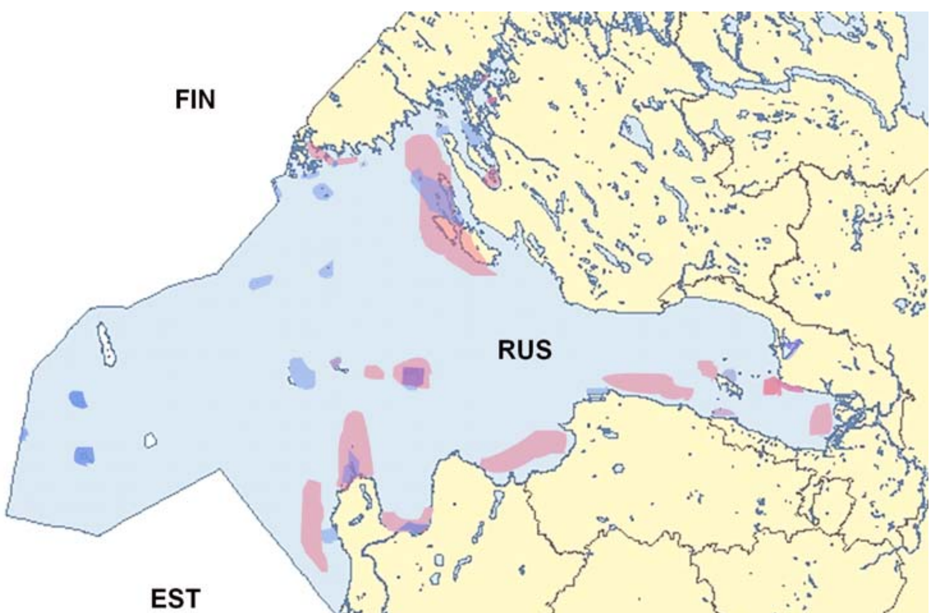


Fig. 4.12.2. Mass breeding areas (shown in blue), spring and autumn migration stop-overs (shown in red) of the water bird species in the Russian part of the Gulf of Finland.

It should be noted that both in winter and in summer the gulls can contaminate their feathers not only in the Gulf of Finland, but also on the landfills, which they use as the main place to gather food. Besides oil and petroleum products, there are other persistent pollutants, such as chemicals and dyes. In the Leningrad region, there additional coastal and inland sources of oil contamination for some species of gulls and ducks, besides landfills.

Apart from seagulls, the oil stained loons, grebes and individual long-tailed ducks were also found on random occasions in the Russian part of the Gulf of Finland. For the summer period partial oiling of less than 10% of all aquatic birds, mostly gulls can be expected. In most cases, oiled areas of feathers, feet, beak are small, less than one fifth of the body area. We have not ever observed any heavily oiled birds or birds corpses in the Russian part of the Gulf of Finland.

The proportion of oiled birds was determined visually, and not during modern direct counts and census of water birds and gulls. Annual work in the colonies, and mixed populations of seabirds, and observations of migratory flocks, constitute the basis for such approximate estimates. 10 percent level is high enough for water birds, but since the feather contamination mainly consists of small fragments, and is not fatal for most of the individuals, we can use this level as a 'good status indicator'. Herring gulls with partially oiled feathers are able to reproduce. It is expected to be true in the current population status. Yet the long-term prospects of a 10 percent contamination are unknown and possible reduction of reproductive success in local populations may lead to a slow decrease of abundance.

4.12.4. Usage of the indicator and the design of the monitoring

Only partial estimation of the basic indicator 'Proportion of seabirds being oiled' is possible within the Russian part of the Gulf of Finland - only for some areas and only for breeding and summering birds. The area from the Estonian border (the Narva estuary) to the cape Kolgompja including the Luga Bay with its extended port facilities could serve as a model area. To date, there are some base estimates of abundance of nesting birds on the coast and the islands of the Luga and Narva bays. The estimates of the number of water birds migrating in the region in summer are absent, but may be obtained in the current operating mode. The number of dead and dying birds found on the sandy shore can be estimated additionally on the 18-kilometer-long beach in the Narva Bay. Annual monitoring can be conducted in the period from April to September, with a five days periodicity, or daily in case of oil spills.

Since the Russian part of the Gulf of Finland has a primary value for migratory waterbirds, it is important to estimate the proportion of water birds affected by oil pollution in the period of spring stop-overs. Although the oil spill, and use of water for rest by migratory birds are relatively random phenomena, nevertheless, it is possible to determine the sites where these events can co-occur with high probability. The main sources of oil pollution are localized near terminals, ports, raids and fairways. Most migratory birds often use the same stop-over sites. The challenge is in identifying and delineating stop-overs, counting the number of migrants and assessing the likelihood of contamination based on proximity to the source of pollution and the predictive model of oil spills. This is not an easy task, however, given the exponential growth of the oil sector in the Kara, Barents and Baltic Seas, the status of migratory Arctic birds should be monitored along all the way from wintering to breeding sites.

The oil spill cases should be monitored in the Russian part of the Gulf of Finland simultaneously with standard field work through a network of public observers and public media. In the case of the oil accident, expert ornithologist visits the site. It is necessary - and feasible in the Leningrad region - to obtain the following indicators as a part of the monitoring program.

1. Real spatial position of the navigation accidents risk zones in the waters of the Russian part of the Gulf of Finland compared to the risk zones established by regional plan of the Russian Federation (LARN), taking into account existing accident statistics, vessel traffic and dynamics, the impact of meteorological conditions, etc.;

2. The frequency and volume of different types of oil spills arising from accidents of navigation, overload and bunkering at ports and roadsheds, ship discharges of oily water in the Gulf of Finland, which at present reach a few spills per hour of monitoring from aircraft;

3. The level of existing oil pollution and oil spill elimination units, negative impact of spills on seabirds nesting, feeding and resting in the waters of the Russian part of the Gulf of Finland, their vulnerability depending on the time of year and the type of the oil spill.

In spite of an absence of remarkable accidents with waterbirds being oiled, there is dangerous neighborhood of birds and their nesting places to the risk areas. It is illustrated below by several original photographs (figs. 4.12.3- 4.12.7). On the other hand these pictures demontrate succsseful co-existence of waterbirds with oil-operating sea-ports and with oil transportation routes.

Fig. 4.12.3. Colony of Lesser black-backed gulls (Larus fuscus) and nesting place of Common Eider (Somateria mollissima) in vicinities of Lukoil terminal in the Gulf of Vyborg (photo by V. Fedorov).

Fig. 4.12.4. Ust'-Luga oil terminal with numerous waterbirds on a sandbank (photo by V.Buzun).

Fig. 4.12.5. Stopover of migrating Common Goldeneye (*Bucephala clangula*) at the Ust'-Luga sea-port terminal (photo by V.Buzun).

Fig. 4.5.6. Route of tanker's traffic close to Virgin Islands – the nesting place of many waterbirds (photo by V. Buzun).

4.12.5. Proposal for monitoring

Work on monitoring the effects of oil pollution on birds can be performed by the laboratory of Vertebrate Zoology, Biological Faculty, St. Petersburg State University in the presence of targeted additional funding or state orders for such monitoring (and/or including of this indicator in the state monitoring program). Suggested duration of the works is 1-3 years or longer. The minimum group should include 2 ornithologist for field work and one volunteer for collecting materials on the overall situation of oil pollution in the Russian part of the Gulf of Finland, as well as for the simulation of vessel accidents and oil spills.

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4.13. ABUNDANCE OF KEY FISH SPECIES

4.13.1. Brief description of the indicator

The abundance of key species represents one of the CORE coastal fish indicators (HELCOM, 2012a). The indicator estimates the abundance of key fish species in Baltic Sea coastal areas, such as perch (*Perca fluviatilis*) or flounder (*Platichthys flesus*) depending on the monitoring area. Piscivorous species like perch have important structuring roles in coastal ecosystems in the Northern parts of the Baltic (Eriksson et al., 2009; 2011), and is a highly valued species for both small-scale coastal fisheries and recreational fishing in the coastal area (Swedish Board of Fisheries, 2011). As perch is recognized as being rather local in its appearance (Saulamo, Neumann, 2002), it is also used as model species in environmental monitoring programs of HELCOM.

4.13.2. Implementation of indicator in Russian waters of the Gulf of Finland

In Russian coastal waters perch is a key fish species indeed and distributed everywhere. Flounder in opposite is a very rare species because of a low salinity. Findings of flounder mostly were registered in the westernmost parts of Russian waters, closely to borders with Estonia and Finland. However flounder (*Platichthys flesus*) may survive in a fresh water, but according to historical data, the flounder never was registered to the east of Kotlin Island (Kronshtadt) in the Neva Bay (Berg, 1949). One specimen of flounder once was caught in the river Neva within the city St.-Petersburg, what is only existing observation (Antsulevich, unpublished data).
When speaking about these two key fish species in Baltic Sea coastal areas in frames of Russian part of the Gulf of Finland, only one (perch) may remain as a key species. An other additional key fish species may be chosen for Russia, however such other indicator species could be hardly comparable with other Baltic countries data.

4.13.3. State of the indicator in Russian waters of the Gulf of Finland

The eastern part of the Gulf of Finland having a relatively small area (about 12.5 thousand km^2) contains a set of highly complex ecosystems that differ in both structural and functional characteristics, as well as in the influence of abiotic factors. The properties of a natural habitat of aquatic organisms are set by the highly complex coastline, creating a few isolated areas (the Luga, Koporskaya, Neva, and Vyborg Bays, the coastal area, the deep-water area). The main rivers flowing into the bay (the Neva, Luga, Narva and other rivers) determine it as a transition region from freshwater to brackish water. The water salinity changes from from 0.2 ppm in the east to 7.6 ppm in the west of the bay. The depth vary in the same direction - from the shallow water near the river mouths to 60-70 m near the island of Gogland - thus forming shallow coastal and deep-water areas with their specific biocenoses.

The variety of habitats determines the differences in the structure of local fish communities. Therefore, fish monitoring is carried out usually across all the Gulf of Finland - along the north and south coasts and in the Neva Bay.

4.13.4. Materials and methods

Monitoring is carried out mainly by the forces of the State Institute of Lake and River Fisheries, and also with the participation of St.-Petersburg University. Limited resources - material and technical resources and the number of research groups does not allow to monitor all areas of the Russian part of the Gulf of Finland within one season (year). A complete survey of the waters usually takes several seasons. The material was collected using different fishing gears.

To study the coastal fish communities) we used the beach seine, with wings of equal length: length - 30 meters, working height - 2 meters, the mesh size in the codend - 6 mm, catchability coefficient - 0.3, fishing area - 0.0675 hectares (675 m^{-2}). Its design is reminiscent of the manually operable trawl (figs. 4.13.1 - 4.13.2). The depth range was 2.5 - 0.5 m With a very steep slope of the sea bed of the Russian part of the Gulf of Finland, this instrument is widely used on large areas of shallow water and gives good results. The small mesh size also allows to account for the small sized fish and juveniles, which cannot be caught in gillnets (fig. 4.13.3).

Fig. 4.13.1. A research beach seine (the Luga Bay; photo by A.Antsulevich)

Fig. 4.13.2. A beach seine in preparation to research catch (the Neva Bay, Petergof; photo by N.Antsulevich)

Fig. 4.13.3. One catch by a beach seine on sandy bottom (the Gulf of Finland, Repino; photo by A.Antsulevich)

In the study of deeper and less accessible areas the bottom-set combined gillnets were used as a fishing gear (length - 48 meters, height - 1.8 meters, a set of gears with mesh size 12 - 60 mm, catchability coefficient - 0.3) and the standard bottom-set nets with a mesh of 30-40 mm. Exposure time was 10-16 hours, mostly during the night. The method of using multimesh gillnets (Appelberg, 2000) guarantees the estimate of the total species composition of fish fauna, the quantitative values of the relative density and biomass, and size structure of fish communities in temperate waters (Fig. 4). Each net comprises a set of gears with the mesh size 12, 15, 20, 25, 30, 35, 45 and 60 mm, placed in random order. Exposure time is typically 12 hours in the night from 20^{00}-21^{00} to 8^{00}-9^{00}.

Fig. 4.13.4. A combined gill-net (the Gulf of Finland, Bjerke Zund; photo by A.Yakovlev)

This method is commonly used in national and regional programs for fisheries research in Sweden (SEPA 1995). Testing of the method in the eastern part of the Gulf of Finland was carried out under the supervision of experts from the Finnish Game and Fisheries Research Institute as a part of collaborative research (Lappalainen, Shurukhin *et al,* 2000). Additionaly, the set nets were used with one of a mesh sizes from 20 to 70 mm, with a height of 1.8-3.0 m.

For the study of pelagic and demersal fish in the open part of the bay (at depths of 7 feet or more), we used a bottom trawl 27 m to 15 m, working height - 5.8 m, with a mesh size of 8 mm in the codend and catchability coefficient - 0.3. Standard trawl survey suggested an hour trawling at the towing speed of 2.5 knots, with a wing spread of 12-15 m, over a fishing area of 5.4 ha. In the open part of the bay, the pelagic trawl was used usually utilized for fishing herring and sprat in the waters of the Gulf of Finland. Fish surveys in the southern part of the Gulf of Finland were carried out with the support of the Russian enterprise RosMorPort, and in the northern part - with the support of the international corporation «NordStream AG».

4.13.5. The southern part of the Gulf of Finland (the Luga Bay)

The Luga Bay until last several years was an example of a relatively stable ecosystem, little prone to human impact. The absence of major population centers, heavy boat traffic and industrial construction assumed the local biocenoses to be in a relatively stable state.

The fish fauna of the bay is formed by freshwater and brackish-water species. Regular research on the state of the fish fauna of the bay has been carried out since the mid '90s.Then, 34 species of fish and lamprey were noted in a fish community. Fish productivity in coastal waters was 200 kg/ha. Deep-water area of the bay is less productive compared to the coastal zone, but compared to the other areas of the Gulf of Finland it was assessed as highly productive (fish biomass up to 60 kg/ha). Change of the Luga bay status and its transformation into an industrial node has caused a change in the structure of its communities, including fish.

Regular ichthyological studies (fig. 4.13.5) of the bay were carried out between 2003-2012, and most intensively in 2009-2010. This was due to the implementation of the project of a major port complex and the research was largely carried out by request and at the expense of its investors.

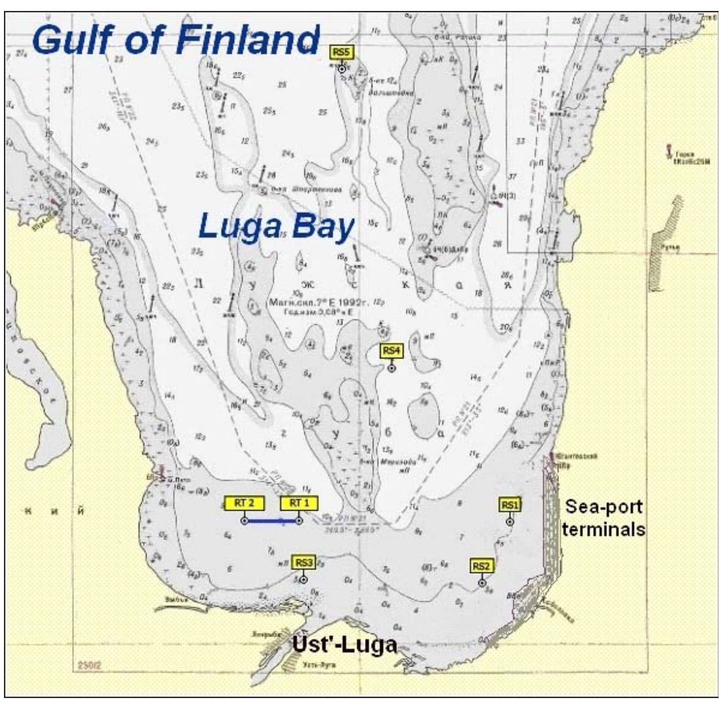


Fig. 5. Locations of sampling stations in the Luga Bay in 2003-2012

Under the influence of fresh water of the Luga river the fish fauna was dominated by freshwater species - ruffe, perch, silver bream, bleak, bream. But the main inhabitant of the littoral zone, especially in the first period of the growing season, was three-spined stickleback. Later (in the middle of the summer and closer to the autumn), the species from the carp family - bream, silver bream, bleak and roach - became dominant. In general, during all period of observations (2003-2012) in the Luga Bay 25 species form 11 families and lamprey were registered (Table 4.13.1).

It should be noted that this species list did not include salmon, which is usually caught by specialized teams, their materials were not taken into account.

Table 4.13.1. Species composition of fish community of the Luga Bay in 1994-2010

Fam. Petromyzontidae *Lampetra fluviatilis* (L.) - lamprey
Fam. Clupeidae *Clupea harengus membras* (L.) – baltic herring *Spratus spratus* (L.) - sprat
Fam. Coregonidae *Coregonus lavaretus* (L.) - white fish *Coregonus albula* (L.) - vendace
Fam. Osmeridae *Osmerus eperlanus* (L.) - eperlan smelt
Fam. Esocidae *Esox lucius* (L.) - pike
Fam. Cyprinidae *Rutilus rutilus* (L.) - roach *Abramis brama* (L.) - bream *Blicca bjorkna* (L.) - silver bream *Vimba vimba* (L.) - vimba *Pelecus cultratus* (L.) - rasor fish *Alburnus alburnus* (L.) - bleak *Gobio gobio* (L.) - gudgeon *Leuciscus leuciscus* (L.) - dace *Leucaspius delineatus* (Heckel) - belica *Leuciscus idus* (L.) - orfe
Fam. Gadidae *Lota lota* (L.) - burbot
Fam. Gasterosteidae *Gasterosteus aculeatus* (L.) - three-spined stickleback *Pungitius pungitius* (L.) - nine-spined stickleback
Fam. Percidae *Perca fluviatilis* (L.) - perch *Gymnocephalus cernua* (L.) - ruffe *Stizostedion lucioperca* (L.) - pike-perch
Fam. Gobiidae *Pomatoschistus minutus* (Pallas) – little goby
Fam. Zoarcidae *Zoarces viviparus* (L.) - eel-pout
Fam. Pleuronectidae *Platichthys flesus flesus* (L.) – plaice (river flat fish)

In the southern shallow zone, the eastern and western regions were distinct in terms of fish abundance. Until recently, the eastern region was much richer than the western (on average abundance was 4 times and biomass - 6 times higher). During the season, on average, biomass of fish reached the highest values (210 kg/ha) in this area.

The deeper region was dominated by the brackish water species, there was also a high proportion of marine species. The key species (fish species with more than 50% occurrence) included baltic herring, eperlan smelt and three-spined stickleback. In recent years, quantitative indicators of the state of the fish communities decreased and their seasonal dynamics changed. The highest abundance and biomass and, in some years (2004, 2007, 2008), comparable with the '90s, was observed is in May and June - the period of spawning migrations of fish; later in summer and autumn, they were less by an order of magnitude.

Extremely low values were observed in 2006 The average abundance for the season was 0.2 thousand ind./ha, biomass - 8.8 kg/ha. After a slight increase of these indicators in 2007 and 2008, in 2009 they decreased again, reaching 0.1 of the background values. A similar pattern was observed in the central part of the bay.

At the same time, the quantitative indicators of the fish communities in the area west of the Luga river mouth (except in 2006), were not only comparable to background rates of 1994-97, but in some years exceeded them several times (Shurukhin et al, 2010).

Seasonal dynamics of spawning and feeding migrations of fish remains a major factor in shaping the local fish community that forces to carry out fishing at least three times a year - in spring, summer and autumn - for complete and accurate information.

For example, in the late spring - early summer, the main contribution to abundance and biomass of fish in the coastal stations was usually made by representatives of the perch family - ruffe, pike-perch and perch made up 70-80% of the population and 80-95% of the fish biomass (Table 4.13.2).

Table 4.13.2. Abundance *(N,* ind./ha) and biomass *(B,* kg/ha) of fish in the Luga Bay (end of May 2009).

Fish species	Coastal stations						Stations at bottom ground dumping area				Trawl station RT1-RT2	
	RS1		RS2		RS3		RS4		RS5			
	N	***B***	***N***	***B***	***N***	***B***	***N***	***B***	***N***	***B***	***N***	***B***
Perch	**221**	**18,4**	18	2,4	**73**	**5,9**	53	3,5	68	2,9	77	5,9
Pike-pearch	55	2,7	-	-	36	2,0	-	-	51	3,7	5	0,5
Ruffe	**184**	**6,9**	**128**	**8,6**	**294**	**15,4**	**268**	**15,0**	**408**	**17,5**	31	1,7
Roach	-	-	-	-	-	-	-	-	17	1,3	22	1,1
Bream	-	-	-	-	-	-	-	-	17	6,8	38	7,7
Silver-bream	55	1,6	-	-	36	0,9	-	-	17	0,3	127	5,5
Balt. herring	55	0,7	36	0,5	55	0,7	143	1,7	34	0,3	**1867**	**22,3**
Sprat	-	-	-	-	-	-	17	0,1	-	-	**3442**	**18,8**
White fish	-	-	-	-	-	-	-	-	-	-	2	0,02
Smelt	36	0,5	-	-	92	2,9	215	4,6	**544**	**14,4**	9	0,1
Stickleb.-3	-	-	-	-	-	-	-	-	-	-	622	1,7
Vimba	18	3,5	-	-	-	-	-	-	51	2,7	-	-
Plaice	-	-	-	-	-	-	-	-	-	-	2	0,1
TOTAL	**624**	**34,3**	**182**	**11,5**	**586**	**27,8**	**696**	**24,8**	**1107**	**50,3**	**6244**	**65,5**

The deep-water zone (the trawl station) was dominated by the marine species - baltic herring and sprat, which formed 83% of the total population and 58% of the total biomass of fish in the area.

In the bottom ground dumping area located in the intermediate zone - under the influence of the Luga river runoff and salt water - the smelt (31% of the total catch) and baltic herring (21%) were plentiful. The most abundant fish in the catch were ruffe (42%) and smelt (21%), while ruffe (55%) prevailed by biomass.

The maximum density of fish population was observed during this period in the western (the trawl station) and in the bottom ground dumping areas, which was very different from the results of similar surveys in 2008, when the maximum fish biomass had been observed in the shallow areas of the eastern parts of the bay. At that time in the bottom ground dumping area the fish population abundance had been much lower.

In the middle of the growing season (July) the fish density dynamics at the survey field sites is usually changing. Thus, in the south-eastern part of the bay, in shallow water, the abundance and biomass were nearly three times higher in May than in July. In the western sector of the bay (the trawl station) with a 1.5-fold decrease in the relative abundance of fish, their relative biomass remained almost unchanged (Table 4.13.3).

Table 4.13.3. Abundance *(N,* ind./ha) and biomass *(B,* kg/ha) of fish in the Luga Bay (July 2009)

Fish species	Coastal stations						Stations at bottom ground dumping area				Trawl station RT1-RT2	
	RS1		RS2		RS3		RS4		RS5			
	N	***B***	***N***	***B***	***N***	***B***	***N***	***B***	***N***	***B***	***N***	***B***
Perch	34	1,7	0,0	0,0	20	0,8	98,0	5,4	51	2,5	25	1,1
Pike-pearch	-	-	18	5,2	0,0	0,0	140,0	10,5	-	-	27	4,1
Ruffe	155	4,5	276	9,8	143	2,9	223,0	4,9	446	20,1	617	15,0
Roach	34	3,6	37	4,4	61	7,3	139,0	10,8	115	13,4	58	1,7
Bream	34	2,8	18	2,0	-	-	-	-	-	-	5	0,7
Silver-bream	-	-	55	2,6	61	4,7	223,0	4,6	179	5,6	231	9,6
Balt. herring	-	-	-	-	-	-	42,0	0,8	230	5,5	2332	25,6
Sprat	-	-	-	-	-	-	-	-	13	0,1	231	1,2
Smelt	-	-	-	-	-	-	42,0	0,6	13	0,3	366	3,9
Lamprey	-	-	-	-	-	-	-	-	-	-	1	0,1
Stickleb.-3	-	-	-	-	-	-	-	-	-	-	289	1,0
Stickleb.-9	-	-	-	-	-	-	-	-	-	-	77	0,2
Eel-pout	-	-	-	-	-	-	-	-	-	-	77	1,2
Vimba	-	-	37	11,1	20	4,9	-	-	51	7,5	2	0,8
TOTAL	**257**	**12,6**	**441**	**35,1**	**305**	**20,6**	**907**	**37,6**	**1098**	**55,0**	**4336**	**66,2**

Some changes have occurred in the ratio of fish species in different parts of the research area.
In the coastal zone, the share of the carp species (mainly silver bream and roach) increased, the number of the pike-perch near the bottom ground dumping area risen dramatically. In the western part (the trawl site) the sprat virtually disappeared from the catches. In general, as before, the ruffe dominated almost the entire research area and the baltic herring was abundant along the west coast.

At the coastal stations the ruffe share was up to 60% by number and 36% by biomass, the fish from the carp family (bream and roach) - 26% by number and 51% by biomass.
In the bottom ground dumping area the proportion of the carp and perch fishes was about 40%. Along the western coast the greatest values of number and biomass belonged to the baltic herring - 54 and 25%, respectively.

In autumn (October), the fish community structure stabilized, but some changes were still visible. In the shallow zone, the abundance and biomass were at the level of July, in general. The species composition changed little - the fishes from the perch family dominated (over 70%). But in the area of the bottom ground dumping at one of the stations the overall abundance halved, the biomass - decreased 1.5 times, and on the other - the abundance fell by more than 4 times, biomass - more than two times, with 30% accounted for the baltic herring . Species diversity in October was extremely low. At coastal stations fish fauna was represented by two species from the perch and carp families, and in the bottom ground dumping area in addition by the baltic herring and smelt (Table 4.13.4).

Table 4.13.4. Abundance *(N,* ind./ha) and biomass *(B,* kg/ha) of fish in the Luga Bay (end of October 2009).

Fish species	Coastal stations						Stations at bottom ground dumping area			
	RS1		RS2		RS3		RS4		RS5	
	N	***B***	***N***	***B***	***N***	***B***	***N***	***B***	***N***	***B***
Perch	45	2,4	29	1,2	59	4,8	42	3,0	-	-
Pike-perch	15	1,1	15	1,5	0,0	0,0	57	4,3	40	15,9
Ruffe	120	3,6	177	5,3	250	8,8	128	4,1	93	3,3
Roach	60	4,9	59	4,1	103	6,0	128	5,7	-	-
Bream	-	-	-	-	15	1,4	-	-	-	-
Silver-bream	15	0,6	44	2,8	59	3,8	42	2,4	-	-
B.herring	-	-	-	-	-	-	28	0,6	79	1,4
Smelt	-	-	-	-	-	-	14	0,1	39	0,6
Vimba	-	-	15	1,2	29	2,2	14	1,4	-	-
TOTAL	**255**	**12,6**	**339**	**16,1**	**515**	**27**	**453**	**21,6**	**251**	**21,2**

To evaluate the changes of the fish community we can compare the rates of development in recent years with background level for 1994-97, when large-scale hydrotechnical works have not yet started (Table 4.13.5).

Table 4.13.5. Abundance *(N,* thous.ind./ha), biomass *(B,* kg/ha) and number of fish species *(S)* in the Luga Bay during navigation period (May-November) by years

	May-June			July			August			September			Octob.-Novemb.		
Years	N	B	S	N	B	S	N	B	S	N	B	S	N	B	S
Southern shallow water zone to the east from river Luga mouth*															
1994-97	2,1	**79,8**	6	6,4	**310,0**	10	3,5	**293,4**	8	0,2	**13,8**	4	-	-	-
2004	1,3	**63,4**	8	1,0	**52,8**	6	-	**-**	-	0,6	**8,3**	5	1,8	**67,6**	10
2006	0,1	**1,9**	5	0,6	**18,5**	9	0,1	**10,3**	7	-	**-**	-	0,1	**4,6**	5
2007	2,1	**97,0**	10	-	-	-	-	**-**		0,1	**4,8**	8	0,1	**4,1**	7
2008	1,8	**90,1**	7	-	**-**	-	0,8	**45,2**	7	-	**-**	-	0,3	**9,9**	6
2009	0,5	**24,5**	7	0,3	**22,8**	7	-	**-**	-	-	**-**	-	0,4	**18,6**	6
Southern shallow water zone to the west from river Luga mouth															
1994-97	0,3	**11,5**	3	1,8	**57,1**	7	0,5	**35,8**	5	0,2	**13,6**	2	-	-	-
2006	1,1	**19,5**	8	0,3	**19,3**	8	0,7	**23,8**	12	-	**-**	-	8,9	**138,8**	15
2007	3,9	**35,1**	10	-	**-**	-	-	**-**	-	0,8	**13,1**	7	4,7	**74,4**	9
2008	7,6	**117,6**	6	-	**-**	-	4,1	**192,1**	14	-	**-**	-	20,1	**601,9**	14
2009	2,7	**46,8**	13	6,3	**52,9**	14	-	**-**	-	-	**-**	-	0,4	**21,4**	8

*** - area of hydrotechnical works**

In 2010, a somewhat different picture of the fish population distribution was observed in the Luga Bay (Tables 4.13.6 – 4.13.7). The maximum concentrations of fish at the beginning of the summer were noted in the western area (the trawl station) and in the bottom ground damping area, which was very different from the results of similar surveys in 2009, when the maximum fish biomass had been observed on the eastern shallow water mouth (stations 1-3). At that time, in the bottom ground dumping area the abundance of the fish population had been much lower.

Table 4.13.6. Abundance *(N,* ind./ha) and biomass *(B,* kg/ha) of fish in the Luga Bay (June 2010).

Fish species	Coastal stations						Stations at bottom ground dumping area				Trawl station RT1-RT2	
	RS1		RS2		RS3		RS4		RS5			
	N	***B***	***N***	***B***	***N***	***B***	***N***	***B***	***N***	***B***	***N***	***B***
Perch	334,5	24,37	501,7	47,018	821,4	89,06	25,3	3,03			39,5	1,6
Pike-perch	23,9	0,86	0,0	0,000	0,0	0,00	50,5	11,36	55,2	13,81		
Ruffe	692,8	28,19	238,9	10,464	492,8	20,53	227,3	10,13			10,7	0,38
Roach	47,8	3,63	0,0	0,000	0,0	0,00						
Bream											1,6	0,123
Bleak					23,5	0,37					22,2	0,345
Silver-bream	119,5	2,48	0,0	0,000	23,5	0,65						
B. herring							50,5	0,76	165,7	3,32	766,7	18,9
Smelt	23,9	0,52					50,5	0,75	82,9	1,38	209,9	2,88
Stickle.-3			47,8	0,191							76,5	0,18
Orfe					23,5	6,689						
TOTAL	**1242,3**	**60,06**	**788,4**	**57,67**	**1384,6**	**117,32**	**404,1**	**26,01**	**303,9**	**18,51**	**1127,2**	**24,48**

In the middle of the growing season, dynamics of changes in the density of the fish population at the survey sites varied. Thus, in the south-eastern coastal part of the bay, the population and biomass were almost three times lower than in the spring, and in the bottom ground damping area along with relatively constant abundance, the biomass was almost twice as high. In the western sector of the bay (the trawl station) with a decrease in the number of fish their relative biomass remained almost unchanged (Table 4.13.7).

Table 4.13.7. Abundance *(N,* ind./ha) and biomass *(B,* kg/ha) of fish in the Luga Bay (August 2010).

Fish species	Coastal stations						Stations at bottom ground dumping area				Trawl station RT1-RT2	
	RS1		RS2		RS3		RS4		RS5			
	N	***B***	***N***	***B***	***N***	***B***	***N***	***B***	***N***	***B***	***N***	***B***
Perch	46,5	3,5	18,2	5,8	98,2	11,3	63,1	8,7	78,9	8,3	37,0	2,5
Pike-perch	23,3	28,1	-	-	-	-	-	-	-	-	7,4	1,0
Ruffe	23,3	0,9	144,7	4,3	171,9	5,4	78,9	1,9	63,1	3,6	1,9	0,02
Roach	116,3	17,0	48,2	6,8	73,7	10,8	31,6	4,7	78,9	11,4	83,3	9,9
Bream	69,8	6,5	24,1	1,2	73,7	8,1	-	-	31,6	5,8	51,9	6,9
Silver-bream	69,8	5,4	-	-	-	-	299,9	23,8	126,3	10,7	11,1	0,4
B. herring	-	-	-	-	-	-	-	-	-	-	351,9	7,5
Sprat	-	-	-	-	-	-	-	-	-	-	3,7	0,03
Smelt	-	-	24,1	0,4	-	-	-	-	-	-	14,8	0,17
Vendace	-	-	24,1	0,7	-	-	-	-	-	-	1,9	0,04
Stickle.-3	-	-	-	-	-	-	-	-	-	-	44,4	0,12
Rasor fish	-	-	-	-	-	-	-	-	-	-	1,9	0,03
TOTAL	**348,9**	**61,4**	**313,4**	**19,2**	**442,0**	**39,5**	**489,3**	**42,3**	**378,8**	**39,9**	**611,1**	**28,5**

Some changes have occurred in the ratio of fish species in different parts of the waters.
In the coastal area, the share of carp fish (mainly silver bream, roach, bream) in the bottom ground dumping area the number of perch and ruffe dramatically increased with a maximum of abundance and

biomass created by the silver bream. The western sector (the trawling zone) was dominated by the baltic herring, and the carp fishes - roach and bream. In general, as before, the perch and roach dominated almost the entire research area and a significant amount of the baltic herring was present along the west coast.

As can be seen from the above data in recent years in the area of hydrotechnical works (southern shallow area east of the mouth of the Luga river) the observed dynamics of the basic parameters of fish communities varied, some of the parameters were comparable in some periods, others differed sharply. (Reports of the State Institute of Lake and River Fisheries, 2009, 2010).
The example of the most intensive studies in 2009 and 2010 evidence that the previously observed tendency of a certain degradation of the bay fishery has been preserved.

4.13.6. The northern part of the Gulf of Finland (the Vyborg Bay on the example of the Portovaya bight and adjacent areas).

The Portovaya bight, located in the Vyborg bay, is the starting point of the offshore section of the North European gas pipeline «Nord Stream».This area is characterized by a highly productive fish community composition comprising valuable protected species (salmon), as well as the commercial species (baltic herring, smelt, and others). The presence of spawning and feeding grounds together ensures a high fish productivity of this area of Gulf of Finland, and as a consequence gives it great commercial importance. Considering that a year ago the supply of gas started through the pipeline, and this year the second line is launched, the control of the environment (including the fish community) becomes even more important.

Materials and methods. The multimesh gillnets were used to study the fish fauna (Appelberg, 2000). At each station the fishing gears were set two times.
Control trawling surveys along the gas pipeline in the deep-water area were conducted at four sites from the island Malyj Fiskar to the island of Hogland. The standard trawl commonly applied in the pelagic fisheries in the Gulf of Finland was used.

For each catch the mass, number, species and size composition were measured, and the group and individual weighing were performed. The following indicators were used In the analysis of the fishing results:

- S - number of species found in the catch;
- B - relative biomass of fish (kg) per unit of fishing effort - the catch in a given period of time,
- N - relative abundance of fish (ind.), calculated per unit of fishing effort - the catch for a certain period of time, occurrence (%) of fish species;

structural indices: D - indicator of dominance, E - evenness sensu Piel, H - Shannon index of species diversity.These indices of species diversity integrally assess the condition of the fish communities. Communities with stable conditions are characterized by high levels of H and E, but low rates of D. $D = (S - 1)/lgN$, where S - number of species, N - number of individuals; $D = \sum (n_i/N)^2$; $H = - \sum n_i/ N \log(n_i/N) = \sum n_i/ N \cdot 1,443 \cdot \ln(n_i/N)$, where n_i - estimate of the importance of each species, N - total importance; $E = H/\log S$, where H - Shannon index, S - number of species. Research net fishing was carried out at 9 coastal stations located throughout the waters of the bay (fig. 4.13.6). Trawl station were taken offshore by the way of underwater pipe-line.

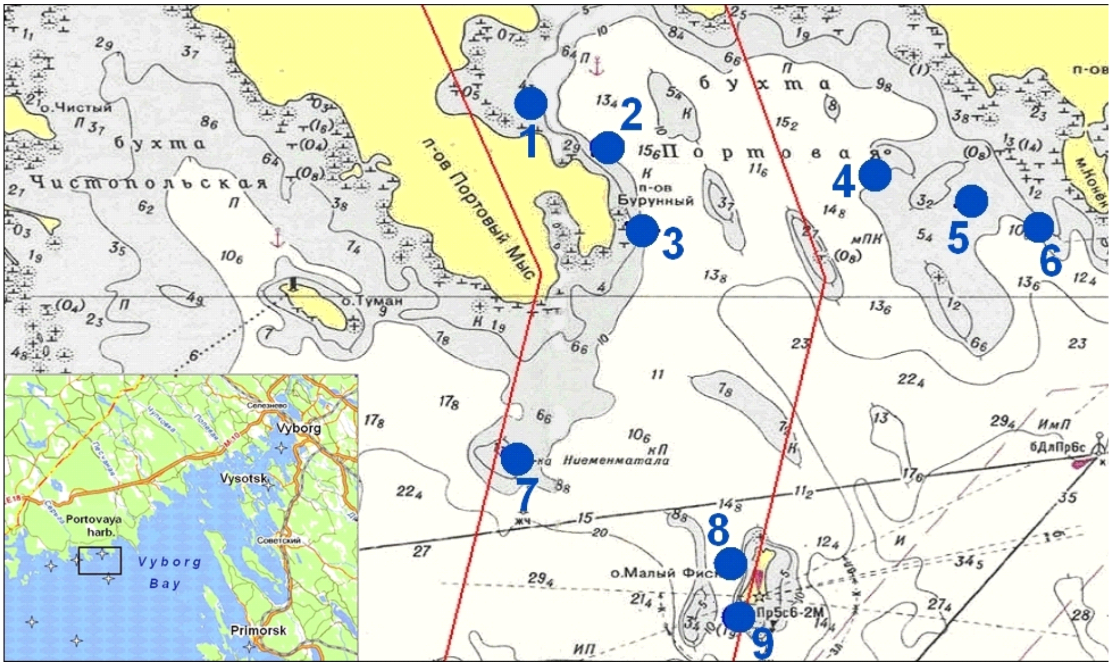


Fig. 4.13.6. Research stations (1-9) position. Vyborg bay, Portovaya bight.

Results. The fish population of the Portovaya bight has a mixed composition. In the presence of native freshwater fish fauna, during certain periods (spring, fall) herring, sprat, smelt, whitefish and lampreys also appear.

Fish surveys gave an opportunity to assess the state of fish communities at the beginning and end of the growing season in different parts of the Portovaya bay, as well as to determine the qualitative and quantitative composition of fish fauna along the route of the gas pipeline in deep-water area.

Fish surveys were conducted in June, August and September 2012. As a result of the surveys 16 species of fish belonging to 6 families were recorded (Tables 4.13.8, 4.13.9).

Table 4.13.8. The species composition of the fish population

Fam. Cyprinidae
Rutilus rutilus (L.) - roach
Alburnus alburnus (L.) - bleak
Blicca bjorkna (L.) – silver bream
Abramis brama (L.) - bream
Scardinius erythrophthalmus (L.) - redeye
Leuciscus leuciscus (L.) - dace
Vimba vimba (L.) - vimba
Fam. Percidae
Perca fluviatilis (L.) - perch
Stizostedion lucioperca (L.) - pike-perch
Gymnocephalus cernua (L.) - ruffe
Fam. Clupeidae *Clupea harengus membras* L. – baltic herring
Sprattus sprattus baltica (Schneider) - sprat
Fam. Coregonidae
Coregonus albula (L.) - vendace
Coregonus lavaretus lavaretus (L.) – white fish
Fam. Osmeridae *Osmerus eperlanus* (L.) - smelt
Fam. Gasterosteidae *Gasterosteus aculeatus* (L.) - three-spined stickleback

Several species were the main contributors to abundance and biomass in the Portovaya bay: bream, roach (stations 1-4, 6) from the carp family, perch (stations 8, 9) and vendace (one of the dominant species at the end of the summer at the station 7). Baltic herring was plentiful at stations 6, 7, 8 and 9, located both on the outside and inside part of the bay, but it never dominated there (Table 4.13.9). At the deep-water (trawl) stations four species of fish were observed: baltic herring, sprat, smelt, three-spined stickleback. The dominant species was herring accounting for 88% by number and 96% by biomass.

Table 4.13.9. Dominant species of fish in the gillnet catch in 2012

Station No	June	August
1	Bream	Roach
2	Roach	Roach
3	Roach	Bream
4	Bream	Bream
5	Perch	Roach
6	Roach	Bream
7	Perch	Vendace
8	Perch	Perch
9	Perch	Perch

June. During this period, the number and biomass of fish, and the pattern of distribution are largely determined by their spawning and post-spawning migrations.

Fish fauna of the surveyed area consisted of 10 species belonging to four families: perch (perch, pike-perch, ruffe), carp (roach, silver bream, bream, bleak), herring (baltic herring, sprat), smelt (smelt) (Table 4.13.10). The share of baltic herring in the deep-water (trawl) catches was 90% by number. In the coastal zone the catch was dominated by representatives of the carp (roach, bream) and perch families (perch).

Table 4.13.10. The species composition of fish fauna in June

Fam. Osmeridae
Osmerus eperlanus (L.) - smelt
Fam. Cyprinidae
Rutilus rutilus (L.) - roach
Alburnus alburnus (L.) - bleak
Blicca bjorkna (L.) – silver bream
Abramis brama (L.) - bream
Fam. Percidae
Stizostedion lucioperca (L.) – pike-perch
Perca fluviatilis L. - perch
Gymnocephalus cerna (L.) - ruffe
Fam. Clupeidae
Clupea harengus membras L. – baltic herring
Sprattus sprattus baltica (Schneider) - sprat

The analysis revealed that the number of species in fish communities tended to decrease, compared to previous years. It should be also noted that the species from the whitefish family and the lampreys were absent in the spring surveys.

The species dominant by number were the roach, the bream, and the perch. They also were the main contributors to the biomass, as well as silver bream, and ruffe (Fig. 4.13.7 and Table 4.13.10). The baltic herring and the smelt were represented in the catches by single specimens. The bleak was common in the catches at the coastal stations. The species from the whitefish family were absent. The ratio of the number and biomass at individual stations is given in Figures 4.13.8 – 4.13.9 and Table 4.13.12.

Fig. 4.13.7. A sample of ruffe on scales (photo by A.Yakovlev)

Structural indices allow an integrated assessment of the community. Communities with stable conditions have high levels of H and E, but low rates of D (Table 4.13.11). In June, the fish community in the Protovaya bay area was characterized by relatively high stability.

Table 4.13.11. Structural indicators of the fish communities in June (Vyborg Bay)

S	D		H		E	
	by N	by B	by N	by B	by N	by B
9	1,791	0,006	2,209	2,199	0,487	0,566

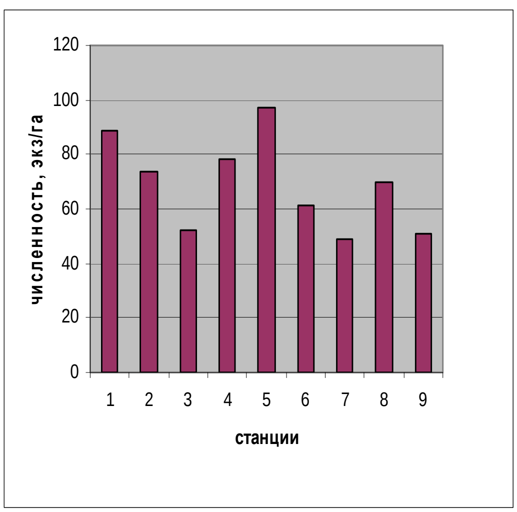


Fig. 4.13.8. The total number of fish in June.

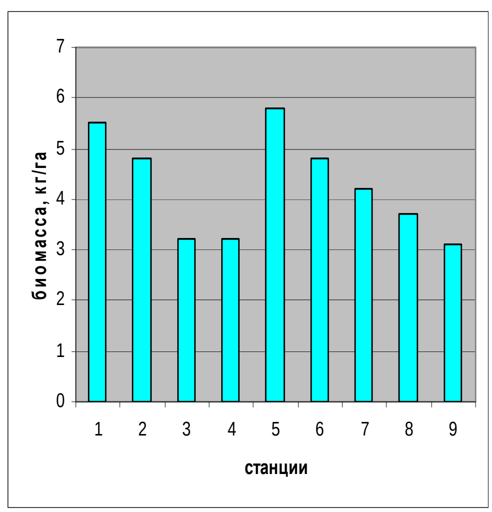


Fig. 4.13.9. The total biomass of fish in June.

Table 4.13.12. Number (N, ind./ha) and biomass (in kg/ha) of fish in June (Vyborg Bay)

Fish species	Station 1		Station 2		Station 3		Station 4	
	N	B	N	B	N	B	N	B
Perch	11	1,5	7	1,1	9	1,1	14	0,5
Ruffe	7	0,2	13	0,3	4	0,1	11	0,3
Roach	22	0,8	33	1,7	24	1,0	20	0,7
Bleak	3	0,1	2	0,1	2	0,1	6	0,1
Silver bream	14	0,3	4	0,1	4	0,4	9	0,3
Pike-perch	-	-	1	0,2	-	-	4	0,7
Bream	32	2,6	14	1,3	8	0,4	12	0,5
Baltic herring	-	-	-	-	-	-	2	0,1
Smelt	-	-	-	-	1	0,1	-	-
Total	89	5,5	74	4,8	52	3,2	78	3,2

Table 4.13.12 (continued)

Fish species	Station 5		Station 6		Station 7		Station 8		Station 9	
	N	B	N	B	N	B	N	B	N	B
Perch	49	3,5	12	0,7	16	1,4	19	1,7	17	1,5
Ruffe	12	0,3	-	-	7	0,2	2	0,1	3	0,1
Roach	16	0,9	28	2,2	10	0,8	15	1,1	5	0,2
Bleak	2	0,1	4	0,1	2	0,1	2	0,1	1	0,1
Silver bream	9	0,2	7	0,2	6	0,4	8	0,2	-	-
Pike-perch	3	0,5	5	1,2	1	0,2	2	0,1	3	0,6
Bream	1	0,1	3	0,3	3	1,0	-	-	1	0,2
Baltic herring	3	0,1	2	0,1	4	0,1	12	0,2	17	0,3
Smelt	2	0,1		-	1	0,1	10	0,2	4	0,1
Total	97	5,8	61	4,8	50	4,3	70	3,7	51	3,1

In spite of pike is actually common fish in the Vyborg Bay none specimen of pike was caught in coastal stations of Predportovaya harbor. In deep-water zone the fish fauna was represented by three species: baltic herring, sprat and smelt. The relative abundance and biomass of these species is reported from the trawl surveys (Table 4.13.13).

Table 4.13.13. Number (N, ind./ha) and biomass (B, kg/ha) of fish from the trawl surveys in June.

Species	1		2		3		4	
	N	B	N	B	N	B	N	B
herring	401	7,7	547	8,0	397	7,0	508	7,2
sprat	188	1,5	223	1,3	145	0,9	148	1,0
smelt	41	0,02	7	0,01	11	0,01	16	0,01

August.

During this period, the number and biomass of fish, and the pattern of distribution are mainly determined by the feeding and spawning (for the fall-spawning species) migrations.

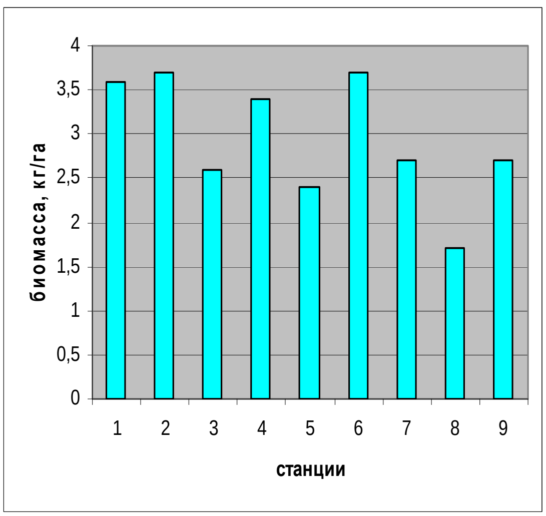
The fish fauna of coastal habitats, like in the corresponding period of the previous year, was represented by 14 species. At most stations the dominant species in numbers were the bream, roach and perch. Vendace dominated at one station (№ 7). At the deeper stations the main contribution to the biomass was made by perch, while at the coastal stations - roach and bream (Table 4.13.15). This period of the growing season is usually marked by intense feeding of juveniles and adults of almost all species of fish. It is also the time when the fish concentrates in the feeding area and the first pre-spawning aggregations form for the fall-spawning species (from the whitefish and salmon families). Species diversity was quite high. In the catches, the species from the whitefish family were reported (white fish and vendace) as well as dace, redeye, and vimba. The fish families were represented in the area almost proportionately: carp - 7 species, perch - 3 species, whitefish - 2 species, herring and smelt - 1 species each (figs. 4.13.10 – 4.13.11). While the first two families are permanent residents of coastal habitats, the others appear mostly seasonally.

Structural indicators - high ***H*** and ***E,*** and low ***D*** - characterized the community state as stable (Table 4.13.14). In August, the fish community in the area has relatively high stability.

Abundance and biomass at various stations are highly variable during the growing season and depend, as a rule, on the hydrological and meteorological conditions (temperature, wind direction and strength, etc.). In addition, the spawning migrations of the whitefish and vendace and feeding migrations of baltic herring were observed near the Portovaya bay. At the same time, some carp (bream) and perch (large specimens of perch, pike-perch) moved to deeper sites in the open part of the Gulf.

Table 4.13.14. Structural indicators of the fish community in August

S	D		H		E	
	by N	by B	by N	by B	by N	by B
14	2,18	0,007	2,327	2,599	0,688	0,739



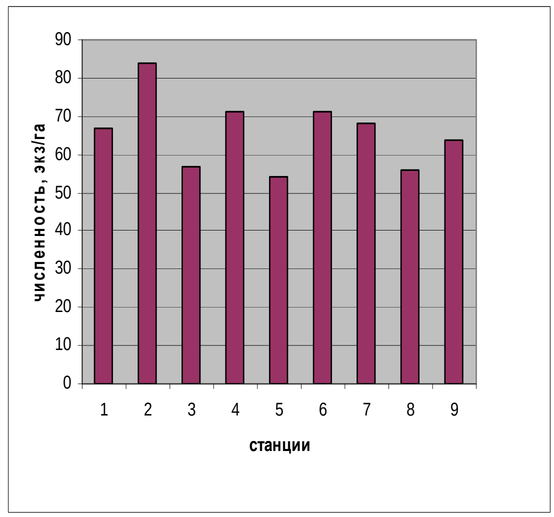


Fig. 4.13.10. The biomass of fish in August. Fig. 4.13.11. The number of fish in August (by nine stations, location of the stations as on the map - fig. 4.13.6.)

Table 4.13.15. Number (N, ind./ha) and biomass (B kg/ha) of fish species in August

Fish species	Station 1		Station 2		Station 3		Station 4	
	N	B	N	B	N	B	N	B
Perch	14	1,0	22	1,1	9	0,4	11	0,6
Ruffe	8	0,2	12	0,2	6	0,2	5	0,2
Roach	25	0,8	29	1,2	14	0,2	10	0,4
Bleak	1	0,1	3	0,1	1	0,1	-	-
Dace	1	0,1	-	-	-	-	-	-
Redeye	-	-	-	-	1	0,1	-	-
Silver bream	7	0,9	6	0,2	3	0,2	16	0,3
Pike-perch	1	0,1	-	-	2	0,1		
Bream	7	0,3	9	0,7	18	1,2	20	1,4
Vimba	3	0,1	2	0,1			4	0,2
Baltic herring			1	0,1	3	0,1	4	0,2
Smelt			-	-			1	0,1

Vendace	-	-						
Whitefish	-	-	-	-			-	
Total	67	3,6	84	3,7	57	2,6	71	3,4

Table 4.13.15 (continued).

Fish species	Station 5		Station 6		Station 7		Station 8		Station 9	
	N	B	N	B	N	B	N	B	N	B
Perch	7	0,3	9	0,8	15	0,4	17	0,5	27	1,6
Ruffe	1	0,1	11	0,2	7	0,2	2	0,1	-	-
Roach	19	0,6	3	0,1	11	0,4	9	0,2	4	0,1
Bleak	-	-	1	0,1	-	-	-	-	-	-
Dace	-	-	-	-	-	-	-	-	-	-
Redeye	-	-	-	-	-	-	-	-	-	-
Silver bream	7	0,3	8	0,2	4	0,1	1	0,1	-	-
Pike-perch	1	0,2	2	0,2	4	0,3	2	0,1	4	0,1
Bream	5	0,2	22	1,5	1	0,1	-	-	6	0,4
Vimba	6	0,4	3	0,2					2	0,1
Baltic herring	4	0,1	6	0,1	2	0,1	9	0,2	16	0,2
Smelt	3	0,1	2	0,1	5	0,1	7	0,1	1	0,1
Vendace	1	0,1	2	0,1	18	0,9	6	0,2	4	0,1
Whitefish			2	0,1	1	0,1	3	0,2	-	-
Total	54	2,4	71	3,7	68	2,7	56	1,7	64	2,7

September. Trawl survey was carried out along the pipeline route at 4 stations. The deep water fish fauna was represented by four species - baltic herring, sprat, smelt and three-spined stickleback. There were no lampreys in the catches, as opposed to the surveys of previous years, while the three-spined stickleback had been registered. The relative abundance and biomass of these species were assessed from the trawl surveys (Table 4.13.16).

Table 4.13.16. Number (N, ind./ha) and biomass (B, kg/ha) of fish from the trawl surveys

Fish species	1		2		3		4	
	N	B	N	B	N	B	N	B
Baltic herring	437	8,2	502	8,5	488	8,6	538	8,0
Sprat	111	0,6	197	0,9	261	1,1	177	0,8
Three-spined stickleback	9	0,008	32	0,0071	-	-	3	0,001
Smelt	49	0,4	36	0,2	1	0,08	20	0,17

No surveys suggesting the catch of salmonids (salmon, sea trout) were planned for Autumn that year in the Portovaya bight. From the autumn-spawning species, the first approaches of vendace to the spawning grounds were observed. A small number of whitefish in the catches did not allow to talk about the formation of spawning concentrations in the Portovaya bay during this period.

Discussion

The results of this work evidence that the diversity of fish communities in the Portovaya bight was quite high and remained at the same level compared to previous years. In addition to the native species, linked to local habitats, the fish of the open part of the Gulf of Finland appeared there: baltic herring, sprat, smelt, whitefish, vendace. Abundance, biomass, and the ratio of species varied considerably. It was especially noticeable in late summer and autumn, when migrations of the autumn-spawning species and the feeding migrations of the baltic herring and sprat happen. However, compared to 2010 and 2011, the number and biomass decreased greatly (almost in half) not only for baltic herring and whitefish, but also for other species virtually at all the coastal stations; this may indicate a steady trend to lower fish production in this part of the Gulf of Finland.

Size and age structure of the most common fish species in the study area were typical for them and remained virtually unchanged from the previous years.

Brief description of the key species of fish community in the Portovaya bight and the deeper part, along which the gas pipeline lies, is given below.

Baltic herring (*Clupea harengus membras* L.). Spring-spawning baltic herring forms a local population in the eastern part of the Gulf of Finland. Baltic herring is distributed throughout the eastern part of the

Gulf of Finland except areas with salinity below 2 ppm. The main factor determining the high abundance of the species is the ability to use as spawning ground numerous banks and shoals - the prevailing elements of the bottom topography in the eastern part of the Gulf of Finland.
Baltic herring belongs to early-maturing species, its' maximum lifespan is 6-7 years. Most of the herring becomes sexually mature at the age of 2 years, at the age of 3 years nearly all individuals complete maturation. In our catches the baltic herring in the age of 4-5 years dominated (Fig. 4.13.12).

Fig. 4.13.12. A trawl catch of herring west from Vyborg Bay (also one white fish and crustaceans *Saduria entomon)*

Intensive spawning of the baltic herring occurs on sand and gravel sediments, covered with thickets of red and brown algae. Spawning usually begins in the second half of May. The maximum spawning occurs in June when the water temperature is 8-13^{o} C and salinity is 2.6 ppm and above. Spawning in the most populations of the spring-spawning of herring occurs at depth of 3 to 17 m Fecundity ranges from 5-12 thousand eggs. The sex ratio in the spawning herring is close to 1:1.

Smelt (*Osmerus eperlanus* L.) is the most abundant of the anadromous fish. Spawning, embryonic and larval development (May-June) occurs in the brackish water area of the Gulf. Larvae that started exogenous feeding exploit a plankton community in the open coastal area. After the transition to a predominantly benthic feeding, smelt spreads widely over the Gulf.

Spawning grounds are located mainly on the dense sands and sandy-gravel sediments at depths of 1.5-3 meters. Spawning usually begins at the end of April, when the water temperature reaches 5^{o} C and ends at the end of May, with temperatures 12^{o} C and above.

Smelt usually matures at the age of two to three years, sometimes at the age of one year, and males mature earlier than females.

Bream (*Abramis brama* L.) - an abundant commercial species - is widely distributed in the coastal zone, living in areas with depths up to 20 m and salinity up to 3 ppm.
Spawning of the bream usually begins in May when the water temperature reaches 13-18^{o}C (mass spawning at 16-17^{o}C). The eggs are laid on the aquatic vegetation in sheltered coastal areas and bays.

Fecundity ranges from 40 to 300 thousand eggs. Males mature at the age of 6-7 years, females - a year later. The sex ratio is close to 1:1 in the first spawning period, later the ratio of 2:1 is common.

Roach (*Rutilus rutilus* L.) - one of the dominant fish species of the Gulf of Finland. It is common in the coastal zone. For reproduction roach usually chooses shallow areas with depths of up to 1 m. After ice melting, when temperature rises to 12.8 C roach lays eggs on aquatic macrophytes, flooded bushes, driftwood. Hatching occurs at a temperature of 14-15^{o}C 10-12 days after fertilization.

Mass maturation in roach happens during the second year of life. The spawning stock consists mainly of the fish aged 4-5 years. On the spawning grounds their ratio is close to 1:1. Fecundity ranges from 5.5 to 112 thousand eggs. Roach is almost omnivorous.

Perch (*Perca fluviatilis* L.) is one of the most common species of fish.Perch is typically attached to habitats and lacks considerable feeding and spawning migrations. Smaller individuals usually put on weight in the coastal area intensely consuming zooplankton, and partly benthos and juvenile fish. Large individuals prefer more open and deeper parts of the intertidal zone, where they live as active predators.

Vendace (*Coregonus albula* L.) is not the dominant type of fish the Gulf of Finland, but it is quite abundant. This year in August, it prevailed in the catches at one station (station 7). It has a well studied biology. Mass spawning occurs at the end of October - beginning of November, when the water temperature is 4-6^{o}C. In the Gulf the spawning occurs at depths of 3 - 10 m (usually 3-5 m) on sandy, rocky and sandy-silt sediments.

The hydrotechnical works can increase the probability of drastic habitat changes for aquatic organisms that may result in significant changes in the structure of fish communities and its components. However, after analyzing the surveys of the fish communities in the Portovaya bay, we can say that in 2012, given a high level of species diversity, abundance and biomass decreased noticeably.

The absence of lamprey - typical species in this area - in the catch most likely was due to the early termination of research. The appearance of lamprey in the Portovaya bay should be expected a little later with a steady decrease in water temperature.

Analysis of changes in the structure of fish populations during several years.

The fish surveys conducted along the pipeline route in 2005 and 2006 (the baseline survey) allow us to compare the materials of those years with the latest data and assess the state of fish communities in different ecological zones of the Gulf - from coastal habitats with almost fresh water to the deeper brackish water parts.

The species composition changes with the distance from the coast, and with salinity increase. As a result of netting and trawl surveys 20 species of fish belonging to 9 families and one lamprey species were registered in 2005 (Table 15).

That year, the main contributors to the fish fauna in the Portovaya bight were the freshwater species - roach, silver bream, perch, ruffe. The share of Baltic herring was not more than 16%. The same species dominated by number and biomass. Pre-spawning migrations of whitefish and vendace explain their presence in the catch. In the deep-water parts, baltic herring is the leading species in abundance and biomass (up to 90% of the catch), the share of sprat and smelt slightly increases along with a distance from the northern shore.

In 2006, as a result of netting and trawl surveys 24 species of fish belonging to 10 families and one lamprey species were registered. The number of species was highest this year. Total and species-wise abundance and biomass of fish remained relatively unchanged, almost at the level of the previous year. Changes in the species composition repeat the pattern of the previous year: it changes along with the distance from the shore and along with increasing salinity. The coastal habitat is the most diverse and has high density and biomass. Several rare (other than the usual and dominant) species were encountered in the deep-water zone: common sea snail, shorthorn sculpi, little goby.

The results of the last two years (after the launch of the first gas pipeline) suggest a decline in species diversity of the fish communities of the Portovaya bay and the deeper area along the gas pipeline, decreased values of abundance and biomass, total and species-wise. At the same time, the size and age characteristics of the fish remained within the typical ranges. The fish from the carp (roach, bream) and perch (ruffe, perch) families remain dominant species in the coastal zone. The ratio of species in the coastal zone (occurence in % of catch unit) did not change during the years of observation (Table 4.13.17). In the deeper part baltic herring apparently dominates, the share of the other species is negligible. The most valuable commercial species (salmon, sea trout, eel) in all the years of research have not been encountered.

Table 4.13.17. Occurrence (%) in catches of fish in 2005, 2006, 2010, 2011 and 2012.

Fish species	Occurrence, %				
	2005	**2006**	**2010**	**2011**	**2012**
Perch	100	100	95	90	96
Ruffe	93	90	84	77	71
Baltic herring	90	13	97	83	64
Roach	100	83	91	80	97
Smelt	7	10	45	41	38
Silver bream	97	87	57	85	68
Pike-perch	53	83	43	47	39
Whitefish	37	-	30	21	12
Bleak	7	7	20	14	36
Vendace	-	3	20	15	24
Bream	30	37	17	29	63
Sprat	20	-	4	7	5
Dace	-	3	3	1	1
Redeye	-	-	2	1	1
Vimba	3	10	-	7	7
Three-spined stickleback	-	-	-	1	2
Dace	-	3	-	-	-
Orfe	-	3	-	-	-
Plaice	-	3	-	-	-
Lamprey	13	4	7	5	-

Some of the findings require some adjustment. For example, trawl surveys have their own specifics, the results of benthic and pelagic trawling surveys are markedly different, and therefore part of the species sometimes is not collected and does not get into the overall calculation. Lack of the autumn surveys in 2012 does not allow to estimate the spawning migration of whitefish and vendace to Portovaya bay, for the same reason lamprey was absent from the catch (and thus from the analysis) that year. Thus, it is clear that local fish community has a relatively high diversity, seasonal dominance in freshwater and marine fish while maintaining a relatively high environmental stability (Table 4.13.18).

Table 4.13.18. The species composition of fish in different years in Vyborg Bay

Fish species	2005	2006	2010	2011	2012
Fam. Cyprinidae					
Roach	+	+	+	+	+
Bleak	+	+	+	+	+
Silver bream	+	+	+	+	+
Bream	+	+	+	+	+
Orfe	+	+	-	-	-
Dace	-	+	+	+	+
Vimba	+	+	-	+	+
Gudgeon	-	+	-	+	-
Redeye	-	-	+	+	+
Fam. Percidae					
Perch	+	+	+	+	+
Pike-perch	+	+	+	+	+
Ruffe	+	+	+	+	+
Fam. Gasterosteidae					
Three-spined stickleback	+	+	+	+	+
Nine-spined stickleback	+	+	+	-	-
Fam. Clupeidae					
Baltic herring	+	+	+	+	+
Sprat	+	+	+	+	+
Fam. Coregonidae					
Vendace	+	+	+	+	+
Whitefish	+	+	+	+	+
Fam. Osmeridae - Smelt	+	+	+	+	+
Fam. Gobiidae - Shorthorn sculpin	+	+	+	-	-
Little goby	-	+	-	-	-
Fam. Cyclopteridae **–** Common sea snail	+	+	-	-	-
Fam. Engraulidae - anchovia	-	-	+	-	-
Fam. Zoarcidae - Eel-pout	+	+	-	-	-
Fam. Pleuronectidae - Plaice	-	+	-	-	-
Fam. Petromyzontidae - Lamprey	+	+	+	+	-

Conclusions for the northern part of the Gulf of Finland

In the north-western part of the Vyborg Bay (the construction site) fish fauna in 2012 was represented by 16 species of fish (6 families); there were 6 key fish species: roach, perch, silver bream, bream, ruffe and baltic herring, the dominant species were bream, roach (stations 1-4, 6), perch (stations 8, 9) and whitefish (at station number 7 in August); the level and stability of species diversity were quite high and almost unchanged as compared to the previous year, and seasonal changes in the state of the local fish communities were clearly observed; species diversity, total abundance and biomass decreased compared to the previous years (2005, 2006 and 2010); the study area has favorable conditions for spawning, as well as growth and development of fish; deep waters are inhabited by a limited number of species with the dominance of the baltic herring (up to 95% by number); the spring surveys confirmed the presence of spawning and nursery grounds for coastal species and baltic herring in the Portovaya bay;

Due to the fact that each fish species is involved in specific migrations, abundance and species composition of fish in the surveyed area is undergoing seasonal changes, and so the present data are incomplete. For a complete description of the fish community in Bay Port, and in the deep part of the Gulf of Finland the research need to be conducted in different seasons. In particular, it is important to supplement it with spring and autumn surveys when the spawning migrations happen for the spring and autumn-spawning fish species.

4.13.7. Proposals for fish abundance monotoring in the Russian part of the Gulf of Finland

Abundance of key fish species investigations carry out by Lakes and Rivers Fishery Institute and by University. These works exist separately from the other main components of the state monitoring. These investigations goes on either enterprising or upon of requests from investors. Thus such important characters of real monitoring as regularity, stability, position of stations and periods of research catches most often beeing dictated by current tasks (contracts) and willings of investors. That is why an improvement of state supported regular monitoring system of fish abundance is needed.

For such monitoring it is proposed to reduce the number of monitoring stations to 5-6 in the whole area, to distribute these stations on norther and southern sides of the Gulf. Preferably if fish monitoring stations will coincide spatially with selected coastal monitoring stations of the «Roshydromet» monitoring network.

4.14. ABUNDANCE OF FISH KEY FUNCTIONAL GROUPS

4.14.1. Description of the indicator

This indicator was tested and implemented for coastal fish community only. It is based on estimates of the abundance of two different and artificially combined groups of species: *Abundance of cyprinids* (carp family) and *abundance of piscivores*. The two metrics as recruitment and mortality included in the indicator are expected to differ in their responses to anthropogenic pressure factors; the a*bundance of cyprinids* is expected to show the strongest link to eutrophication and *abundance of piscivores* the strongest relationship to fishing pressure (CORESET working materials). It is considered the temporal development of coastal fish communities might reflect the general environmental state in the monitoring area. (Saulamo, Neuman, 2005).

The functional group of cyprinids include all carp fishes (family Cyprinidae), typically roach (*Rutilus rutilus*), bleak (*Alburnus alburnus*) and breams (*Abramis spp.*); some more species of cyprinids can be added from Russian waters of the Gulf of Finland. Cyprinidae is the largest family of freshwater fishes in the world. With over 200 genera and over 2000 species Cyprinidae may even be the largest family of vertebrates. Cyprinids are mostly bottom invertebrates feeding fishes.
Piscivorous coastal fish as perch (*Perca fluviatilis*), pikeperch (*Sander lucioperca*) and pike (*Esox lucius*) have important structuring roles in coastal ecosystems (Eriksson et al., 2009; 2011), and is highly valued species for both small-scale coastal fisheries and recreational fishing (Swedish Board of Fisheries, 2011).

It is known, the abundance of cyprinids in the Bothnian Bay, Bothnian Sea, Archipelago Sea and Gulf of Finland has generally increased, concurrent with a decrease in the abundance of piscivores in Archipelago Sea, Gulf of Finland, northern Gulf of Riga and western Baltic Proper (CORESET working materials). However, the linkage of this data with global changes is still uncertain, because piscivorous coastal fish in all areas are most attractive prey for anglers and recreational fishery; that is why they may have positively selective human pressure.

4.14.2. Implementation of indicator in Russian waters of the Gulf of Finland

This indicator has not been developed in Russian waters and never was specially measured or implemented. However existing fragmentary fish monitoring data allows to recalculate it for some sites (areas of water). Involvement of background (historical) data and creation long-term rows of data from previous years seems to be problematic, because for truthful estimations the data should be standard by sites (stations), by fishing tool used and by season. Such long-term data sets is possible to obtain in a future.

In Russia for classification of continental water bodies and for eutrophication level estimation an other fish-based indicator beeing in use: the relation between abundance of Cyprinidae and Salmoniformes (=Salmonidae + Coregonidae). However in the eastern part of the Gulf of Finland the abundance of the last has strictly seasonal appearance and this relation may not be implemented correctly.

4.14.3. State of the indicator in Russian waters of the Gulf of Finland

For **materials and method** description (fish sampling methods, research fishing stations position, maps, total species composition, etc.) see the previous chapter ‘Abundance of key fish species’.
The data presented below was obtained by selection and recalculation of general data on key fish species abundance. Under the term ‘abundance’ here we understand two main characters: the number of fish individuals (density) per hectar and the biomass of those (by species and by functional groups), because evidently that biomass is a function from fish density and their age-size-individual mass and both characters are equally important.

The line ‘Fish total’ in the tables belongs to all fish species of the studied fish community, where several other species besides two functional groups ‘cyprinids’ and ‘piscivores’ are included.

For research stations position see fig. 4.13.5 , chapter ‘Abundance of key fish species’.

Abundance *(N,* ind./ha) and biomass *(B,* kg/ha) of fish functional groups and species in the Luga Bay (year 2009)

Table 4.14.1. End of May 2009

Fish groups and species	Coastal stations					
	RS1		RS2		RS3	
	N	***B***	***N***	***B***	***N***	***B***
CYPRINIDS						
Roach	-	-	-	-	-	-
Bream	-	-	-	-	-	-
Silver-bream	55	1,6	-	-	36	0,9
Vimba	18	3,5	-	-	-	-
Cyprinids totally	**73**	**5,1**	**-**	**-**	**36**	**0,9**
% of fish total	**12**	**15**	-	**-**	**6**	**3**
PISCIVORES						
Perch	221	18,4	18	2,4	73	5,9
Pike-pearch	55	2,7	-	-	36	2,0
Piscivores totally	**276**	**21,1**	**18**	**2,4**	**109**	**7,9**
% of fish total	**44**	**62**	**10**	**21**	**19**	**28**
FISH TOTAL	**624**	**34,3**	**182**	**11,5**	**586**	**27,8**

Table 4.14.2. July 2009

Fish groups and species	Coastal stations					
	RS1		RS2		RS3	
	N	***B***	***N***	***B***	***N***	***B***
CYPRINIDS						
Roach	34	3,6	37	4,4	61	7,3
Bream	34	2,8	18	2,0	-	-
Silver-bream	-	-	55	2,6	61	4,7
Vimba	-	-	37	11,1	20	4,9
Cyprinids totally	**68**	**6,4**	**147**	**20,1**	**142**	**16,9**
% of fish total	**26**	**51**	**33**	**57**	**47**	**82**
PISCIVORES						
Perch	34	1,7	-	-	20	0,8
Pike-pearch	-	-	18	5,2	-	-
Piscivores totally	**34**	**1,7**	**18**	**5,2**	**20**	**0,8**
% of fish total	**13**	**13**	**4**	**15**	**7**	**4**
FISH TOTAL	**257**	**12,6**	**441**	**35,1**	**305**	**20,6**

Table 4.14.3. End of October 2009

Fish groups and species	Coastal stations					
	RS1		RS2		RS3	
	N	***B***	***N***	***B***	***N***	***B***
CYPRINIDS						
Roach	60	4,9	59	4,1	103	6,0
Bream	-	-	-	-	15	1,4
Silver-bream	15	0,6	44	2,8	59	3,8
Vimba	-	-	15	1,2	29	2,2
Cyprinids totally	**75**	**5,5**	**118**	**8,1**	**206**	**13,4**
% of fish total	**29**	**44**	**35**	**50**	**40**	**50**
PISCIVORES						
Perch	45	2,4	29	1,2	59	4,8
Pike-pearch	15	1,1	15	1,5	-	-
Piscivores totally	**60**	**3,5**	**44**	**2,7**	**59**	**4,8**
% of fish total	**24**	**28**	**13**	**17**	**11**	**18**
FISH TOTAL	**255**	**12,6**	**339**	**16,1**	**515**	**27**

As follows from the presented data seasonal changes in two fuctional groups abundance is rather high (Tables 4.14.1 – 4.14.3). In spring time piscivores are absolutely predominate by density and especially by biomass. In July of 2009 situation remarkably changes: cyprinids become dominating functional group creating more than one half of biomass of the whole coastal fish community.

In autumn (October), the fish community structure stabilized, but some changes were still visible. In the shallow zone, the abundance and biomass were at the level of July, in general. Species diversity in October was extremely low. At coastal stations fish fauna was represented by two species from the perch and carp families; most abundant fish is roach.

To evaluate the changes in the fish community the investigations on the same research stations and by the same method were prolonged for next year 2010. Unfortunately the periods of sampling in compare with one from year 2009 were a little (about one month) moved (Tables 4.14.4 – 4.14.5).

Abundance *(N,* ind./ha) and biomass *(B,* kg/ha) of fish functional groups and species in the Luga Bay (year 2010)

Table 4.14. 4. June 2010

Fish groups and species	Coastal stations					
	RS1		RS2		RS3	
	N	***B***	***N***	***B***	***N***	***B***
CYPRINIDS						
Roach	47,8	3,6	-	-	-	-
Bream	-	-	-	-	-	-
Silver-bream	119,5	2,5	-	-	23,5	0,7
Vimba	-	-	-	-	-	-
Bleak	-	-	-	-	23,5	0,4
Orfe	-	-	-	-	23,5	6,7
Cyprinids totally	**167,3**	**6.1**	**-**	**-**	**70,5**	**7.8**
% of fish total	**13**	**10**	**0**	**0**	**5**	**7**

PISCIVORES						
Perch	334,5	24,4	501,7	47,0	821,4	89,0
Pike-pearch	23,9	0,9	-	-	-	-
Piscivores totally	**358,4**	**25,3**	**501,7**	47,0	821,4	89,0
% of fish total	**29**	**42**	**64**	**81**	**59**	**76**
FISH TOTAL	**1242,3**	**60,1**	**788,4**	**57,7**	**1384,6**	**117,3**

Table 4.14.5. August 2010

Fish groups and species	**Coastal stations**					
	RS1		RS2		RS3	
	N	***B***	***N***	***B***	***N***	***B***
CYPRINIDS						
Roach	116,3	17,0	48,2	6,8	73,7	10,8
Bream	69,8	6,5	24,1	1,2	73,7	8,1
Silver-bream	69,8	5,4	-	-	-	-
Vimba	-	-	-	-	-	-
Bleak	-	-	-	-	-	-
Orfe	-	-	-	-	-	-
Cyprinids totally	**255,9**	**28,9**	**72,3**	**8,0**	**147,4**	**18,9**
% of fish total	**73**	**47**	**23**	**42**	**33**	**48**
PISCIVORES						
Perch	46,5	3,5	18,2	5,8	98,2	11,3
Pike-pearch	23,3	28,1	-	-	-	-
Piscivores totally	**69,8**	**31,6**	**18,2**	**5,8**	**98,2**	**11,3**
% of fish total	**20**	**51**	**6**	**30**	**22**	**29**
FISH TOTAL	**348,9**	**61,4**	**313,4**	**19,2**	**442,0**	**39,5**

Judging from the results of year 2010 the situation in both years of observations seems quite similar. In the beginning of summer (June) the abundance of cyprinids was remarkably less than abundance of piscivores (both absolute and partial abundance data) (Table 4.14.4). However in August the situation changed to quite opposite (Table 4.14.5). There is no certain evidence how these changes linked with recruitment and mortality (also because of fishery) or migration of fish of two named functional groups.

4.14.4. Proposals for monitoring

There are two certain conclusions arising thereof two-yeared observations as follows:
- the abundance of two functional groups cyprynids and piscivores in coastal areas is subject to change significantly (in 2-4 times) during short period of middle-summer;
- implementation of this indicator should be done very carefuly and standardly by season;
- truthful assessment is possible only on a base of long-term monitoring.

The position of monitoring station is recommended on nother coast of the Russian part of the Gulf of Finland (along line Neva Bay – Vyborg Bay) and on southern coast of it (Neva Bay – Luga Bay) and one station on island shallow zone (for example Seskar Isl.).
The total number of stations proposed 5. Period(s) of research fish catch is a subject to discuss; considerably the middle of August, like in other Baltic states (HELCOM, 2012a,c).
Evidently the full cycle of monitoring may be executed not during one year, but during two years. So, the assesment of this indicator regularity may have periodicity once per two years.

Changes in the long-term development of cyprinids and piscivores could hence reflect changes in the level of eutrophication, interactions in the coastal food web, the level of exploitation and natural predation, as well as effects of changes in water temperatures and salinity levels in coastal areas. (HELCOM, 2012a).

In compare with central Baltic Sea region, the peculiarity of Russian part of the Gulf of Finland is in lowest salinity level. Because of it the salinity in all this area is not a limiting factor for disribution and for abundance of fresh water fish from carp family, like for example, it is in coastal waters of W Sweden or Germany. That is why the indicator '*abundance of cyprinids'* in Russian waters may be linked with a temperature and eutrophication, but not with a salinity increase.

4.15. PROPORTION OF LARGE FISH IN THE COMMUNITY

4.15.1. Preface

Large fish is preferable prey both for professional fishermen and for anglers; high proportion of large fish in the community and in the catches is a visible character of good environment. The results indicate that good environmental status of the demersal fish community structure is not yet reached; in the pelagic fish communities the proportion of large fish and mean length of the community has decreased last decades (Oesterwind et al., 2013; Casini, Larson, 2013).

4.15.2. Description of the indicator

This core indicator follows the community structure by computing the proportion of fish that are large enough to contribute significantly to reproduction and predation. As fishing targets large individual fish, the size structure tends to be bias towards fewer large fish under a heavy fishing pressure and natural mortality (HELCOM, 2012a). The proportion of large predatory fish is significant balancing feature in a food web but at the same time target of commercial fishery. The 'large fish indicator' (LFI) is used as a proxy for anthropogenic influence on the ecosystem; while it shall not or only little be influenced by natural variability or processes, like recruitment. Fishing has a direct effect on the structure of fish communities, because it can lead to an increase in the relative abundance of small fish (Jennings et al., 1999) and reduces the mean body size within a population (Oesterwind et al., 2013). The LFI is a strong indicator with significant responses to fishing mortality.

4.15.3. Adaptability of the indicator to the Russian part of the Gulf of Finland

The LFI was defined for the North Sea by Greenstreet et al. 2011, but lately it was tested and modified its application in the Western Baltic Sea - to ICES subdivisions 22–24 (Russian part of the Gulf of Finland belongs to ICES subdivision 32) (Oesterwind et al., 2013).

The indicator is currently limited to the area where the Baltic International Trawl Survey (BITS) is operated and this area is strongly dominated by cod (*Gadus morhua*). Due to the salinity gradients the species community in the northern part of the Baltic and especially in its easternmost part are not comparable to the western part. There are fewer BITS stations in the North and in the East of the Baltic. Cod is currently missing there or absent at all.
A solution for this could be a demersal 'LFI' for the whole Baltic with different definitions or modifications for the different ecological parts, and needs more investigation. Pelagic LFI, covering the whole Baltic Sea, could be used for this purpose (Oesterwind et al., 2013).

In the Russian part of the Gulf of Finland cod is normally missing. Substantial catches ot this fish were registered only in period 1975-1982 years together with increase in sprat catch (in westernmost Russian areas) , what was caused by powerful saline water intrusion (Kudersky et al., 2008). Resently cod can be caught not every year and only in singles and only in the parts of the gulf close to Finnish or Estonian border. The biggest specimen known in the Russian part of the Gulf of Finland during last decade is described on the figure (fig. 4.15.1); it was caught in Bjerke-Zund (near Primorsk) in August of 2011; absolute lenght 32 cm, mass 0.560 kg.

The demersal fish community in the Baltic Sea is clearly dominated by one species – cod. The LFI calculations, thus, follow generally the curve of a single species. Although there are also other more or less large marine species in the W Baltic (like flounder, plaice, turbit and whiting) only about 11% of the fish over 30 cm are of these other species than cod (Oesterwind et al., 2013). Moreover that other species are absent in the Russian part of the Gulf of Finland as well.

Fig. 4.15.1. Cod from the eastern Gulf of Finland, Bjerke-Zund, August, 2011 (photo by A.Yakovlev).

So, we have to confirm it is a weakness that demersal community can be assessed by this indicator only in the southern and central areas of the Baltic Sea (HELCOM, 2012 A;B; (Oesterwind et al., 2013). At that the indicator can be adopted to proportion of large fish in the community assessment in Kaliningrad oblast'.

4.15.4. Determination of GES boundary

There is no Baltic wide conclusion of the boundary for Good Environmental Status (GES) in LFI but one approach is attempted in this core indicator report. Until experience is accumulating of the use of LFI in the Baltic Sea, more emphasis could be given to the temporal development of LFI, i.e. GES is approached when there are more large fish in the community (HELCOM, 2012A; B). The BITS data was analyzed with and without cod, the dominant fish species in the dataset. As the other demersal fish species are shorter, also the limit size of LFI was difficult to set. Based on trial and error, the limit was set to 30 cm in order to get flat fishes into the indicator. It was, however, recognized that 30cm is a small size for cod. Therefore the GES boundary based on 30 cm can give overly positive picture of the state of the fish community. Analysis in ICES subdivision 22–24: no analysis of GES boundaries were performed.

A solution for this could be a demersal 'LFI' for the whole Baltic with **different definitions or modifications for the different ecological parts**, and needs more investigation. Pelagic LFI, covering the whole Baltic Sea, could be used for this purpose (Oesterwind et al., 2013; Casini, Larson, 2013).

Possible problem

In different regions of the Baltic Sea bigger or smaller size of marine fish (i.e.: mean length, maximum length, proportion of large fish in the community) may be caused by regional salinity level like it is known for many other marine organisms. Thus, the differences in LFI values may be the function from regional salinity rather than environmental status indicator. It means GES (for example 'good' proportin of large cod) could be calculated somewhere mostly thanks to high salinity, but for areas with reduced salinity LFI may demonstrate worse environmental status, what may be incorrect.

4.15.5. Possible modifications for different ecological parts (example for the Russisan part of the Gulf of Finland)

The studies show the high potential of the LFI as an indicator for the Baltic Sea fish community. The indicator is currently limited to the area where the Baltic International Trawl Survey (BITS) is operated. However to harvest larger fish and to keep sustainable population is important for every commercial fish species, wherever they inhabit. In the size-structure of population of naturally small fishes we may find larger individuals – 'large fish', even if they are significantly smaller than 40 or 30 cm (fig. 4.15.2).

Fig. 4.15.2. Three Baltic herrings and one sprat (lowest), SW from island Maly Fiskar (eastern Gulf of Finland), June, 2010 (photo by A. Yakovlev).

In spite of human in fish more interested with their mass, measurements of length, which is highly correlated with weight, is more convenient. The proportion of all size classes is important character of population condition, including their natural mortality and fishery press.

If cod and flounder is impossible to use in the Russian part of the Gulf of Finland, then other locally typical fish species should be used. For example the length structures of six fish local populations in Luga Bay are performed on diagramms (fig. 4.15.3 A-F).

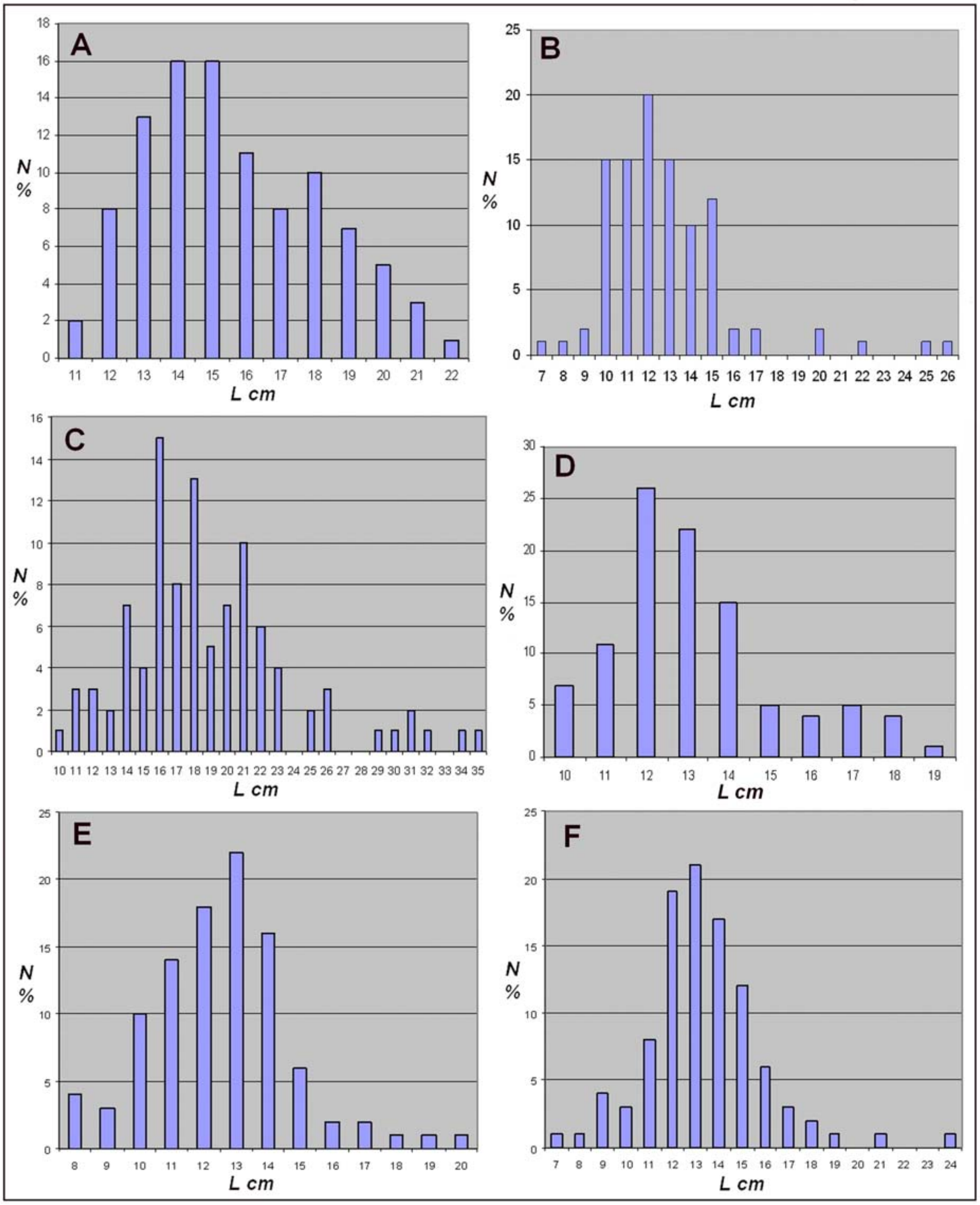


Fig. 4.15.3. Length structure of fish local populations in Luga Bay (2010). L – length (cm); N – proportion (%). A – roach, B – perch, C – brame, D – silver brame, E – herring, F – smelt.

Proposingly the 'proportion of large fish in the community' in the Russian part of the Gulf of Finland is incomparable with LFI in the western Baltic and it can be substituted for other parameter - 'proportion of large fish in the local population' of several common species.

4.15.6. Proposal for monitoring

The scheme of monitoring and methods of data collections are as described for other fish-based indicators: 4.13. ABUNDANCE OF KEY FISH SPECIES and 4.14. ABUNDANCE OF FISH KEY FUNCTIONAL GROUPS. Several most common fish species should be choosed for this reason. Selected species should cover various functional groups as piscifores and cyprinids and also demersal and pelagic fish.

To meet this requirements the list of five species may be proposed as follows: *Rutilus rutilus* (L.) – roach, *Abramis brama* (L.) – bream, *Clupea harengus membras* (L.) – baltic herring, *Perca fluviatilis*(L.) – pearch, *Osmerus eperlanus* (L.) – smelt. These species are common for the Gulf of Finland and many esutuarian parts of central and western Baltic as well.

Fish species-specific GES boundaries for size structure and proportion of large fish in the population may be jointly elaborated by group of HELCOM international experts.

4.16. ABUNDANCE OF SEA TROUT SPAWNERS AND PARR

4.16.1. Description of the indicator

The indicator reflects the effect of a combination of factors that determine the reproduction success of sea trout and current abundance of natural populations of this species (in present sea trout rearing is virtually absent in the Russian part of the Gulf of Finland).The indicator is represented by two independent variables – abundance of parr in the river and abundance of spawners (fig. 4.16.1-2).

	
Fig. 4.16.1. The sea trout parr from one of the Luga River tributaries	Fig. 4.16.2. The sea trout spawner caught in the Russian part of Gulf of Finland (photos by S.Titov)

Abundance of juvenile sea trout in the spawning rivers is usually estimated as parr densities (ind./100m^2). It reflects the ecological status of the spawning rivers (areas of spawning and nursery grounds and their status, the level of the food supply of juveniles), and the level of poaching in the region. In Russia, sea trout of the Baltic Sea is listed in the Red Data Book of the Russian Federation and its catch is forbidden in the territorial waters of the sea and in rivers that flow into the Gulf of Finland.

Abundance of spawners reflects ecological status of the Gulf of Finland, the food availability and the level of poaching (in Russian waters) and commercial fishing (in Finnish and Estonian waters the Russian rivers sea trout is fished by local fishermen.)

Both parameters (parr density and abundance of spawners) give a comprehensive assessment of the current state of atlantic salmon reproduction in the Russian part of the Gulf of Finland and the number of natural populations of this species reproducing in the rivers of the Gulf of Finland.

4.16.2. The state of the indicator in the Russian part of the Gulf of Finland

Currently, natural reproduction of sea trout is observed in at least 25-30 rivers and streams (not including their tributaries) flowing into the Gulf of Finland on the territory of Russian Federation.

Abundance (density) of sea trout parr in most of these rivers has been monitored with varying frequency since 2000 (Mannerla et al, 2011).

Abundance of smolts of this species has also been monitored during the last 12 years in the basin of the river Luga (fig. 4.16.3), which is currently home to the largest population of sea trout (Titov et al., 2007).

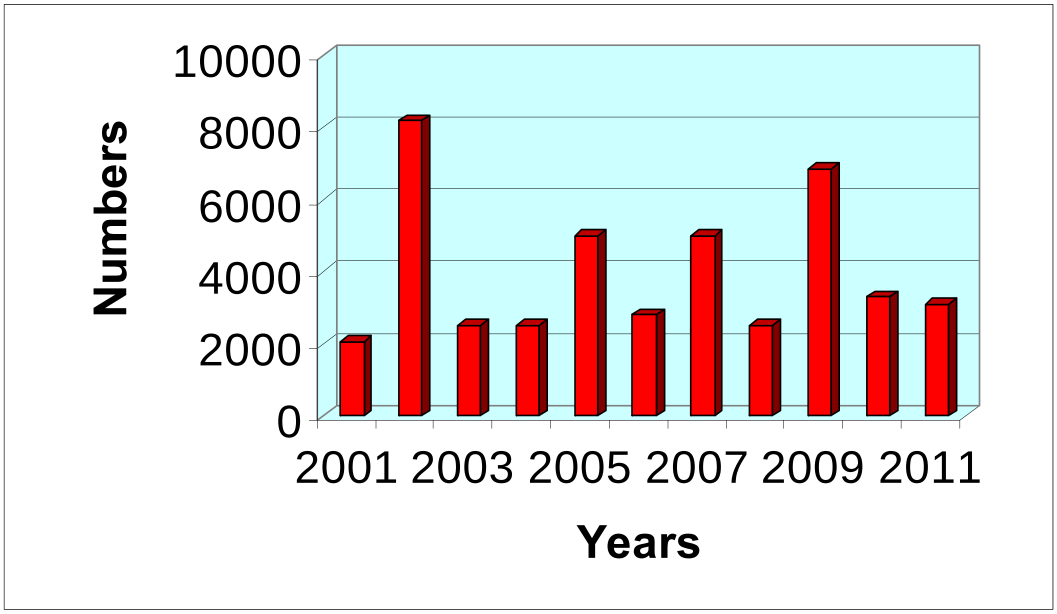


Fig. 4.16.3. The sea trout smolt production in the Luga River (2001-2011)

There is no monitoring of abundance of sea trout spawners, both in the rivers and the marine part of the Gulf of Finland on the territory of the Russian Federation.

4.16.3. Prospects for the use of indicators in the Russian part of the Gulf of Finland

This indicator less accurately assesses the current state of sea trout reproduction, compared with the indicator of smolt production. However, due to simplicity and relatively low cost of monitoring, this indicator is preferred when assessing the condition and size of numerous populations of sea trout that live in the rivers of the Gulf of Finland on the territory of Russian Federation.

Estimation of the number of spawners in the rivers and especially in the marine part of the area, requires considerable financial and time expenditures, compared to the estimates of parr production, and therefore the prospects for the use of this indicator in the Russian part of the Gulf of Finland is low.

4.16.4. Proposals for the monitoring of indicators in the Russian part of the Gulf of Finland

Given that natural reproduction of sea trout in the Russian part of the Gulf of Finland has remained in more than 35-40 rivers (including spawning tributaries), annual monitoring of all water bodies is expensive and impractical. Each year, the monitoring should be carried out in the main spawning tributaries of the river Luga (the rivers Lemovzha, Vruda, Solka, Vidon', Azika), which harbors the largest population of wild brown trout.From the rivers that flow into the Gulf of Finland on the southern coast, annual monitoring should be carried out in the rivers Sista, Voronka, Khabolovka, while on the northern coast - in the rivers Seleznevka, Malinovka, Serga, Gladyshevka (fig. 4.16.4).

Fig. 4.16.4. The places of proposed monitoring in the Russian part of the Gulf of Finland.

Fig. 4.16.5. The monitoring of sea trout parr density by electrofishing (photo from archive of S. Titov).

In the small rivers and streams it is sensible to carry out monitoring at 2-3 year intervals.
Estimation of sea trout parr density in each river should be carried out using electrofishing equipment (Antonova et al., 2000) in at least 2-4 sites, typical habitat for parr (fig. 4.16.5). The work should be carried out in the autumn period (the second half of August to late September). The monitoring can be carried out by Laboratory of migrating fishes of GosNIORH (Res. Inst. of Lakes and Rivers Fishery, St.-Petersburg.

4.17. ABUNDANCE OF SALMON SPAWNERS AND SMOLTS

4.17.1. Description of indicator

The indicator reflects the impact of a range of factors that determine the efficiency of reproduction of atlantic salmon and the current number of its natural and reared populations. The indicator is represented by two independent variables - abundance of smolts and spawners (figs. 4.17.1- 4.17.2).

	
Fig. 4.17.1. The tagged smolts of Atlantic salmon before the releasing to the Gladyshevka River	Fig. 4.17. 2. The Atlantic salmon spawner caughted in the Neva River (photo by S.Titov).

Abundance of smolts reflects, first of all, the ecological status of water bodies (such as spawning rivers, the Gulf of Finland), the suitable food supply of smolts in the Gulf of Finland (in the areas of feeding migrations of salmon), the intensity of fishing, both legal (salmon from Russian rivers fished by both Russian, Finnish and Estonian fishermen) and poaching.

Abundance of spawners reflects not only ecological status of the Gulf of Finland and the availability of food for spawners, but also the level of legal fishing and poaching. To large extent, this indicator also depends on the survival of smolts in the period of marine life.

Both parameters (abundance of smolts and the abundance of spawners) give a comprehensive assessment of the current state of reproduction of Atlantic salmon in the Russian part of the Gulf of Finland and the populations of this species reproducing in the wild, and on hatcheries.

4.17.2. The state of indicator in the Russian part of the Gulf of Finland

Currently, the populations of Atlantic salmon remain in 4 rivers flowing into the Gulf of Finland on the territory of the Russian Federation. In the two rivers - the Neva and Narva - populations are supported solely by the activities of salmon hatcheries.

Natural reproduction of salmon is observed in two rivers - the Luga and Gladyshevka.
Monitoring of the smolt abundance in the natural population of Luga river had been conducted over the last 12 years. The number of smolts of natural origin ranges from 2000 to 8000 individuals (Titov et al., 2007) and remains stable at a low level (fig. 4.17.3).

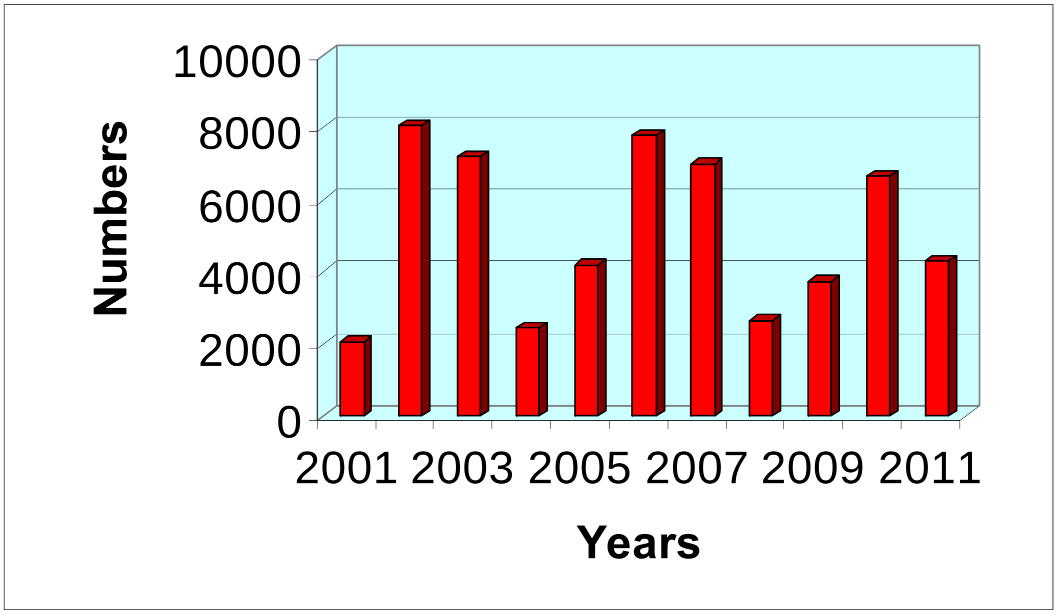


Fig. 4.17.3. The salmon smolt production in the Luga River (2001-2011)

In the Luga River it was revealed the general duration of downstream-migration of salmon usually is about 3-5 weeks long, but the peak of it – from 3 to 7 days. Periods of downstream-migration can vary substantially from year to year depending from climatic conditions of the certain year (fig. 4.17.4).

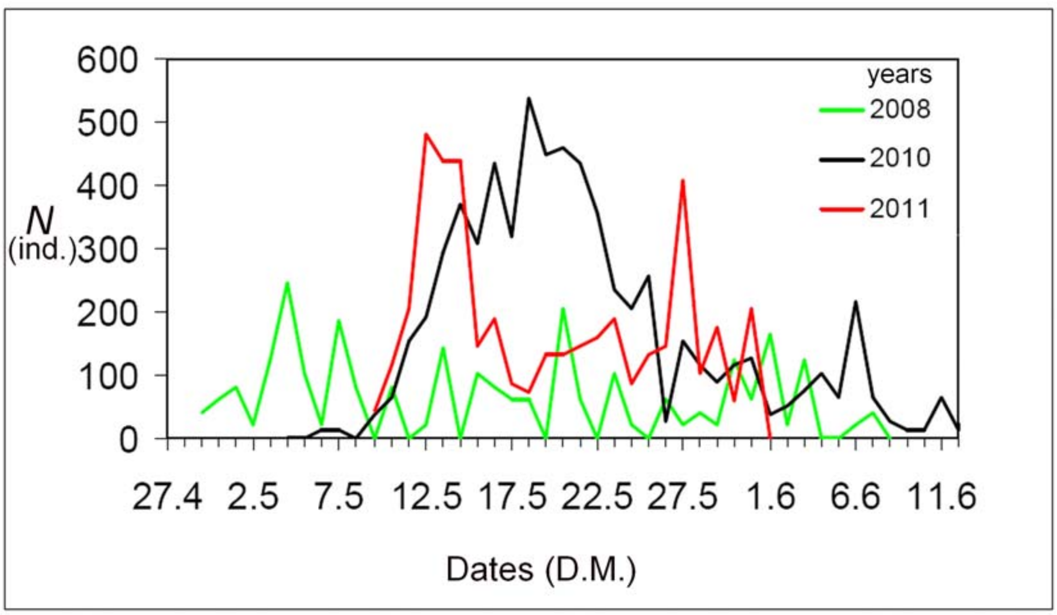


Fig. 4.17.4. Dynamics of downstream-migration of salmon smolts in the Luga River (after Mikhelson, Titov, 2013).

Abundance of smolts in the salmon populations from the Neva River had been monitored from 2005 to 2008. The number of smolts in these years ranged from 20000 to 30000 reared individuals.
Production of smolts of natural origin in the river Gladyshevka has not ever been assessed.

There is no regular monitoring of the number of spawners in the salmon rivers on the territory of the Russian Federation.

4.17.3. Prospects for the use of indicator in the Russian part of the Gulf of Finland

This indicator effectively assesses the current state of reproduction and abundance of Atlantic salmon populations in the rivers of the Gulf of Finland on the territory of the Russian Federation.

It must be taken into account that estimation of the number of spawners in the rivers and especially in the marine part of the area, requires considerable financial and time expenditures compared with an estimate of smolt production. In this regard, assessment of the number of smolt is more promising and feasible for implementation in the Russian part of the Gulf of Finland.

4.17.4. Proposals for the monitoring of indicator in the Russian part of the Gulf of Finland

The data on smolt production in natural populations of Atlantic salmon are most valuable as they reflect the major trends of the modern state of the reproduction of the species.
Given that in the Russian part of the Gulf of Finland natural reproduction of salmon is now preserved only in two rivers - the Luga and Gladyshevka, monitoring the number of smolts should be carried out in those waters.

Smolt production should be assessed using smolt trapping (figs. 4.17.5 – 4.17.6), installed in the lower part of the river (usually in the mouth area). The work should be carried out every year in the spring time (the second half of April to mid-June).

Figs. 4.17.5; 4.17.6. The smolt trapping at the Luga River

The smolt productivity assessment in the marine part of the Gulf of Finland is difficult and unrealistic, because of the high cost of such studies and the lack of conventional procedures for their implementation.

4.18. ZOOPLANKTON MEAN SIZE AND TOTAL ABUNDANCE

Zooplankters are the secondary producers of pelagic marine waters, the part of the marine food web, and an integral component of the ecosystem. Data on variability of mean zooplankter size, zooplankton abundance and biomass are important for understanding changes in food web structure. These variables can be used as indicators of environmental conditions.

4.18.1. Description of the indicator

As a indicator for food web structure, the mean zooplankter size was calculated as a ratio between the total zooplankton abundance and total biomass. Abundant zooplankton with high mean individual size would represent both favorable fish feeding conditions and high grazing potential, whereas all other combinations of zooplankton stock and individual size would be suboptimal and imply limitations of energy transfer from primary producers to higher trophic levels and poorer food availability for planktivorous fish.
According to literature data, the most part of species dominated in zooplankton community of the Neva bay and in the eastern part of the Gulf of Finland are polyphagous and are characterized by filtering nutrition mode with wide feeding spectrum. Small rotifers are microfiltrators feeding on trypton, bacterio- and phytoplankton (0.3–20 µm, preferably particles less than 1 µm). Juvenile copepodits and cladocerans are macrofiltrators feeding on detritus, bacteria, protozoan and phytoplankton (particles size is 2–40 µm). Bacteria, algae and Copepoda nauplia (2–160 µm) are food objects of adult algo- and zoophagous copepods (Monakov, 1976; 1998).

4.18.2. Methods and frequency of data collection, data analyses

Zooplankton samples were collected by plankton net (mesh size 67 µm; diameter 57 cm) at depth horizons 0–20m. Samples for the analysis were taken in end of July – beginning of August in the Neva Bay (2006–2011) and in the eastern part of the Gulf of Finland (2005–2011) including shallow, transitional and deep water regions (fig. 4.18.1). The gratitude for field work organization and for help in zooplankton sampling is expressed here to T. Eremina, A. Maximov, S. Golubkov, M.. Golubkov and M. Orlova.

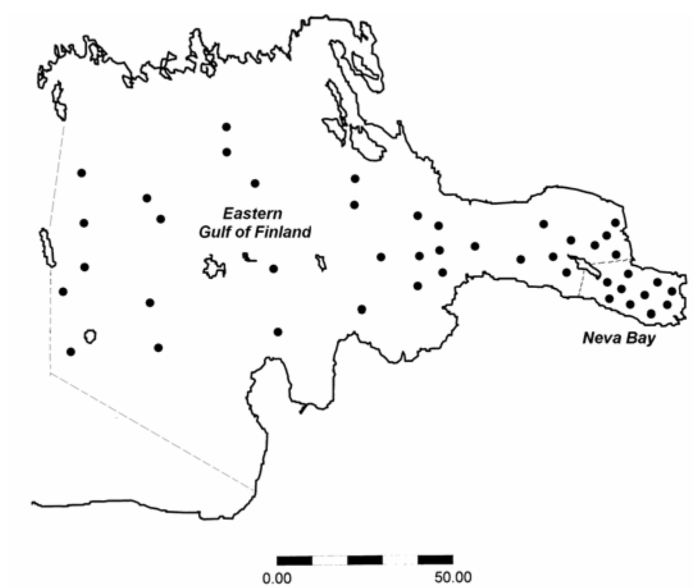


Fig. 4.18.1. The position of regular zooplankton stations in the eastern (Russian) part of the Gulf of Finland and the Neva Bay.

Samples were preserved in formalin upon collection. Copepods were classified according to species, developmental stage (copepodites CI–III and CIV–V classified as younger and older copepodits, respectively), and sex (adults); naupliar stages were not separated. Rotifers and cladocerans were identified to the lowest possible taxonomic level. Collected data were averaged separately for eastern Gulf of Finland and for Neva Bay.

4.18.3. The state of the indicator in the Russian part of the Gulf of Finland and the Neva Bay

The eastern part of the Gulf of Finland is influenced by various, natural and anthropogenic, factors. The hydrobiological regime instability and hydrotechnical works consequences affected all ecosystem components, zooplankton community including. In 2005–2011, significant changes in zooplankton community structure were detected in shallow, transitional and deepwater zones of the eastern part of the Gulf of Finland.

In 2005–2007 years in Neva Bay water area the hydrotechnical and dredging works had been carried out for new passenger terminal of St.-Petersburg construction. As a result, high mineral particles concentration in the Neva Bay and in the eastern part of the Gulf of Finland was registered. Water transparency decreased drastically and photosynthetic planktonic organisms were depressed (fig. 4.18.2; 4.18.3).

Fig. 4.18.2. Contamination of Neva Bay and the eastern Gulf of Finland suspended particles during dredging and land reclamation works in 2006.

Left — data of MODIS instrument from Terra spacecraft on August 23, 2006.
Right — data of MERIS instrument on October 12, 2006. The maximum concentration of suspended matter (more than 500 mg/l, Secchi disk water transparency less than 5 cm) corresponds to light colors (off-white tone), relatively clean water—a dark tone.

Similar situation with water turbidity was observed also during the next year – 2007.
'Under-satellite' photo of such enormous water siltation was taken from board of research vessel in July, 2007 in Neva Bay (fig. 4.18.3). At that period the primary productivity of plankton and chlophyll '*a*' concentration were dropped down up to zero values (Rybalko et al., 2008).

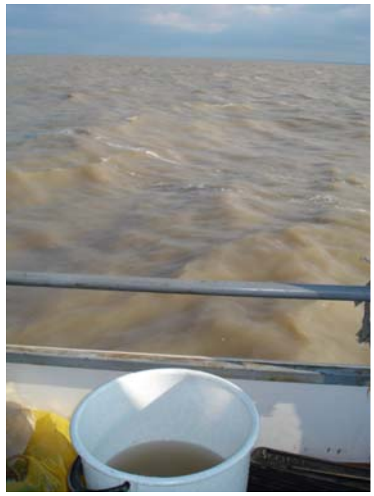


Fig. 4.18.3. The Neva Bay water surface, July 2007 (photo by L. Litvinchuk)

High concentration of mineral particles negatively influenced zooplankton due to traumatic effects on filtering apparatus. This inhibited locomotion and, consequently, respiration and feeding (fig. 4.18.4).

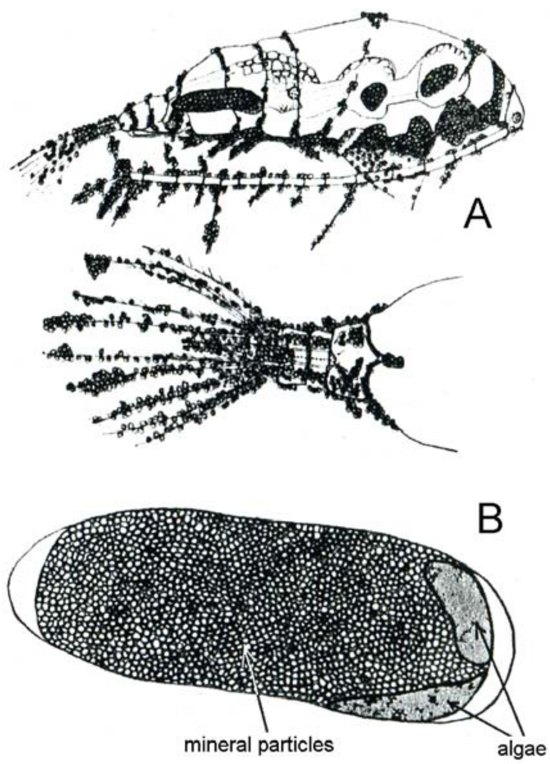


Fig. 4.18.4. Influence of high concentration of mineral particles on Copepoda. A – *Acartia tonsa* with adherent mineral particles; B – pellet contents (after Shadrin, Litvinchuk, 2005).

From 2006 to 2011 mean zooplankton abundance was low. Zooplankton abundance averaged over the study period was 24.24 thousand ind. m^{-3}, average biomass was 0.1 g m^{-3} .

Previously reported average abundance and biomass of zooplankton in summer of1981–1982 were much higher—70 thousand ind. m^{-3} and 0.26 g m^{-3} respectively (Pidgaiko, 1987; Table 4.18.1).

Table 4.18.1. Average abundance and biomass of zooplankton community of the Neva Bay in 1981- 2011. Data for 1981-1982 are from Pidgaiko (1987), 2006-2011 – original data.

	N, thousand ind. m^{-3}	B, g m^{-3}
1981-1982 average	**70**	**0.26**
2006	18.12	0.14
2007	31.05	0.06
2008	9.11	0.05
2009	7.17	0.05
2010	34.33	0.15
2011	45.63	0.13
2006-2011 average	**24.24**	**0.10**

Zooplankton abundance increased due to strengthening of microphages (fig. 4.18.5). In 2007, when the transparency of the water in the Neva Bay was very low (up to 0.15 m), the highest share of macrophages was observed in zooplankton. Accordingly, mean size of zooplankton organisms in this period was minimal (fig. 4.18.6, Table 4.18.2).

In the Neva Bay, the zooplankton community changed under the negative impact of high mineral particle concentrations resulting from dredging. Total zooplankton abundance, total biomass, and mean size of zooplankton decreased markedly. These changes indicate that these variables can be used as indicators of the environmental deterioration (including an increase in turbidity of the water) during the engineering works.

In 80s, the mean size of zooplankton was small (Table 2).The plankton was dominated by small forms, but biomass was high due to high abundance of zooplankton.

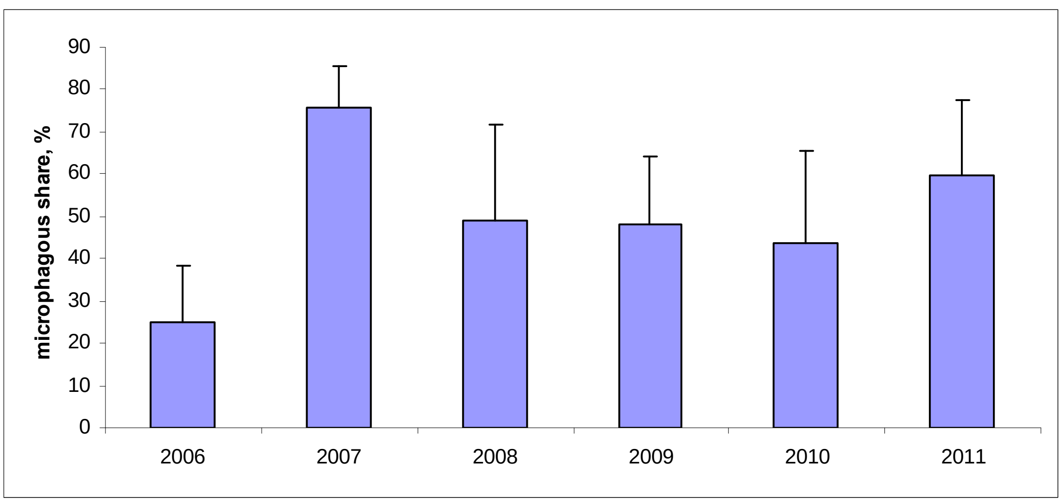


Fig. 4.18.5. Share of microphages in abundance of zooplankton in Neva Bay in 2006-2011.

Table 4.18.2. Mean size of zooplankton in Neva Bay in 1981-2011. Data for 1981-1982 are from Pidgaiko (1987), 2006-2011 – original data.

	X (Mean Size)	SD
1981-1982	**0,0037**	
2006	0,0093	0,0039
2007	0,0012	0,0006
2008	0,0045	0,0025
2009	0,0063	0,0025
2010	0,0059	0,0026
2011	0,003	0,0017
Average for 2006-2011	**0,0051**	0,0028

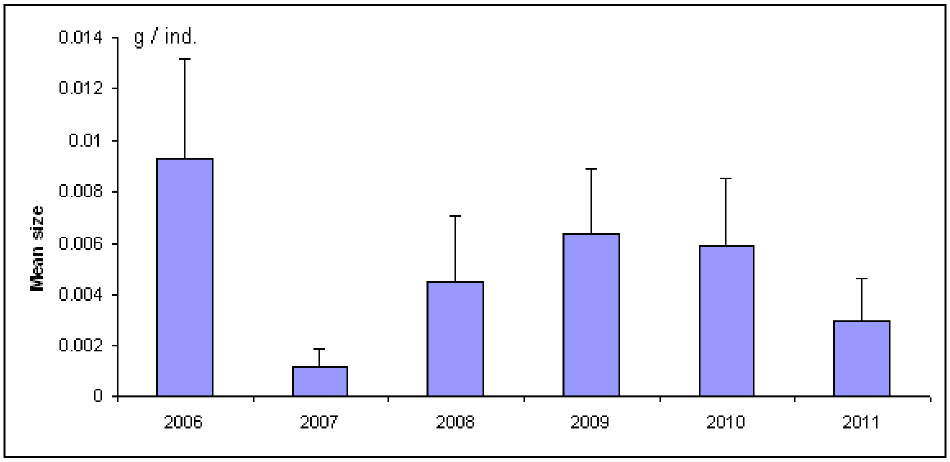


Fig. 4.18.6. Mean size of zooplankton in Neva Bay in years 2006-2011.

During hydrotechnical works not only mineral particles, but also biogenic and organic matter are transported from the bottom to pelagic layers. In the eastern part of the Gulf of Finland from 2005 to 2011, the maximum zooplankton abundance was registered in 2007, the highest biomass—in 2009. The main share of zooplankton community was presented by macrofiltering cladoceran whose feeding spectrum includes detritus, bacteria, protozoan and phytoplankton organisms. These species are indicators of eutrophic conditions, and their mass development evidence increase of eutrophication in the eastern part of the Gulf of Finland. In the eastern part of the Gulf of Finland in 2005-2011, the maximum zooplankton abundance was detected in 2007 (fig. 4.18.7). Rotifers, Cladocera and Copepoda were present approximately in equal proportion (fig. 4.18.8). Small rotifers (*Keratella cochlearis baltica*, *Keratella quadrata platei*), herbivorous cladocerans (*Bosmina coregoni maritima* and *Daphnia cucullata*), nauplia and juvenile copepodit stages of Copepoda prevailed in zooplankton. In 2009, the main part of zooplankton abundance consisted of herbivorous and predatory cladocerans.

The highest zooplankton biomass was registered in 2007, 2009, and 2011 (fig. 4.18.9). In 1980-1990, zooplankton biomass was on average 0.4 g m^{-3}. This created good feeding and growth conditions for fish. In 2007 and 2011, juvenile copepodits, adult Copepoda (*Limnocalanus macrurus*, *Eurytemora affinis*), and herbivorous and predatory cladocerans dominated in zooplankton. In 2009, zooplankton biomass consisted almost only of herbivorous and predatory cladocerans. All dominant zooplankter species (except for *C. pengoi*) are polyphagous filter feeders with wide feeding spectrum (trypton, detritus, bacteria and algae).

Thus, in 2007 and 2009, in eastern part of the Gulf of Finland, the food spectrum of dominant zooplankton species consisted of microplankton components typical for eutrophic conditions.

It is possible, based on quantitative zooplankton data and ratio between main zooplankton groups, to characterize the structure of microplankton and the trophic status of the waterbody. *K. cochlearis baltica*, *K. quadrata platei*, *B. coregoni maritima* and *D. cucullata* are species-indicators of eutrophic conditions

(Andronikova, 1996). Their high biomass indicate that the eastern part of the Gulf of Finland can be considered as eutrophic waterbody. In 2009, the increase role of Cladocera and the decrease abundance and biomass of Copepoda could be an evidence for the increasing trophic conditions in studied area. Absence of rotifers as dominant form in 2009 may be explained by change of microplankton size structure due to increase of individual sizes of its components (for example, protozoan organisms) not available for rotifers..

Maximum mean size of zooplankton was observed in 2009 (fig. 4.18.10).

Thus, in 2007, 2009 and 2011 high zooplankton abundance and biomass in the eastern part of the Gulf of Finland indicated that in these years the favorable conditions for zooplankton development were formed. Dominant zooplankton species of eastern part of the Gulf of Finland are important component in the diet of young herring and sprat. Its mass development in 2007, 2009 and 2011 may be favorable for nutrition of planktivorous fish. Maximum of mean size and biomass in 2009 can evidence the most favorable conditions for fish feeding and growth.

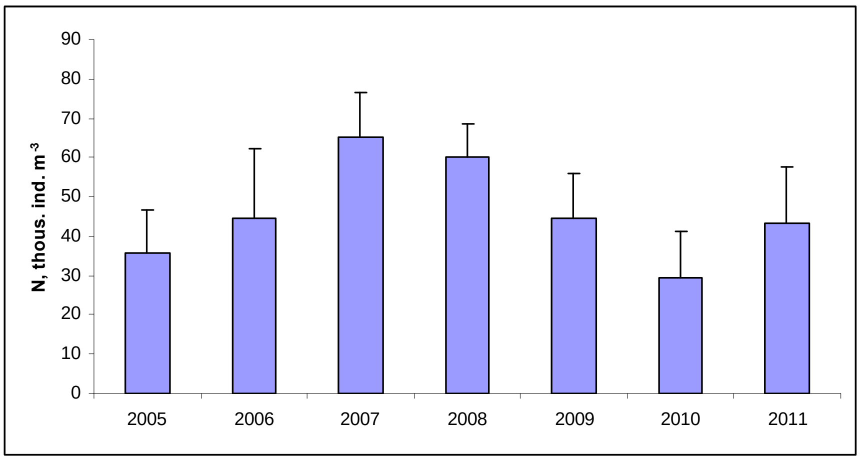


Fig. 4.18.7. Dynamics of abundance of zooplankton in the eastern part of the Gulf of Finland.

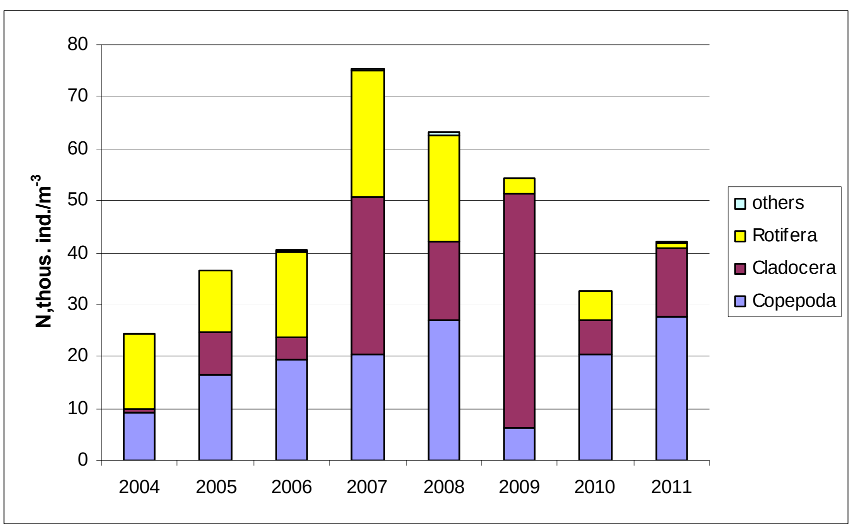


Fig. 4.18.8. Taxonomic structure of zooplankton community in the eastern part of the Gulf of Finland in 2005-2011.

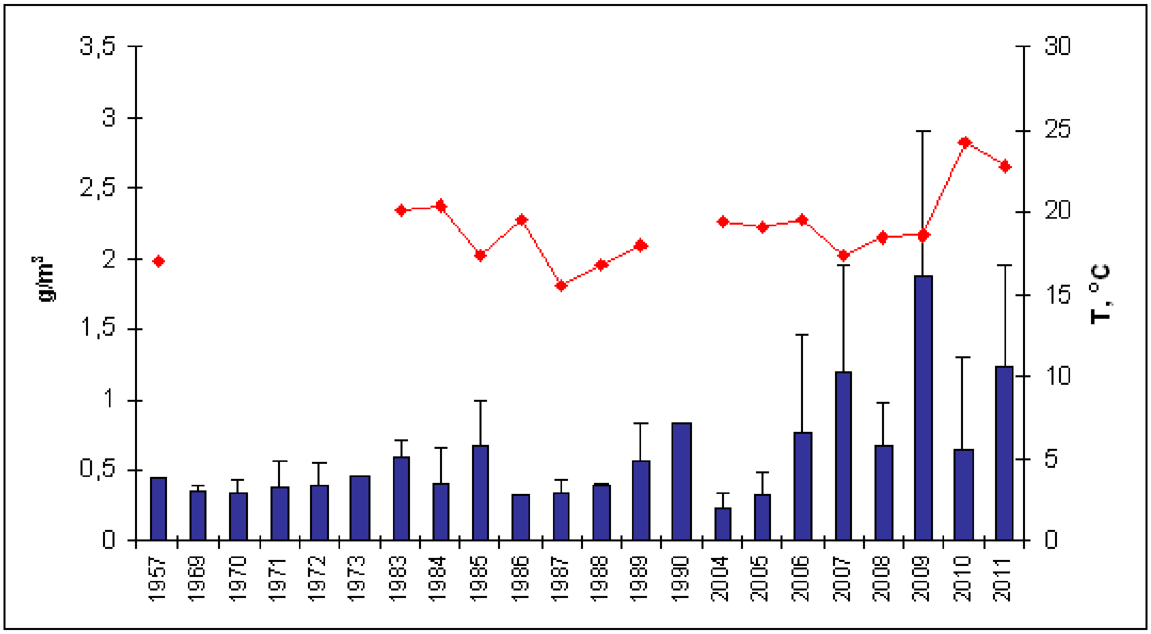


Fig. 4.18.9. Annual dynamics of zooplankton biomass (data for July and August) in the eastern part of the Gulf of Finland. Data for 1957 are from Bitjukov et all. (1971); 1969-1973 – from Skvortsov (1975); 1983-1990 – from Silina (1997); 2004-2010 (Litvinchuk, 2010), 2011 – original data.

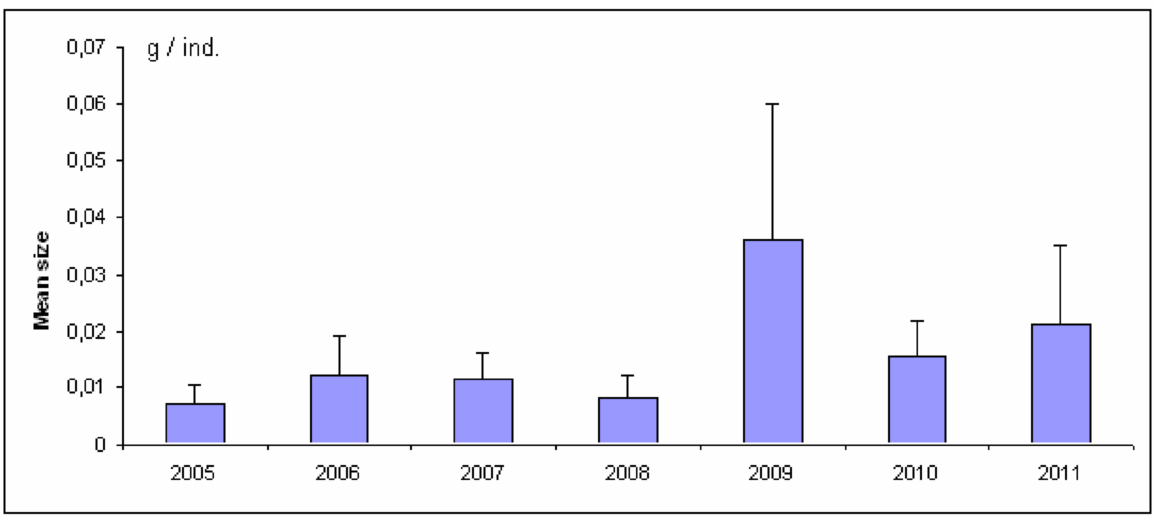


Fig. 4.18.10. Mean size zooplankton changes in the eastern part of the Gulf of Finland.

In the eastern part of the Gulf of Finland mean size of zooplankton organisms, abundance and biomass may be used as indicators of environmental conditions.

4.18.4. Range of indicator values characteristic of GES (good environmental status).

Good environmental status was based on a reference period within existing time series that defines a reference state when the food web structure was not measurably affected by eutrophication and/or representing good fish feeding conditions.

The reference period for the zooplankton indicator was selected when:

1. GES for chlorophyll *a* concentrations and water transparency, that have been specifically defined for the sub-basins of the Baltic Sea (HELCOM, 2009), were in GES , and
2. Growth zooplanktivorous fish (weight-at-age - WAA) and population size were relatively high.

Recently, Ljunggren et al. (2010) have demonstrated that WAA could be used as a proxy for zooplankton food availability and related fish feeding conditions to fish recruitment in coastal areas of the northern and central Baltic Sea.

The change-point analysis of zooplankton communities in the data sets in question is also being conducted to address issues of the regime shift(s) for reference period assessment. See Table 4.18.1 and Figure 4.18.4 for the data coverage and reference periods derived using principle outlined above. GES is met when:

– there is a high contribution of large-sized individuals (mostly copepods) in the zooplankton community that efficiently graze on phytoplankton and provide good-quality food for zooplanktivorous fish, and

– the abundance of zooplankton is at the level adequate to support fish growth and exert control over phytoplankton production.

The GES will be determined for two parameters: the zooplankter mean size and the total abundance or biomass of the zooplankton community.

- The reference period for the mean size: the GES boundary is at lower 95% CI of the mean during a time period when zooplankton is adequate to support high growth of zooplanktivorous fish (measured as weight at age [WAA] and high stock size). The high WAA values in combination with relatively high stock abundance (to avoid density-dependent WAA) indicate good growth of the herring stock because of high abundance of high-quality food (usually large amount of copepods) and, thus, a good reference period with regard to the fish-feeding conditions.
- The reference period for the total zooplankton abundance (or biomass) reflects a time period when effects of eutrophication are low, defined as 'acceptable' chlorophyll a concentration (i.e. EQR > 1) and hence eutrophication-related food web changes are negligible.

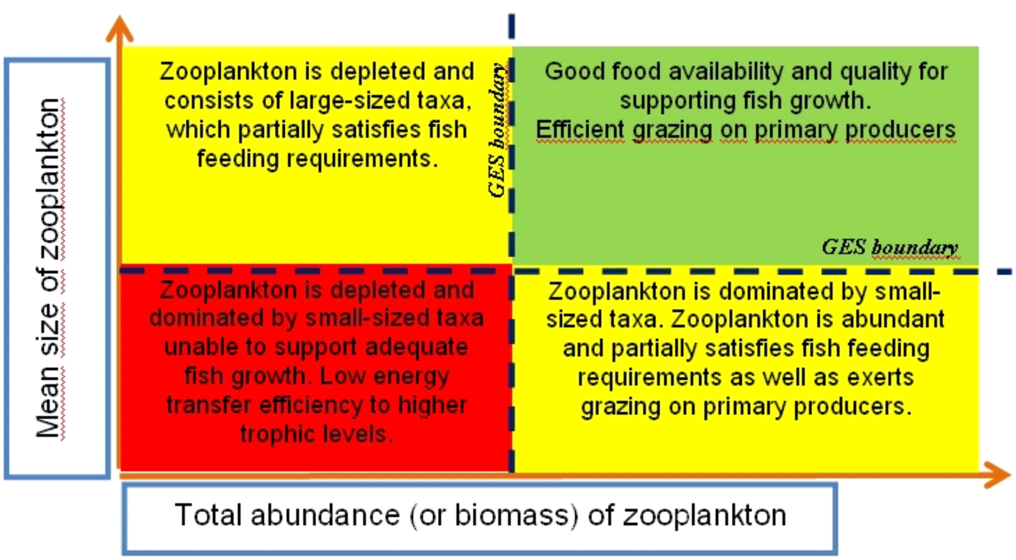


Fig. 4.18.11. A schematic diagram of the use of the indicator. The green area represents GES condition, yellow areas represent sub-GES conditions where only one of the two parameters is adequate and the red area represents sub-GES conditions where both parameters fail (after HELCOM, 2009).

According to our data, moderate (0.4 g m^{-3}) and higher zooplankton biomass and mean size of zooplankton about 0.009 g m^{-3} are a boundary of good environmental status.

4.18.5. Proposals for the scheme of monitoring of the indicator in the Russian part of the Gulf of Finland and the Neva bay

The sampling scheme and the timing of sampling is proposed taking into account the fact that in previous years, the zooplankton samples were collected by a single scheme for the eastern part of the Gulf of Finland, in the comparable period for each year or periods of the growing season and analyzed using published data for the same areas and periods of the growing season. The design should include the following sampling sites and stations (see the scheme on the fig. 4.18.1): Neva Bay (10 stations), the eastern part of the Gulf of Finland: shallow region (5 stations), transitional zone (5 stations), deep water region (15-20 stations). We suggest zooplankton sampling in late July and early August each year.

4.19. STATE OF THE SOFT-BOTTOM MACROFAUNA COMMUNITIES

4.19.1. Description of the indicator

Macrozoobenthos is widely recognized as an indicator of change in environmental conditions in marine monitoring programs, because macrobenthic animals are relatively sedentary and long-life (HELCOM, 2009a). Plankton is closely linked with water masses and its dynamics strictly and rapidly follows the water massess changes; mobile organisms of necton may escape any negative changes in water masses by fast swimming and only not mobile benthic fauna may serve as integral character of demersal environmental conditions.

The indicator describes the the soft-bottom macrofauna communities as a many-sided character of natural and anthropogenic conditions of the environment. It may reflect anthropogenic pressures, like euthrophication, contamination, but just partly. To disjoint natural and anthropogenic impacts to soft-bottom macrofauna communities is a difficult task. This task becomes more difficult in areas with significant gradients of main natural factors, like salinity distribution, oxygen vertical concentration, etc.

The benthic invertebrate communities are an essential part of any environmental assessment. They are sensitive indicators of contamination, eutrophication and physical disturbances. This indicator assesses the state of the soft-bottommacroinvertebrate communities by using indices developed to notice changes in abundance of sensitive species. The indices have been validated against various pressure gradients. The core indicator ‘State of soft-bottom macrozoobenthic communities’ was presented in the CORESET interim report (HELCOM, 2012b).

4.19.2. State of the indicator in the Russian part of the Gulf of Finland

In opposite to Finnish coast, the hard bottom substrata (rocks, bolders and stones) is very poorly presented along the Russian shoreline of the Gulf of Finland and in littoral zone. So, soft-bottom biocenosis most often starts at Russian coasts immediately from the water edge, but hard bottom fauna is much less developed, than in Finland or Sweden.

The inner Gulf of Finland located in a transition zone between fresh and brackish waters is traditionally subdivided into two natural regions: the freshwater Neva Bay and brackish water eastern Gulf of Finland, now separated by building dumb protecting St.-Petersburg from floods. Bottom fauna of the Neva Bay is well studied. The first investigations were carried out even in beginning of XX century (see Maximov, 2004 for review). The bottom fauna of the eastern Gulf of Finland estuary until recent years remained little investigated. The regular monitoring of macrozoobenthos was started only in 1980s (Maximov, 1997).

Neva Bay is factually an extension of river Neva. The diverse and abundant bottom macrofauna of the Neva Bay is consists of fresh-water species. In the open areas more than 100 species are registered. The most part of them occurred also in the river Neva and Lake Ladoga (Nevskaya guba, 1987; Ecosystema, 2008). In quantitative terms macrozoobenthos is practically comprised of three taxonomic groups: oligochaetes, bivalves (fam. Sphaereiidae) and chironomids. Other groups are scarce and constitute lesser than 1-2 % of total macrozoobenthos abundance and biomass.

The abundance of dominant taxonomic groups varies over a wide range in space and time. The most dramatic changes are recorded in the mouth area of the Neva, where amplitude of biomass fluctuations reaches 1–2 orders of magnitude. The analysis of all published materials suggested that these changes were are cyclic and connected with the multidecadal variability in the Neva runoff with periods of about 25–30 years (Maximov, 2004). In high water phases of Neva regime the favorable hydrological conditions and significant supply of allocthonous organic substances promote development of very dense bivalve’s populations with biomass more than 100 g WW m^{-2}, as it was observed in 1900s, 1930s, 1960s and 1980s (Table 4.19.1). In periods of the low river runoff bivalves practically disappear and quantitatively poor benthos (lesser than 20 g WW m^{-2}) with prevalence oligochaetes is formed, as it is typical of the modern period.

Table 4.19.1. Mean biomass (g WW m^{-2}) of the macrozoobenthos in the Neva Bay in period 1935–2010 years

Year	Transect		
	Strelna – Lahta	Petrodvoretz – Lisiy Nos	Lomonosov – Lisiy Nos
1935–1937	390	23,0	–
1958	60,1	–	–
1960–1962	151,2	24,6	4,1
1975–1976	5,4-35,4	14,8-54,6	11,2-2,5
1977–1979	34,9	16,7	9,1
1982–1984	317,8	30,6	13,2
1980–1986	282,6	19,5	8,7
1988–1989	190,5	20,2	8,8
1992–1993	46,6	23,1	13,1
1999–2000	9,0	12,2	10,0
2004-2005	6,0±2,4	15,7±2,6	10,3±1,7
2006-2007	2,1±0,9	6,1±1,5	8,3±1,5
2008-2009	2,2±0,8	4,5±1,0	7,6±1,4
2010	2,5±0,5	3,1±0,3	7,3±2,1

Note. Standard errors are presented for the recent unpublished results (2004–2005). The earlier data originate from literature and archival materials reviewed by Maximov (2004).

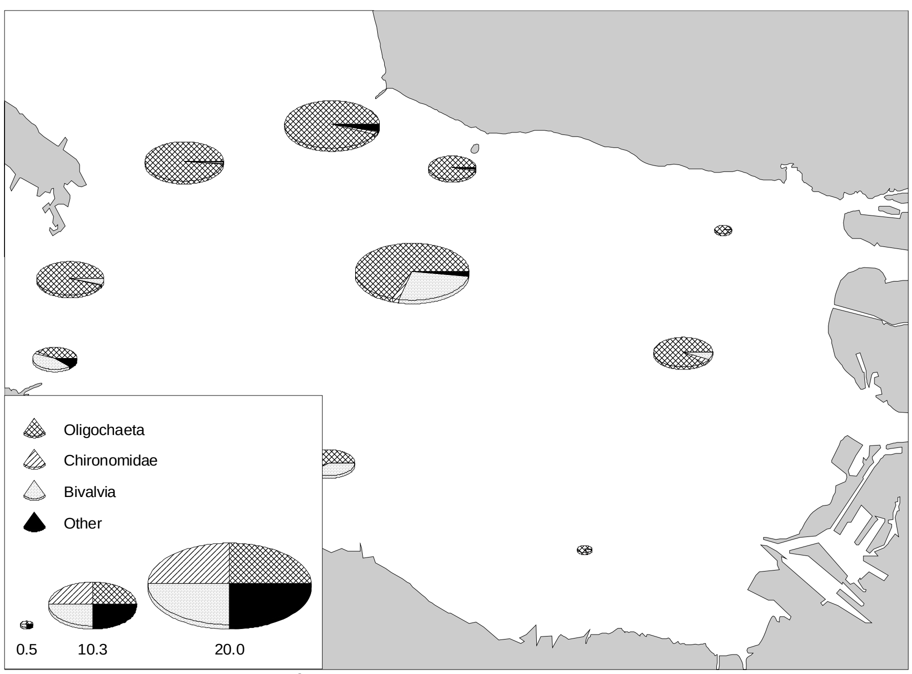


Fig. 4.19.1. Biomass (g WW m^{-2}) of macrobenthic taxa in the Neva Bay in 2006.

In the last decade the negative effect of a natural hydrological factor was further enhanced by hydroengeneering works on building Marine Facade of St.-Petersburg resulting in drastic increase of inorganic particulate matter content in water. In 2006 after beginning of dredging works the quantitative development of benthos declined especially in the eastern areas of Neva Bay (fig. 4.19.1). The most considerable decline was typical for filter-feeding species (pisidiid bivalves and chironomids). During last years the gradual recovery of benthic communities was observed however, up to now, the macrozoobenthos in the Neva Bay was mostly characterized by low biomass and dominated by disturbance-tolerant oligochaetes (fig. 4.19.2). That low biomass was not registered during centennial period of investigation of benthos in the Neva Bay (Table 4.19.1).

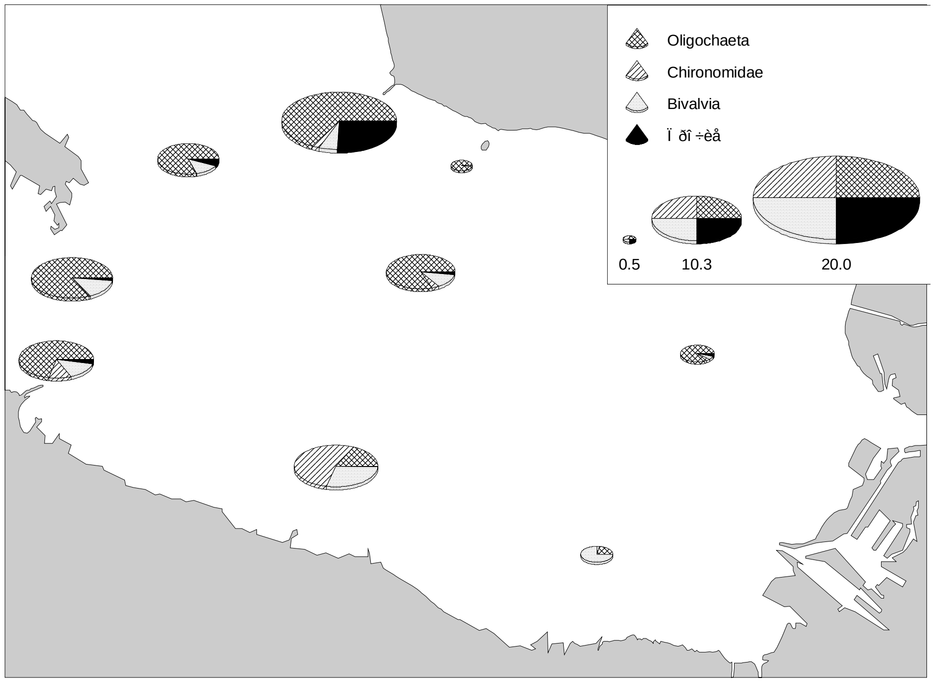


Fig. 4.19.2. Biomass (g WW m^{-2}) of macrobenthic taxa in the Neva Bay in 2012.

The soft-bottom macrofauna of the brackish eastern Gulf of Finland, as well as other nearby areas of the Northern Baltic Sea is very poor and characterized by mixing freshwater and marine faunal components. To the west by island Kotlin the most limnetic 'Neva' species drops out. The total number of macrobenthic species declines although a few marine species appear. In westward direction together with increase of salinity the further decline of faunal richness and replacement of freshwater species by marine ones takes place. However owing to strong vertical salinity and thermal stratification of water column these changes in macrozoobenthos are strongly associated with depth. Altogether during study period in the open areas (deeper than 10 m) of the eastern Gulf of Finland more than 70 macrobenthic taxa are recorded, but distribution of most species is limited only to strongly freshened shallow areas with depth lesser then 20—25 m. The most part of the bottom area is inhabited only by few species (Ecosystema, 2008).

Macrozoobenthos of shallow areas is also characterized by high level of quantitative development. The biomass, as a rule, exceeds 10 g WW m^{-2}. The maximal values (more than 100 g WW m^{-2}) are documented in Luga – Koporye area (Antsulevich, Chiviliov, 1992; Kudersky, 1982, Maximov, 2006; 2009). The typical dominant are marine bivalves *Macoma balthica* (about 70% of total benthic biomass). In the areas of large river water inflow (island Kotlin area, Vyborg Bay, Luga Bay) *M. baltica* disappear and are replaced by freshwater chironomids *Chironomus plumosus* and/or oligochaetes (mainly *Potamothrix hammoniensis*). The macrozoobenthos of shallow bottoms shows considerable spatial and interannual variations because of population fluctuations of dominant species (Maximov, 1997; 2003, Lavrent'eva et al., 1999). The highest total biomass (50 g WW m^{-2} and above) is connected with mass development of large animals *M. baltica* and larvae *Ch. plumosus*. In contrast, when oligochaetes are dominants, biomass, as a rule, is lower (about 10 g WW m^{-2}) (Maximov, 2003). In addition, the long-term tendency for increase of benthic biomass was observed. Since the first quantitative investigation of macrozoobenthos in 1930s (Luga – Koporye area), the biomass increased by 5-7 times. This tendency, which is typical to many other regions of the Baltic Sea, is mostly due to increase in biomass of bivalves *M. baltica* and likely was caused by organic enrichment because of eutrophication (Maximov, 2006).The structure and quantitative parameters of low-diverse macrozoobenthos in the deep-water zone of the eastern Gulf of Finland are radically changing during the last decades. The uniquely simple bottom communities consist of only a few species. As a result the fluctuations in abundance of native dominant animals as well as introduction and development of new non-indigenous species have a great impact on the total community.

Historically the abundant macrozoobenthos in the deep open areas was strongly dominated by glacial relict crustaceans – isopods *Saduria entomon* (L.), amphipods *Monoporeia affinis* (Lindström) and *Pontoporeia femorata* Kroyer which together accounted for more than 90% of total abundance and biomass (Kudersky, 1982; Maximov, 1997, Shishkin et al., 1989). The quantitative parameters of population of these species were relatively high. For example, in 1980s the biomass of crustaceans locally reached 50–100 g WW m^{-2}, the abundance exceeded 10 thousands ind. m^{-2}. However macrozoobenthos showed considerable interannual variations because of cyclic (period 6-7 years) oscillations of amphipods *M. affinis* population.

These oscillations were specially studied in 1980s and were explained by intraspecific competition for limited food resources and the action of the mechanism of density dependent regulation (Maximov, 1996). Abundance of the predatory *S. entomon* preying on amphipods followed for the changes of populations of its victims (Maximov, 1997; 2000). However interannual changes at different sites were not synchronous. Averaged data over more extensive water areas did not demonstrate considerable difference. Despite of large local variations the mean macrozoobenthos biomass values for the whole eastern Gulf of Finland during period 1969 to 1995 varied within narrow range between 21 and 28 g WW m^{-2} (HELCOM, 1996).

In 1996 the catastrophic changes in the macrozoobenthos of the eastern Gulf of Finland began because of drastic deterioration of near-bottom oxygen conditions (Lyakhin et al., 1997). The oxygen depletion resulted in mass mortality of benthic organisms. The hypoxic events reoccurred in 2001, 2003 and 2006.

These events radically altered the soft bottom communities. Abundant populations of glacial relicts crustaceans were wiped out and were replaced by scarce (biomass lesser than 0,1 g WW m^{-2}) populations of oligochaetes (fam. Naididae). The especially considerable changes took place in 2003, when oxygen-poor saline water penetrated to the inner areas of the Gulf, as consequence of recent Major Baltic Inflow (Averkiev et al., 2004). By 2004 the most part of the eastern Gulf of Finland bottom altered to the life-less desert (fig. 4.19.3) (Maximov, Tsiplenkina, 2007, Ecosystema, 2008). It is well known that hypoxia and anoxia are usual phenomenon in the below-halocline waters of the Baltic Sea.

The unfavourable oxygen conditions were responsible for periodical disappearance of macrozoobenthos at the deep bottoms of the Baltic Proper and western Gulf of Finland (e.g. Laine et al. 1997, Laine et al. 2007). In the shallower eastern Gulf of Finland the permanent salinity stratification is absent and annual mixing result in aeration of near-bottom waters. Before 1996 the lifeless bottom was not documented in this area. However there were few benthic studies before 1980s. Analyze of long-term hydrographic data suggests that the hypoxia-induced impoverishment of the macrozoobenthos most likely occurred nevertheless in the past, because severe oxygen depletion was episodically registered in the inner Gulf of Finland.

The cases and causes of the bottom hypoxia in the eastern part of the Gulf of Finland have been detailed in the recent publications (Maximov, 2006). The hypoxic events are observed in the years when inflows of low-oxygen saline waters from the Baltic Proper coincided with severe winters, when early freezing prevents the wind-induced mixing, and are governed by large-scale climatic factors. Deterioration of oxygen regime in 1996, which caused the disappearance of macrozoobenthos, coincided with the end of the 15 year period of positive North Atlantic Oscillation anomalies and the beginning of the transition to the negative phase of the new cycle (Eremina et al., 2012).

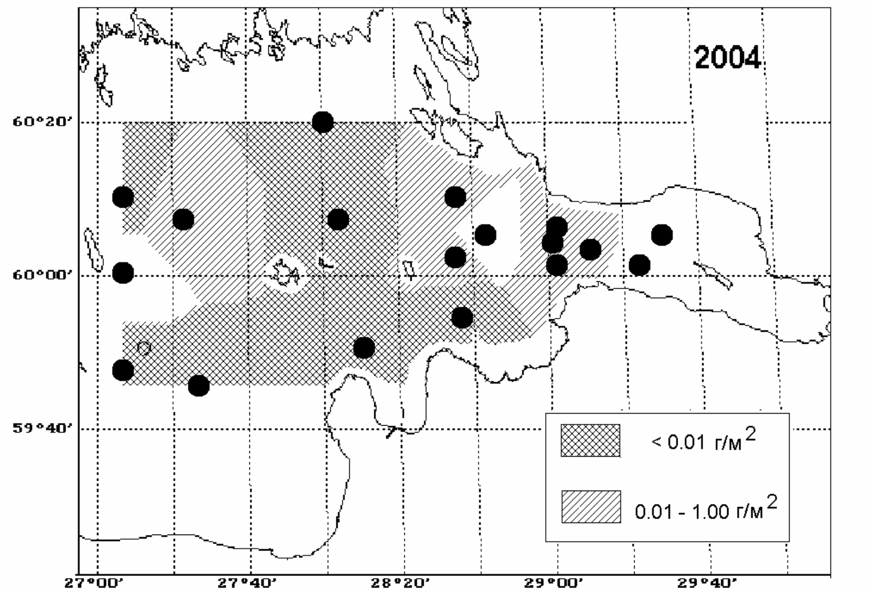


Fig. 4.19.3. The distribution of life-less and impoverished bottoms (biomass ≤0,01 g WW m-2) in the eastern Gulf of Finland after recent hypoxic events (August 2004)

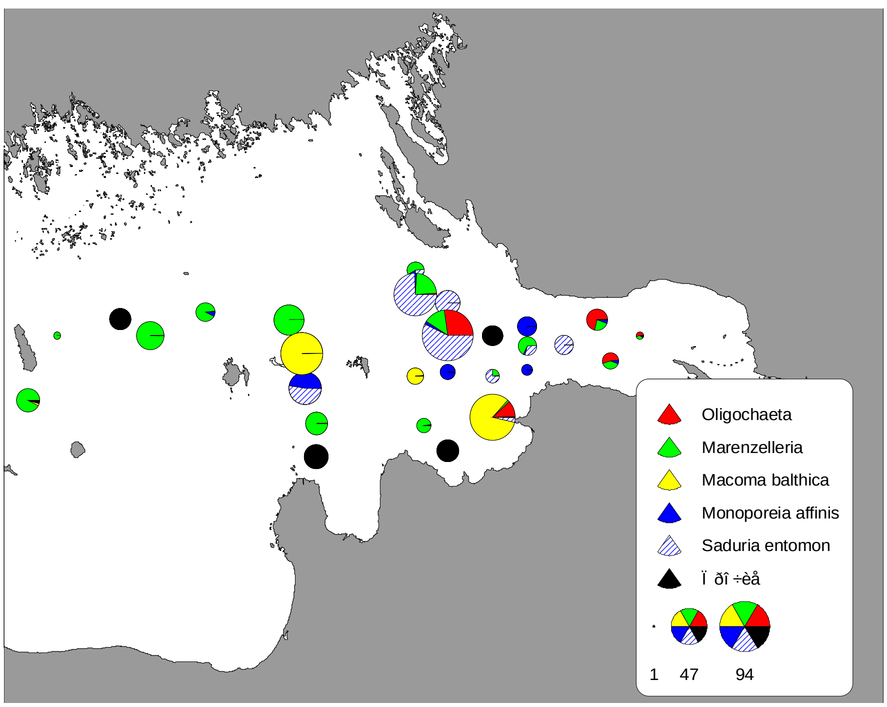


Fig. 4.19.4. The distribution of biomass (g WW m-2) of macrobenthic species in open areas of the eastern Gulf of Finland in July 2009

Hypoxia, apparently, also was the factor favorable to successful expansion of opportunistic polychaetes and oligochaetes into the eastern Gulf of Finland (*Marenzelleria* spp. and *Tubificoides pseudogaster*) (Maximov, Tsiplenkina, 2012). Especially dramatic changes were connected with recent introduction of arctic polychaetes *Marenzelleria arctia* in 2008-2009. By 2009 *Marenzelleria arctia* colonized occupied the most part of the gulf area where it became the dominant component of macrozoobenthos (fig.4.19.4). At some sites all macrofauna consisted practically of monoculture of polychaetes.

The mass development of polychaetes led to the drastic increase of macrozoobenthos biomass in the deep-water zone (Maximov, 2011). Polychaetes *Marenzelleria* spp. have capacity for quickly colonization of vacant bottom areas during improvement of oxygen conditions because of existence planktonic larvae and tolerance to low oxygen level of adult worms. Invasion by these hypoxic-tolerant polychaetes resulted in drastic increase of resistance of macrozoobenthos to hypoxia and acceleration of the recovery successional processes in the eastern Gulf of Finland. In 2010 the extremely severe oxygen depletion was observed in the eastern Gulf of Finland with oxygen level as low as never before (Eremina et al., 2012).

Despite of the record deterioration of oxygen conditions in 2010 bottom communities generally were characterized by high macrozoobenthos abundance and biomass. Disappearance of bottom macrofauna was registered only at few sites with anoxic conditions. Moreover, the averaged biomass of macrozoobenthos in the open areas increased as compared to 2009 and other years with good oxygen situation. This increase of benthos biomass was almost completely caused by mass development of polychaetes (fig. 4.19.5). The polychaetes role was especially significant in the hypoxia-affected zones where macrozoobenthos was very poor or absent before invasion (Maximov, 2013). Now *M. arctia* remains the most spread and abundant macrobenthic species in the eastern Gulf of Finland.

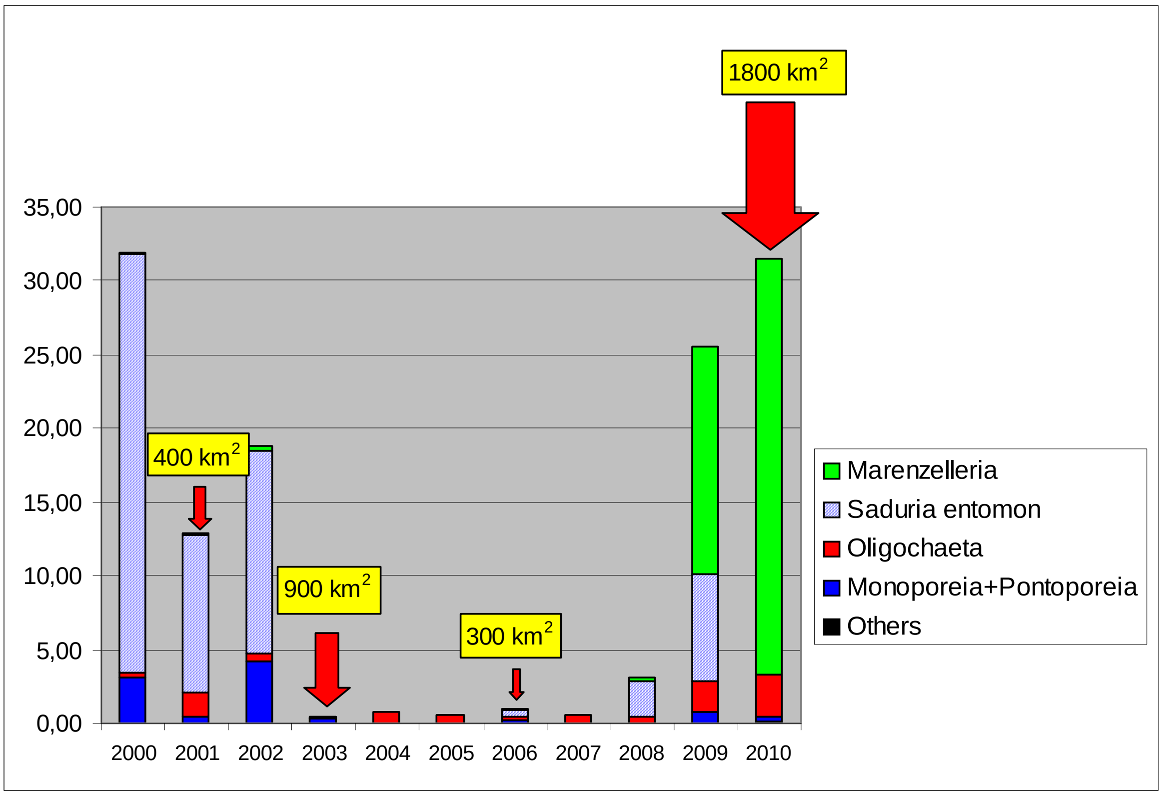


Fig. 4.19.5. Changes in mean biomass (g WW m^{-2}) of macrobenthic species at soft deep bottoms (depth>25 m) of the eastern Gulf of Finland in 2000–2010 years. Arrows indicate hypoxic events. Sizes of arrows are proportional to the areas of hypoxic zones. Hypoxia data accepted from A.V. Isaev (2010).

Thus, we can identify three main different stages in the recent dynamic of the soft-bottom macrofauna communities in the deep open areas of the eastern Gulf of Finland: (1) Crustacean dominated community before 1996, (2) Hypoxia-affected strongly impoverished community from 1996 to 2008 and (3) *Marenzelleria* dominated community from 2009 up to present day. The modern period is characterized by very abundant macrozoobenthos, which on the most part of the bottom area consists practically of monoculture of *M. arctia* (fig. 4.19.6). Biomass of macrozoobenthos in the open areas reaches the record high values. Moreover *M. arctia* introduction leaded to appearance of new functional group in benthos that triggered significant ecosystem-level consequences.

These polychaetes dig the bottom deeper than native inhabitants of the Baltic Sea, essentially affecting the exchange processes at the water – bottom interface. Bioirrigation and bioturbation of the bottom deposits by polychaetes resulted in a drastic increase of nitrogen/phosphorous ratio in the near-bottom waters of the gulf that leaded to cascade changes of the plankton. The abundance of colonial nitrogen-fixing cyanobacteria declined drastically resulting in reduction of total biomass of phytoplankton and chlorophyll-a concentrations. Owing to disappearance of large colonies of cyanobacteria and development of small-celled algae, the food supply for zooplankton improved and their biomass increased. As result, *M. arctia* invasion leaded to cardinal reconstructions of whole ecosystem of the eastern Gulf of Finland (Maximov et al., 2013).

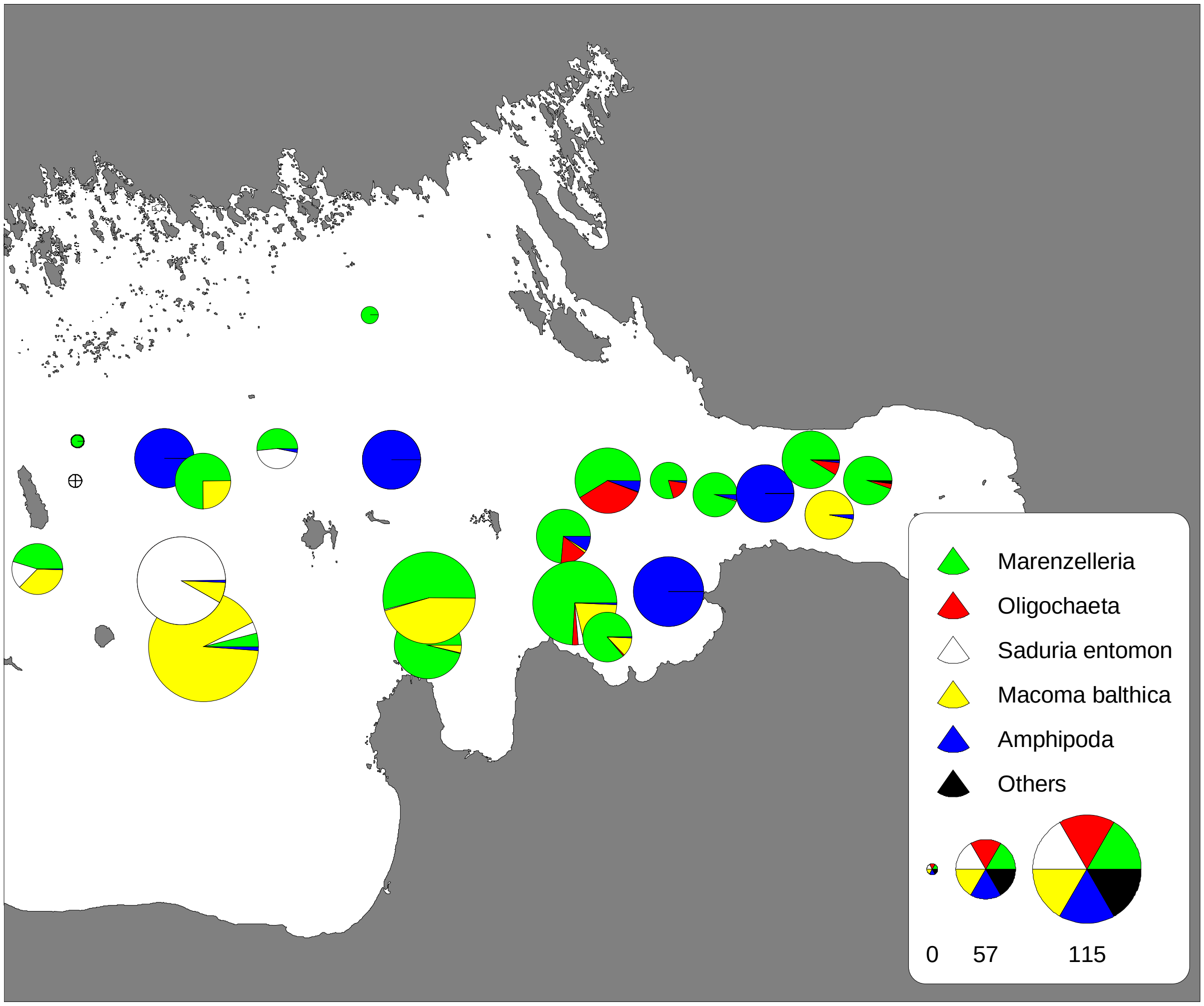


Fig. 4.19.6. The distribution of biomass (g WW m^{-2}) of macrobenthic species in open areas of the eastern Gulf of Finland in July 2012.

The most described changes in macrozoobenthos are repeatedly registered during study period and are properly cyclic. Interannual short-term (with period equal to a few years) variations mainly were connected with natural cyclic processes in biological communities. The more long-term tendencies are caused mainly by large-scale variations of hydrographic conditions in the Baltic Sea. The major factors affecting the long-term macrozoobenthos dynamic are the Neva river runoff and water exchange with the proper Baltic Sea. In the easternmost inner part of the Gulf of Finland (Neva Bay) the key factor was the river runoff.

Accordingly, in the western outer areas the changes in macrozoobenthos were mainly connected with intrusions of oxygen-depleted Baltic waters leading to periodical formation of hypoxia and mass mortality of benthic organisms in the deep-water zone. In the periods of good oxygen conditions bottom communities restore. In contrast to these reversible changes replacement of native benthos by *Marenzelleria* can be characterized as irreversible regime shifts resulting in formation of new alternative community. It is difficult to predict the future trends because of feedback effects of other components of ecosystem. For example, most likely appearance of rich food resource for benthophagous fish because of increase of benthos biomass will influence on the ichthyofauna with possible cascade effects at other trophic levels (Maximov, 2011).

The Russian part of the Gulf of Finland includes as fresh as brackish water areas. In this connection it is necessary to use different methods for sampling, analysis and assessment of the macrozoobenthic communities state. Although from physiographical point of view the Neva Bay is part of the Baltic Sea, the seldom inflows of saline waters have not impact on local fauna, which is present by common inhabitants of rivers and lakes of the North-West Russia. Because of this, in the Neva Bay sampling and assessment of macrozoobenthos can be successfully carried out on in accordance the established national manuals e.g. (Metodicheskie.., 1983, Rukovodstvo.., 1983; 1992). The HELCOM methods of the Baltic Monitoring Program (HELCOM, 1988) is only appropriate for the eastern Gulf of Finland inhabited by Baltic marine species.

There are various benthic indecies which have been developed for assessments on the state of the surface waters under the EU Water Framework Directive and for the HELCOM Thematic Assessment on Eutrophication (HELCOM, 2009b). However applicability of these indexes in the Russian waters of the Gulf of Finland is questionable because of very low species diversity at the most part of the bottom area. All indexes are based on proportions of sensitive taxa and(or) species richness in benthic communities. Early when macrozoobenthos was dominated by amphipod *M. affinis* the abundance of this sensitive to disturbance species was used to evaluate the state of bottom communities in the open eastern Gulf of Finland (HELCOM, 2009b).

It is clear, that in present-day situation of *Marenzelleria*-dominated community the result of assessment depends from estimate of sensitivity of this polychaetes. Two diametrically opposite point of view are possible. On the one hand all *Marenzelleria* species can be considered as very tolerant to pollution because spionid polychaetes are among the organisms most tolerant to stress associated with low oxygen, on the other hand *M. arctia* is species from estuarine arctic faunistic complex as well as wide-recognized sensitive crustaceans *M. affinis* and *S. entomon.* These polychaetes dominated along time ago in bottom macrofauna of clear water arctic estuaries (Pirozhnikov, 1941). In addition *Marenzelleria* spp. is well-known ecosystem engineering (=bioengineering) species enhancing the some ecosystem services.

For example mitigation of eutrophication was recorded in the some Baltic areas after *Marenzelleria* spp. introduction as a result of bioirrigation activity (making of branchy channel net favored the penetration of oxygen into sediments) of polychaetes (Karlsson et al. 2010, Norkko et al. 2012). In this respect, it is of interest the new proposed indicator for soft benthic habitats based on sediment profile imagery (HELCOM secretatiat, 2013), which can produce the direct and objective measure of health of benthic community. In general, taking into account the high biomass values of macrozoobenthos and positive consequence of *Marenzelleria* development at ecosystem level, the modern state of the soft-bottom macrofauna communities in the eastern Gulf of Finland can be assessed as good.

4.19.3. Long-term tendencies of the indicator’s dynamics

There are opposite tendency in the two main regions of study area. In the easternmost inner part of the gulf (Neva Bay) the bottom communities degraded because of unfavourable hydrological changes and anthropogenic impact. In the western outer areas (the eastern Gulf of Finland) shallow bottoms showed long-term tendency for increase of macrofauna biomass because of eutrophication. In the deep zone hypoxia-induced impoverishment of bottom communities in late 1990s and early 2000s followed by large-scale invasion of polychaetes *Marenzelleria arctia*.

4.19.4. Relevancy of the indicator and general monitoring data sufficiency in the Russian part of the Gulf of Finland

Macrozoobenthos is sensitive and relevant indicator of changing environmental conditions in the Russian waters of the eastern Gulf of Finland.

In general, the information is sufficient. However drastically and rapidly changing situation generates the uncertainty of assessment. The changes are occurring more quickly than we understand them.

4.19.5. GES boundaries of the indicator

At present succession stage, the high level of biomass and abundance can be considered as indicator of good environment status. In the future species diversity or any popular multimetric benthic indexes can be used for assessment. But special further investigations in this field are necessary.

4.19.6. Monitoring recommendations for the Russian part of the Gulf of Finland

The annual sampling in July-August is recommended. It is reasonable to base on standard stations of State Observational Net monitored by North-West Administration on Hydrometeorology and Environmental Monitoring of the Russian Federation, because the long-term data series at these stations are available. Recently this sampling net includes 18 stations in the Neva Bay and about 15 stations in the eastern Gulf of Finland. In the Neva Bay several sites which situated in the places of strong local anthropogenic impact (see port, fairways etc.) can be excluded. At each sampling site the abundance, biomass and species composition (with exception of taxonomically difficult groups) must be determined.

The monitoring stations localization as it is shown on maps (figs. 4.19.1-4.19.4; 4.19.6).

4.20. LOWER DEPTH DISTRIBUTION LIMIT OF MACROPHYTE SPECIES

4.20.1. Description of the indicator

This indicator demonstrates the depth distribution limits for alive (attached) macrophytes, combined both with algae and vascular plants representatives. It may be implemented both to macrophytes settlements ('belts') as a whole and to certain local key-species, which are important for habitat structure (like *Fucus spp*., or *Zostera spp*., et al.) (HELCOM, 2012a;b).

The depth distribution limit may be determined as the deepest specimen find or as minimal macrophytes coverage value along the transsect directed to the depth.
It is a slow-reacting indicator, responding to reduced water transparency, eutrophication changes and anthropogenic impacts (like bottom dredging and other way water turbidity increase).
The unit of the indicator measurements is meter.

4.20.2. Appropriateness of the indicator to environmental assessments of the Baltic Sea regions and specifically to the eastern (Russian) part of the Gulf of Finland

Macrophytes are primary producing and habitat-forming organisms of the shallow water area and thus their species composition, condition, abundance and depth distribution limit reflects very well the general environmental condition of the area of water. As habitat builders, macrophyte species are the representative indicators for all species (macrophytes, epifauna, small fish) associated to this kind of habitat/phytal community (HELCOM, 2012a;b). Indirectly the indicator describes such important characters of marine environment as:

- integral water clarity;
- suspended matter concentration (incl. anthropogenic pressures);
- eutrophication level;
- phytobenthos primary production;
- bottom substrata characters and distribution;
- bottom abrasion with ice;
- phytophylic fishes spawning substrata availability;
- and some other.

The width of macrophytes belt offshore is also the character of the bottom relief.
There are many species of aquatic plants (algae and vascular plants) may be reffered to macrophytes in the eastern part of the Gulf of Finland, what makes macrophytes available and important biodiversity environment indicator.

However, because of desalination of the Russian part of the Gulf of Finland some common Baltic marine species of macrophytes are distributed very limited (*Fucus vesiculosus*), and developed poorly or absent at all (*Zostera marina*).

An intercalibration for this indicator general implementation is needed, what is partly has been done among of some HELCOM countries (HELCOM, 2012a).

4.20.3. State of the indicator in the eastern (Russian) part of the Gulf of Finland

4.20.3.1. Implementation of the indicator

Lower depth distribution limit of macrophyte species never was implemented as indicator in a practice of environmental monitoring in the Russian part of the Gulf of Finland. However
the understanding of this indicator validity in desctriptions of environment among of investigators and some observations and disembodied data are exist.

4.20.3.2. Status of recent researches of the indicator and available data

Neva Bay – is a fresh and shallow water body, with flat bottom relief and sandy grounds, charterized by dominated depth about 2 m and with several artificially deepened navigation canals.
Aquatic and semi-aquatic flora of the Neva Bay consists of mostly vascular plants, where the semi-submersible macrophytes or the plants with floating leaves are predominated. Thus their vertical distribution has rather week relation to the water clearness, especially taking into account very shallow bottom.

Typical vertical and horizontal profile of the Neva Bay aquatic plants community is described on the figure (fig. 4.20.1).

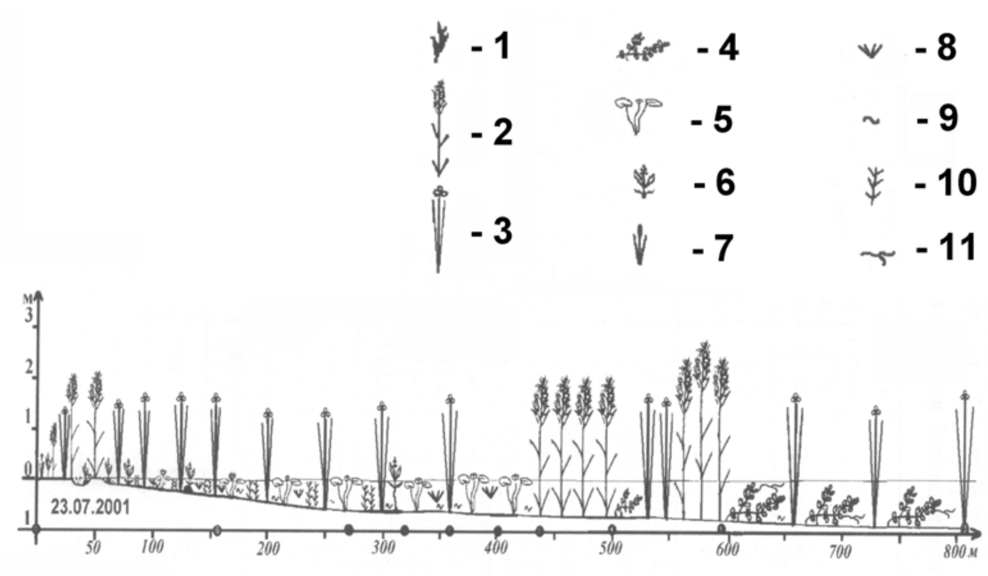


Fig. 4.20.1. Typical vertical and horizontal profile of the Neva Bay (N coast) aquatic plants community (after Zhakova, 2008). 1 – fam. Cyperaceae; 2 – *Phragmites communis* ; 3 – *Scirpus lacustris*; 4 – *Potamogeton perfoliatus*; 5 – *Nymphaea spp.* ; 6 - *Nuphar lutea* ; 7 – aquatic motley grass; 8 - *Typha latifolia*; 9 – *Stratiotes aloides*; 10 – *Potamogeton pectinatus*; 11- *Cladophora glomerata*.

Eastern Gulf of Finland characterized by salinity gradient in interval at the surface as 0-5 %**o** and by apperance of some species of marine algae among of macrophytes. Totally, in the Russian part of the Gulf it was found 42 species of macroalgae – 22 species of green, 14 of brown and 7 of red algae (Balashova, Nikitina, 1989; Kukk, 1995; Balashova et al., 1999; Kovalchuk, 2008). Taxonomical regional lists of the macrophytes can be found in the literature citation therein.

One of the most common and most important macrophytes in the whole Baltic Sea ecosystem is the bladderwrack – *Fucus vesiculosus*. However because of the salinity limitation its distribution within the Russian part of the Gulf is also limited (fig. 4.20.2).
The macrophytes distribution of the northern coast of the E part of the Gulf of Finland (area of the Vyborg Bay and Primorsk) were studied by SCUBA-diving twice during last two decades **(**Lehvo, Bäck, 2000; Kovalchuk, 2007; 2008). It was noted along the islands the *Fucus* zone extended to 2-5 m depth with some poor individuals of *Fucus* plants at 6 metres. Understorey

Fig. 4.20.2. Distribution of the *Fucus vesiculosus* in the eastern Gulf of Finland.

species at most sites were *Cladophora glomerata, Ceramium gobii* and, further down, *Cladophora rupestris.* At open sea islands the red corticate algae *Hildenbrandia prototypus* was the dominant algal species below five metres depth. *Cladophora rupestris* grew in small patches of a few individuals. A few *Sphacelaria arctica* tufts were found at 6 metres depth.
One typical profile of macrophytes distribution on the rocky slope of Bolshoy Fiskar island is described below (fig. 4.20.3).

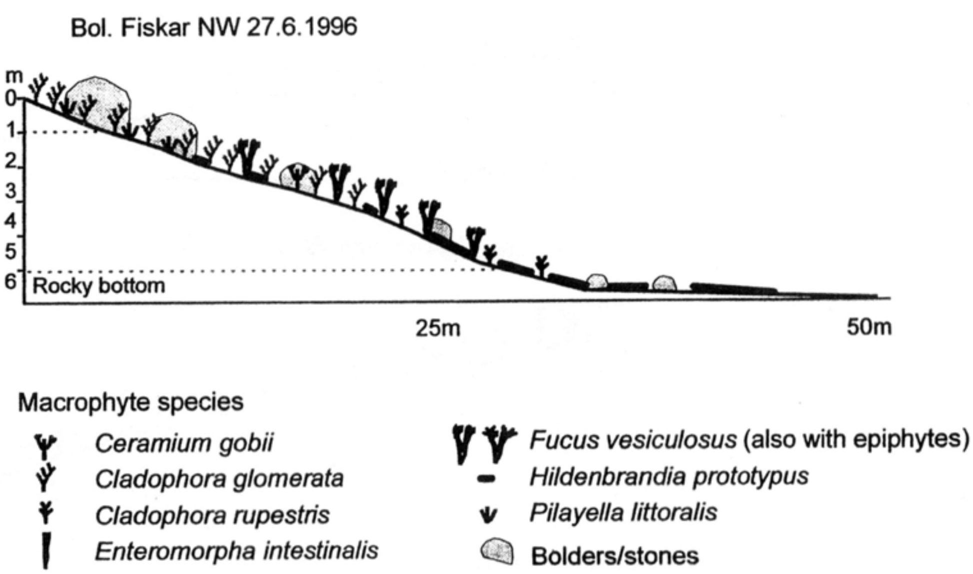


Fig. 4.20.3. The profile of the macrophytes distribution on the Bolshoy Fiskar island (after Lehvo, Bäck, 2000).

More detailed investigations demonstrated that *F. vesiculosus* is abundant species in this area in the depth interval from 0.5-0.8 m to 4.0-4.5 m. It creates the *Fucus*-belt along the western (outer) coasts of Beresovy Islands, but it is along the eastern (inner) shoreline (fig.2). Red algae *Hildenbrandtia* was found as a deepest macrophyte down to the 8.7 m (Kovalchuk, 2007).

Evidently both highest water clarity and the lowest depth distribution limit of macrophyte species may be found at Gogland island, most distantly disposed island (Kukk, 1988; Kovalchuk, personal comm, our own and other unpublished observations), however there is no available recent data from this region.

4.20.4. Enterprising researches of the indicator by SPbSU in summer 2013

The macrophytes distribution of the southern coast of the E part of the Gulf of Finland (area of the Narva Bay, Luga Bay and Koporskay Bay) was studied during enterprising researches of the indicator by SPbSU in summer 2013 by using SCUBA-diving, boat dredge and underwater TV-camera.

There are four offshore transsects were traced out from 0 to 5 m depth (fig. 4.20.4). The bottom relief in this area is so flat, that distal point of the transsect (5 m isobath) could be as 1200-1500 m far away offshore (fig. 4.20.5).

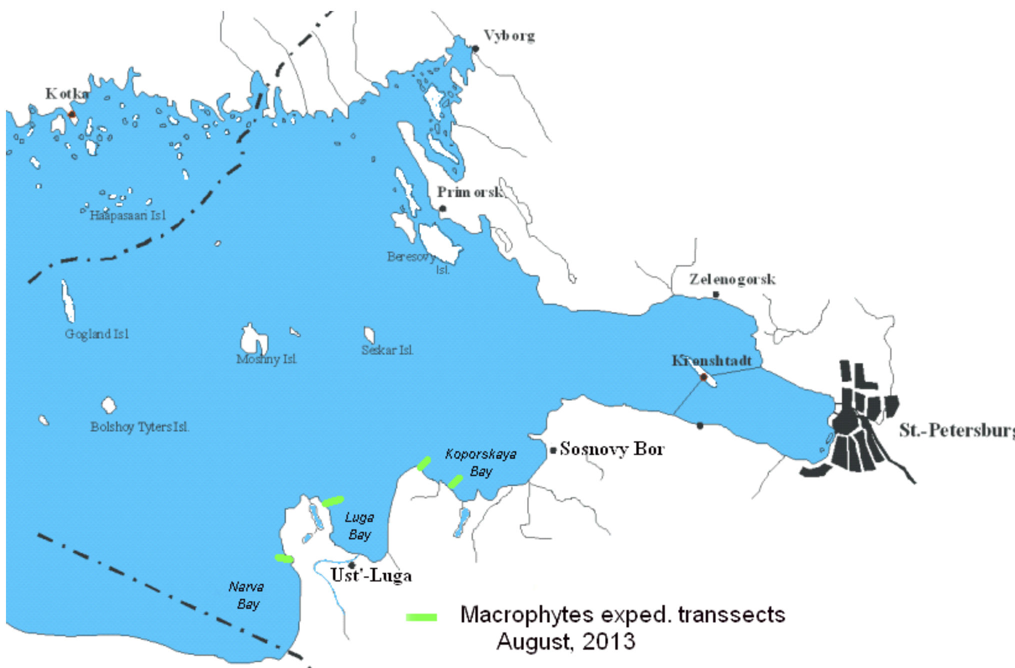


Fig. 4.20.4. Offshore macrophytes research transsects of SPbSU expedition (August, 2013).

The flora of macrophytes of ivestigated southern coast area has some distinguishes from one, described on the north coast area. For example, red algae *Hildenbrandtia*, so common at the northern coast, was not registered at all. It is possible that *Ceramium gobii* and *Enteromorpha intestinalis*, noted on the north ((Lehvo, Bäck, 2000) are the same two species actually as *Ceramium tenuicorne* and *Ulva prolifera* (SPbSU recent research). One typical profile from western part of Koporskay Bay is descrbed below (fig. 4.20.5).

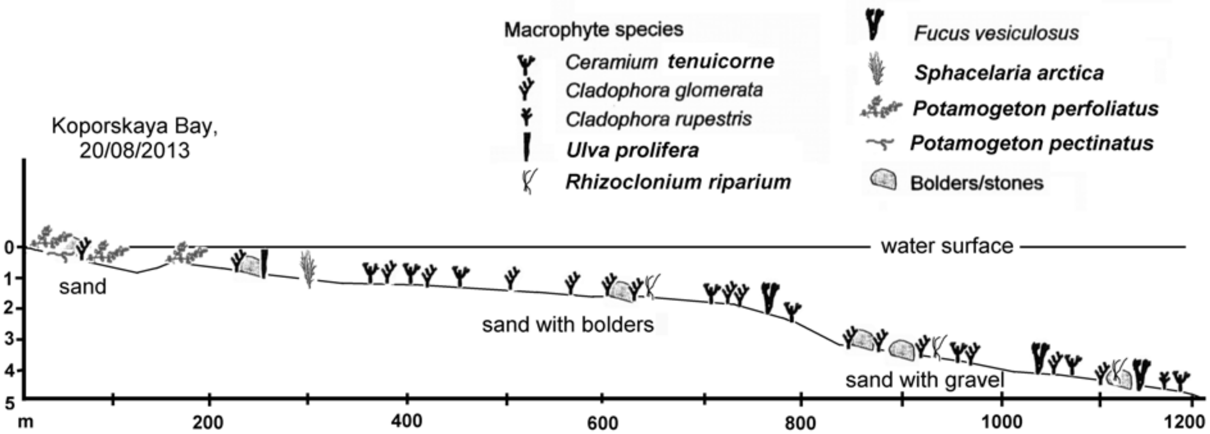


Fig. 4.20.5. Vertical and horizontal profile of the transsect in Koporskaya Bay of SPbSU expedition

Fucus vesiculosus was found on three transsects from four. It was absent only from the S part of Narva Bay (S part of Kurgalsky peninsula), where it is declining because of the influence of fresh water of Narova (Narva) river runoff. It is known that well-developed *Fucus* fields are already present in the Narva Bay at the middle and northern coasts of this peninsula up to isobath 4-5 m (unpublished SCUBA-diving observations of A. Antsulevich), where the runoff impact of Narva river is insignificant.

There are few specimens of *Fucus* with folded thallus were found. In spite of some authors (Kovalchuk, 2007) had reffered such specimens to a separate form *F. vesiculosus f. plicata* Kjellm., here it is not accepted (fig. 4.20.6).

Two species - *Ceramium tenuicorne* (Rhodophyta) (fig. 4.20.7) and *Cladophora rupestris* were found at deepest part of the transect.

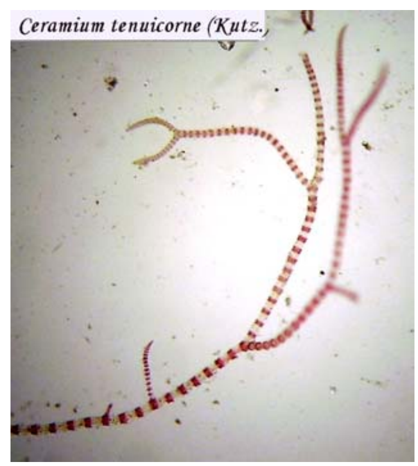


Fig. 4.20.6. Usual and folded thallus of *F. vesiculosus* from site of E part of Luga Bay.

Fig. 4.20.7. *Ceramium* the same *tenuicorne* (W part of Koporskaya Bay)

In all transsects the lowest depth distribution limit of macrophyte species was about 4-5 m; the deepest algae for the **southern coast** were as follows:
- *Cladophora rupestris* - 5 m (recent research of SPbSU)
- *Ceramium tenuicorne* - 5 m (recent research of SPbSU)
- *Fucus vesiculosus* - 4.5 m (recent research of SPbSU).
- *Hildenbrandtia sp.* – not found.

For **northern coast** and open Gulf area it was more:
Cladophora rupestris - 5.5 m (Lehvo, Bäck, 2000);
Ceramium tenuicorne (? = *C. gobii* sensu Lehvo, Bäck, 2000) – 5.5 m (Lehvo, Bäck, 2000);
Fucus vesiculosus – up to 4.5 m (Lehvo, Bäck, 2000; Kovalchuk, 2007); some more at Gogland.
Hildenbrandtia sp. – 8.7 m (Kovalchuk, 2007).

It was demonstrated that lowest depth distribution limit of macrophyte species is very sensitive to dramatic changes of water clarity, what may be caused by natural, but mainly by anthropogenic factors (like bottom dradging or sea-ports building). During the intensive building of SPb-City ferries passenger's terminal (so-called 'Marine Front of St.-Petersburg') in period of 2007-2009 it was noted the decrease of lowest depth distribution limit of macrophyte species not only in the Neva Bay (vascular plants), but also more distally (red algae) (Antsulevich, unpublished report, 2008; Kovalchuk, 2008). However, one-two years after the stop of impact it was registered the restoration of the macrophytes vertical distribution.

When looking to 35-years old background data from the same area (Kukk, 1979), the same group of macrophyte species were distributed 1-3 m lower than recently, what means the indicator demontrates the negative tendency last decades.

4.20.5. Determination of GES boundary

The establishment of GES boundary for this indicator is very complicated problem. Firstly, we have to answer several questions as follows:
- should it be uniform for the entire Baltic Sea or it should be regional (or even subregional)?
- should it be based on the same (or similar) list of macrophytes species, or the macrophytes-indicators may be various regionally?
- should be the scale of indicator's measurement (in metres) uniform for the Baltic Sea, or this parameter may (should) vary from region to region?

Because of the greate non-uniformity of the Baltic Sea and the Gulf of Finland specifically as well the uniformity of the indicator is rather problematic. Fortunalely, there are few of Baltic Sea common species are inhabit in the Russian part of the Gulf. Mostly they have extremal distribution limit in the E part of the Gulf of Finland, what means they inhabits there in non-favourable environmental conditions.

The boundary for GES of macrophyte indicator has been intercalibrated among the Baltic countries (excl. Russia), even though the target setting methods have differed among countries and areas. Targets for some species have been estimated on the basis of wide datasets in varying environmental conditions. The intercalibration of the national indicators was not finalized.

In Finland, in the Haapasaaret area, close to Russian border a dense *Fucus vesiculosus* zone was recorded at a depth of 1-5.5 metres (Lehvo, Bäck, 2000). This lower depth distribution (5.5 m) for *F. vesiculosus* may be estimated as 'good environmental status' for the eastern part of the Gulf of Finland what can be accepted for neighboring area of the Russian part of the Gulf of Finland. Evidently the lower depth distribution of *F. vesiculosus* as 4.0-4.5 can be regarded as lower boundary for GES (the presence of available substrata on the bottom is considered).

4.20.6. Monitoring proposal

It is suggested that this indicator should not be used at single sites but rather for a larger area (HELCOM, 2012).

SCUBA-diving in combination with underwater video registration and/or photography are pehaps the most important method for observations, sampling and mapping of the macrophytes distribution. It may be accompanied with dredging just to reduce the diver’s work, because diving is very demanding in terms of time, costs effort, equipment and specialized skills of investigators.

Judging from known vertical destribution of key macrophytes species the distal point of the transcect should be placed on the depth 6-7 m for the eastern part of the Gulf of Finland. In conditions of very shallow water and flat bottom relief peculiar for majority of sites in the Russian part the length of transsect for such depth may reach over 1000 m in many cases, what brings additional difficulties for diver’s work. In bad visibility underwater it is useful to collect not only plants, but also big stones with algae for careful investigation afterwards (fig. 4.20.8).

Fig. 4.20.8. Lifting up a big stone with filamentous algae (Narva Bay, August, 2013)

The list of macrophytes for monitoring should be restricted by few most common and important species like *Ulva (Enteromorpha) spp*., *Cladophora rupestris, Ceramium tenuicorne* with special attention to *Fucus vesiculosus*. The quality of the core indicator will improve with addition of more species into monitoring.

Monitoring sites are approximately shown on the map (fig. 4.20.9). All sites within the area are habitable by *Fucus.*

Each site may be represnted by 2-3 transects, regularity of monitoring – once per two years. Areas were choosed at the coasts to allow to make monitoring using small boats. However the open sea islands are interesting as well and monitoring on 1-2 islands (for example Moshny and/or Gogland) can be done once per four years. Recommended monitoring period – August, September.

Such monitoring can be executed by Biological devision of St.-Petersburg State University (Dept. of Ichthyology and Hydrobiology and Dept. of Botany), where the specialists are present.

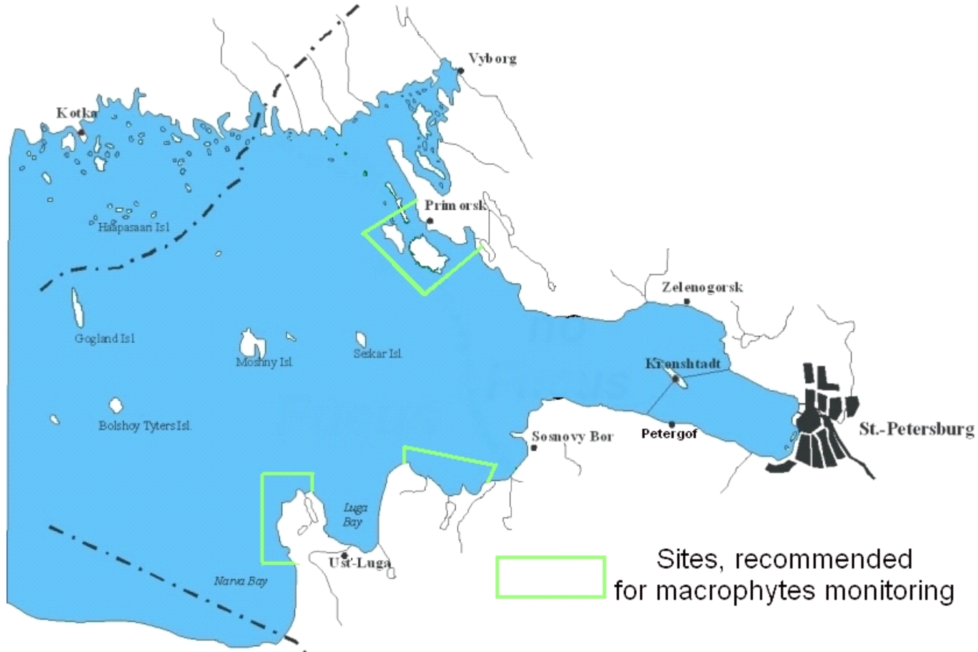


Fig. 4.20.9. Areas (sites) recommended for macrophytes monitoring.

4.21. POPULATION STRUCTURE OF LONG-LIVED MACROZOOBENTHIC SPECIES

4.21.1. Description of the indicator

Long-lived species such as the bivalve molluscs *Mytilus edulis/trossulus, Cerastoderma glaucum, Arctica islandica* and *Macoma balthica*, the isopod crustacean *Saduria entomon* or decapod crustacean species are key species in the benthic community and reflect its condition. The population structure, measured as abundance per size class, is proposed to reflect physical disturbance as well as the indirect effects of eutrophication and selective extraction of species. Continued development of this indicator requires that the response to different pressures as well as the definition of the natural size spectrum be analysed. Although current monitoring in the Baltic Sea does not fully support this indicator, with slight modifications in the analyses the proportion of large individuals can be counted (HELCOM, 2012a).

It should be additionally noted as follows:

- the decapod crustaceans, *Cerastoderma glaucum* and *Arctica islandica* are not peculiar for the Russian part of the Gulf of Finland;
- no commercial exploitation of mentioned above long-lived species goes on in the Russian part of the Gulf of Finland; i.e. no selective extraction of these species and special pressures to larger individuals have place in this area of water.
- *Saduria entomon* according to HELCOM is included here into the list of long-lived species, however evidently its life duration is not longer than two years (Haahtela, 1990).

CORESET benthos experts group concluded that the survey of the population structure of large, long-living macrobenthic invertebrates (especially bivalves) can be a valuable tool for the assessment of the state of the macrobenthic community in soft-bottom habitats (HELCOM 2012a, b). This conclusion is based conceptually upon ability of long-lived species to integrate long-term environmental conditions. Also, it is well known, that large-sized and long-lived species are, as a rule, sensitive to disturbances. The size structure of population of these species is good indicator responding to hypoxia and physical disturbances such as bottom trawling, dredging etc.

4.21.2. State of the indicator in the Russian part of the Gulf of Finland

Long-lived mollusks represented by few freshwater species of fam. Unionidae (the Neva Bay), by marine native species *Macoma balthica* and by non-indegenous *Dreissena polymorpha* (eastern Gulf of Finland). In November, 2013 at the western borderline of Russian area of water was found a settlement of little blue mussells (Narva Bay, Maly Tyuters Isl.).

Isopod crustacean *Saduria entomon* somewhere is abundant in the eastern Gulf of Finland bottom communities.

Unionidae

The settlements of Unionidae demonstrate substantial long-term dynamics of abundance and area of distribution. The first quantitative researshes of benthic fauna in the Neva Bay, carried out in 1930-th, showed wide distribution and significant abundance of large long-lived mollusks of genera *Anadonta* and *Unio*, up to 260 g/m^2 (Materialy..., 1949). In 1960-th large mollusks were absent in open part of the Neva Bay (Kokolia, 1963). Lately in the second half of the XX century large Unionidae were noted as rare and not numerous component of benthos (Salazkin, 1982; Finogenova et al., 1987). However to the end of XX century powerful settlements of these bivalves (banks) with biomass up to 200 g/m^2 had appear again (Finogenova et al., 1999 a;b). Judging from recent researches their biomass is declined again to the average values 3-4 g/m^2 in the central part of the Neva Bay and to 10 g/m^2 - it in its NW part. However their functional role in the Neva Bay ecosystem is still rather important.

One reason of unionids biomass decrease is dredging works has been done for St.-Petersburg passengers terminal construction and for so-called ‘Marine Facade of St.-Petrersburg’ raised beach creation. These works brought to sharp water siltation, what had a negative impact to mollusks filtration ability. An other reason of total unionids biomass fall and of evident decrease of larger individuals proportion (no special data for this changes) is the high level of toxic secondary pollution, caused by the the same dredging works. The last was confirmed by high level of heavy metals in tissues of unionids (Golubkov et al., 2011).

Macoma balthica

Long-term tendency of these marine bivalves' biomass increase evidently linked with eutrophocation. Last 60 years the biomass of *M. balthica* have increased 5-7 times more (Maximov, 2006). Short-term changes in *M. balthica* abundance fallow presumably the salinity fluctuations. In 1980-th the biomass of these mollusks was regustered up to 50 g/m2 close toKotlin Island (at the same period catches of cod were usual in the westernmost areas of the Russian part of the Gulf of Finland; see the chapter 4.15 of this report), but to 1990-s *M. balthica* had already disappeared from this shallow water area (Maximov, 2003). This evidently was dependend from the stop of big North Sea water intrusions to the Baltic Sea have been registered in period 1985-1993 (HELCOM, 1996; Liyahin et al.m 1997). Density of *M. balthica* is influenced by anthropogenic pressures as well as by natural hydrological factors. This bivalves disappear soon from the sites of intensive hydrotechnical works (like bottom dredging, sand extraction and dredged material dumping) (Maximov, pers. data).

In strongly contaminated areas of the Baltic Sea, *M. balthica*, as abundant species, is a promising test-object for a quality of environment assessment (Smolarz, Bradtke, 2011; Basova et al., 2012).

Several investigations of *M. balthica* population structure were carried out in the White Sea area, however they still not executed in the Russian part of the Gulf of Finland, what is certainly a gap in our knowledge.

Dreissena polymorpha

This alien species was firstly found for the Gulf of Finland in 1990 (Antsulevich, Lebardin, 1990; Antsulevich et al., 2003; for short history and distribution see the chapter 4.24. of this report).
For *D. polymortha* of the Gulf of Finland inter-annual abundance fluctuations, caused by irregular population replenishment with the juveniles are peculiar (Antsulevich et al., 2003; Orlova et al., 2006).

It is only long-lived macrozoobenthic species from the Russian part of the Gulf of Finland with well studied (once) structure of the population.

Zebra mussels inhabit only on hard bottoms or other hard substrates, attaching to vertical walls or sheltering inside of natural hollows, that is why SCUBA-diving is the most adequate way for their sampling and studies.

Because the position of northern extreme of *D. polymorpha* distribution is very important and it is still the question of discussions, the data from Russian NW was analysed. Additional material was collected in the mouth of Severnaja Dwina river (estuary of the White Sea), near the city Arkhangelsk (64^{o}33' N). The data on the zebra mussel growth from its native area (Don river basin, Russia) was in use for comparison with the data from the Gulf of Finland (Antsulevich et al., 2003).

Quantitative studies have been done by sampling or calculations directly under the water with the frames 0,25 and 1 m^{-2} or along the bottom transsects, depends on the mussels density and water transparency. The structure of the zebra mussels populations from various sites of the Gulf of Finland was studied by measuring and scaling of the mussels with following analysis. Totally about one thousand of specimens were investigated for this reason.

For studies of dreissena spat settling, the density, biomass and the growth rate of the juveniles the special underwater experiments have been carried out during six years in the Luga Bay (two sites, 1993-1996), Santio island (two sites, 1995-1998) and Haapasaari Archipelago (one site, 1996-1999). For these purposes an artificial substrata maiden of PVC plastic and asbestos-concrete have been deployed on the depth 2-8 m (8-12 substrates X 0,25 m^{-2} per each site). Substrata were checked by divers twice per season - in the beginning and in the end of presumable period of mussels reproduction (June-September).

Several substrata (usually 2-3 per each site) were marked and left untouched for two-three seasons. This way initial generations as the just-settled mussels (age 0+) and ones of age 1+ and 2+ were collected and observed in 'clean' conditions of controlled experiment in a nature. Young mussels were measured to the nearest 0.1 mm using an ocular-micrometer. The position of first and second (if it present) annual rings was measured as well, what has a great importance for correct determination of age of bigger individuals. Totally about 200 of young mussels were investigated from artificial substrates (Antsulevich et al., 2003).

Growth rate investigations were executed for five local zebra mussels settlements, disposed in various sites of the Gulf of Finland, both in Russian and in Finnish areas of water. Additionally for comparison most northern known settlement of *D. polymorpha* from the region of Arkhangelsk was investigated and involved to the growth rate analysis. For this goal 313 of mussels (from 20 to 139 per local settlement), representing an actual structure of each local population (what means - all age and size groups in natural proportion) were examined. Individual age was identified by studies of external shell morphology. As marks, fixing winter stops of mussels growth (annual rings), were accepted only full-cyclic morphological structures, creating the step-shaped zones on a shell. Measurements of about 200 of 1-2-years-aged juveniles from the controlled artificial substrata (artificial reefs) were used for the verification of the grouth rates and shell's marks position (first 'rings') on the initial stages of mollusks life-cycle and growth. About 1500 of annual rings measurements were executed and analysed. Mussels life duration in every site was studied by this way as well.

The growth rate of the zebra mussels was studied by reconsructing their ontogenetic growth. The swing of variation and standart error bars were indicated on a growth curves. Zebra mussels growth rates from different habitats were classified by cluster analysis procedure. It was demonstrated that
within neighbouring Russian and Finnish areas of the Gulf of Finland the growth rates and the populatioln structure are similar. But in Severnaja Dvina River the growth rate is faster and maximal size is larger (table 4.21.1). The mussels from native habitats (Tsymljansk reservoir, Don river, Azov Sea basin) the growth rate of the zebra mussels is much faster and the definitive shell length is much bigger (up to 38-40 mm) (fig. 4.21.1).

Lately it was found *D. polymorpha* in the Russian part of the Gulf of Finland in general is faster growing and beeing finally larger, than in more western and northern habitats in Finland. Spatial disribution of the zebra mussel goes as far to the west as Pellinki Archipelago (Finland). Evidently zebra mussels inhabiting westernmost parts of the Gulf of Finland beeing supressed by higher salinity (they needs more of energy for osmatic regulation) and, probably, by lower sum of temperature (Antsulevich, personal unpublished data).

Table 4.21.1. Growth indices of the zebra mussels from studied localities of the Gulf of Finland (GoF) and the White Sea estuary (Arkhangelsk) (after Antsulevich et al., 2003).

Locality	Index	Zebra mussels shell length on winter growth stop at age (*mm*):										
		0+	1+	2+	3+	4+	5+	6+	7+	8+	9+	L_{max}
1. Santio Isl. (E GoF	ΔL	1,1-3,6	4,2-6,8	6,9-11,3	10,-14,6	12,8-16,6	14,9-19,5	16,9-22,0	19,3-21,3	-	-	
at FIN-RUS border)	L_{ave}	2,5±0,4	5,5±0,2	8,7±0,4	11,9±0,6	14,5±0,5	16,8±0,7	18,9±1,0	20,4±1,2	-	-	24,0
2. Haapasaari	ΔL	0,6-2,4	2,5-6,8	6,6-9,5	8,5-12,2	10,3-15,2	12,6-16,4	13,8-18,1	15,5-18,8	16,4-19,5	-	
Isl. (East. GoG)	L_{ave}	1,6±0,2	5,8±0,2	8,1±0,3	10,5±0,4	12,6±0,5	14,3±0,6	16,0±0,6	17,4±0,9	18,8±0,5	-	20,5
3. Bolshoy	ΔL	1,3-1,2	4,0-6,6	6,9-9,9	8,2-13,5	10,3-14,6	12,0-16,7	12,7-16,8	17,7-18,2	19,0-19,3	19,9-20,2	
Fiskar Isl. (Rus. GoF)	L_{ave}	1,7±0,2	5,2±0,3	8,0±0,4	10,2±0,4	12,3±0,3	14,5±0,6	15,5±1,0	18,0±0,3	19,1±0,3	20,1±1,4	20.4
4. Primorsk	ΔL	1,2-4,0	3,5-7,0	5,1-11,0	9,2-13,9	12,5-15,7	15,0-17,1	16,3-20,1	18,4-21,9	19,7-23,5	-	
(GoF, Vyborg Bay)	L_{ave}	2,5±0,2	4,6±0,4	8,0±0,5	11,4±0,5	14,3±0,4	16,2±0,5	17,8±1,2	19,6±0,8	20,9±1,7	-	24,2
5. Vistino	ΔL	1,6-5,4	4,3-7,6	6,9-10,6	8,4-14,9	9,8-17,0	12,9-19,2	16,4-20,7	19,2-22,2	-	-	
(GoF, Luga Bay)	L_{ave}	2,6±0,2	5,6±0,2	8,7±0,3	11,6±0,4	14,0±0,6	15,7±0,8	18,0±1,0	20,5±1,8	21,3	-	22,8
6. Arkhangelsk	ΔL	2,2-7,2	6,5-12,8	9,0-18,3	14,0-20,8	17,9-22,7	21,7-24,1	-	-	-	-	
(Sev. Dvina river)	L_{ave}	4,4±0,6	9,5±0,8	14,3±0,7	17,5±0,6	20,1±0,8	22,7±0,5	24,8	-	-	-	25,3

Notes: ΔL - variation of zebra mussels shell length (mm); L_{ave} - average shell length with standard deviation (mm); L_{max} - absolute maximal shell length (mm), observed in the local population.

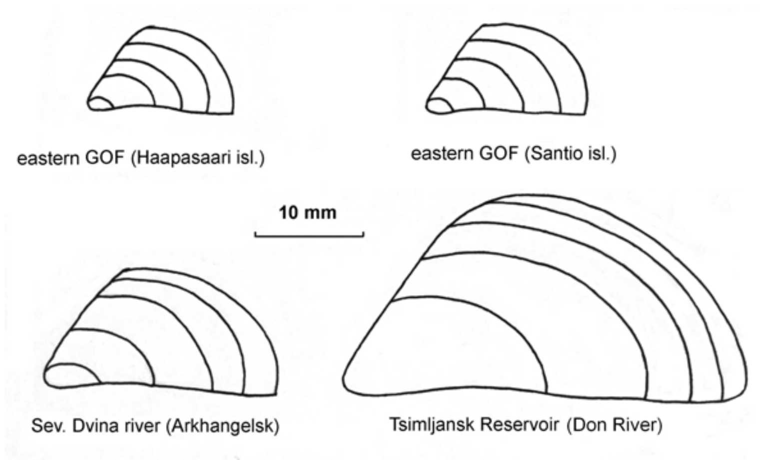


Fig. 4.21.1. Four averaged by mean size zebra mussels of the same age (4+) from four different areas (upper two shells are from the eastern Gulf of Finland) (after Antsulevich et al., 2003).

There are about two decades passed from the zebra mussels structure of population researches have been, what may be correlated with the climat changes or other developments in the environment. described above. During this period *D. polymorpha* has became more abundant both in Russian and in Finnish parts of the Gulf of Finland (Orlova et al., 2006; Antsulevich, 2012). It shoud be studied again if any changes in the zebra mussels structure of population have occured in the Gulf of Finland

Saduria entomon

The structure of population of this species depends very much on the period of observation. Untill the period of reproduction the density of population is not big; it is represented only by adult crustaceans of 1-2-years old. The period of reproduction in the eastern Gulf of Finland for this species is usually the second half of June - July. One female may release from brood chamber up to 80-110 of active mobile juveniles about 2.5-3 mm long (fig. 4.21.2). Then the structure of population reforms very remarkably thanks to addition of numerous juveniles, which are several tens times more abundant, than adult crustaceans (Antsulevich, pers. unpublished data).

Fig. 4.21.2. One adult female of *Saduria entomon* with whole content of its brood chamber – about 80

'new-born' juvenile crustaceans (Luga Bay, 21-st of June; depth 9 m) (photo by A.Antsulevich).

These glacial-relict crustaceans distributed in the westernmost regions of the Russian part of the Gulf of Finland. Isopods *S. entomon* can be found on the depth from 2 to 50 m, but they populate mostly deep water benthic habitats. *S. entomon* tactfully reacts for the oxigen declining. On the deep water station #

3 in the Russian part of the Gulf of Finland (60° 07,0′ N, 28° 04,0′ E, depth 50 m) this isopods have disappeared after hypoxia occurrence. Long-living bivalves *M. balthica* together with alien polychaetans *Marenzelleria spp.* were one from first settlers on lifeless sites of the bottom after the oxigen conditions recovery; the structure of the bottom community was changed this way remarkably (fig. 4.21.3).

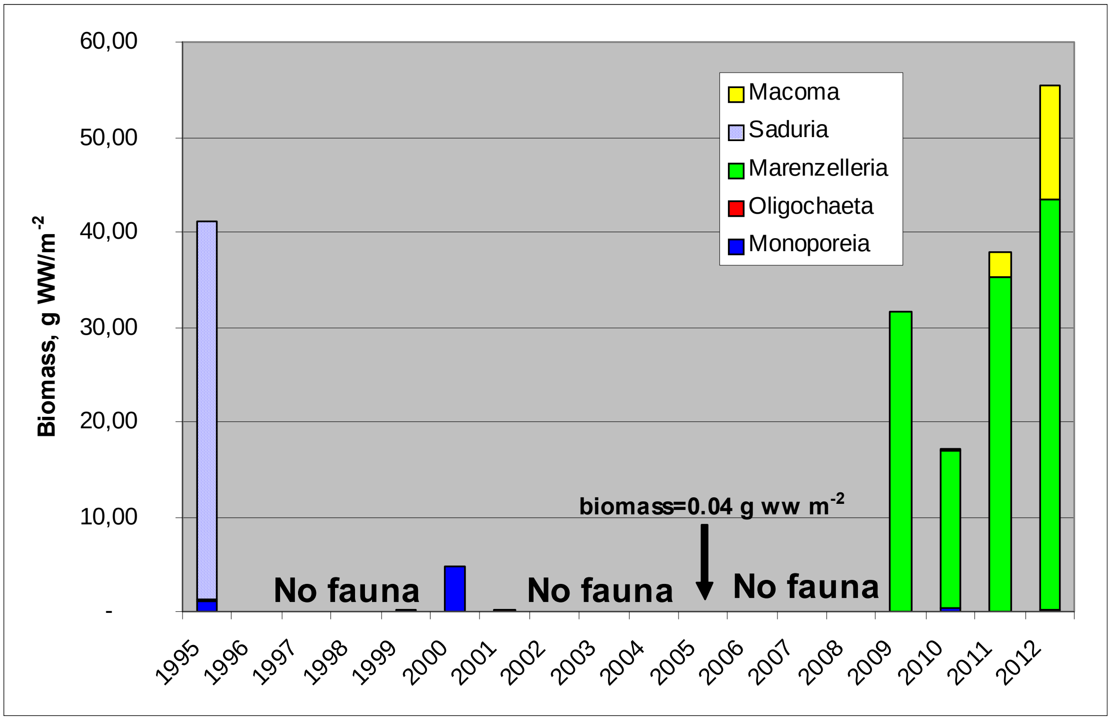


Fig. 4.21.3. Changes in biomass (g WW m^{-2}) of macrobenthic species on research Station # 3 (60° 07,0′ N, 28° 04,0′ E, depth 50 m) in 1995-2012. The absence of macrofauna is connected with mortality during hypoxic events.

Mytilus trosssulus

Recently the limits of the blue mussels distribution to the west in the Gulf of Finland are situated close to Pellinki Archipelago (Finland) at the northern coast (Antsulevich et al., 2003) and in the Narva Bay close to Estonian – Russian water border. In spite of notification of Gogland Island as marginal habitat of blue mussels in Russian area of water by Järvekülg (1979) (without confirmation of this statement by any data and/or references), blue mussels were not registered at Gogland untill now.

The only known small settlement of blue mussels (*M. trosssulus*) in the Russian part of the Gulf of Finland was found just not long ago at the Maly Tyuters Island in Narva Bay (depth 9 m; November, 2013; biomass about 95 g/m^2 of subtrata) by Alexey Maximov. This locality is in accordance to existing imaginations on blue mussels distribution in the Gulf of Finland. Evidently, it is a dependent settlement existing thanks to mussels' larvae inflow from Estonian side. In 1990-s blue mussels were not found both at Gogland and at Maly Tyuters islands (Galtsova et al., 1996, Galtsova et al., 1997). Their appearance can be explained by fluctuations or replacement of distribution area margins, caused by favourable for blue mussels saline water temporal intrusion to the east of the Gulf of Finland.

4.21.3. Relevance of the indicator for the Russian part of the Gulf of Finland

Population structure of long-lived macrozoobenthic species is a relevant indicator for all areas of the Baltic Sea. It reflects the sustainability or indicates disorders in local populations (=settlements) of one of main components of the ecosystem. Size-age structure of long-lived macrozoobenthic species is a character of their population condition, where main sign is the regularity of population replenishment with new young individuals.

It is well known the population structure may react sensitively to any changes in environment, caused by natural of anthropogenic factors. In opposite to indicators based on plankton data, population structure of long-lived macrozoobenthic species shows integral situation, formed during long-term developments.

4.21.4. Weakness of the indicator for the Russian part of the Gulf of Finland

There are two types of weakesses can be distinguished as follows:
A. Objective weaknesses, which are valid everywhere;
- long-lived macrozoobenthic species (adult ones) often more or less large, not abundant and scattered on the bottom; the bottom grab and other traditional tools brings insufficiant material for population structure investigations – as a result multiple sampling is needed or usage of other methods of sampling (SCUBA-diving, special dredges, trawls with very little mesh size, etc.; underwater photography or video may not help in this);
- some of long-lived macrozoobenthic species (blue mussels, zebra mussels) are hard bottom inhabitants, where bottom grabs are useless – special methods are needed there (SCUBA-diving, artificial substrata, etc.);
- fine quantitative investigations of juveniles is of great importance; usually they are small (1-3 mm), numerous and easy be damaged, what brings additional difficulties to sampling, sorting and processing the material;
- natural and anthropogenic impacts on the population structure are difficult to distinguish, especially if animals inhabits in environmental conditions, which are close to their ecological tolerance limits;

B. Subjective weaknesses, which are peculiar to the Russian part of the Gulf of Finland.
- just two species from HELCOM-CORESET proposal for long-lived macrozoobenthic species are available in the Russian part of the Gulf of Finland: *Macoma balthica* and *Saduria entomon*;
- there are ecological borders of distribution of all potential indicative species (*M. balthica, S. entomon, D. polymorpha,* Unionidae) placed within the Russian part of the Gulf of Finland. It means the population structure of all of them gradually or sharply changes within the area up to the total decline of the species because if salinity gradient **only** (then no indication of other pressures).
- existing monitoring data are represented by species abundace values and no monitoring data on population structure of long-lived macrozoobenthic species (with exception for *D. polymorpha*) is available at the moment from the Russian part of the Gulf of Finland.

The indicator by now may be considered as relevant, useful and envisaging further development one, rather than ‘plug-and-play’ one in the Russian part of the Gulf of Finland.

4.21.5. GES boundaries

The presence in the local populations of all generations (cohorts) in more or less stable proportions, what is the character of successfull and regular reproduction and juveniles survival every year.
Another GES character is the sustainability of reproductive cohorts mean size.

The supression and especially the decline of any kohort is a certain sign of non-GES of the local population, as well as the decrease of mean size in repoductive part of population.

4.21.6. Monitoring proposal

- firstly it is recommended to repeat large-scale population structure investigations of *D. polymorpha*, because of the presence of good comparative data. The same sites (local populations) as earlier should be studied;

- the population structure researches of *M. balthica* and *S. entomon* should be initiated on 3-5 sites of the eastern Gulf of Finland. Each site may be represented by several (3-5) closely disposed standard stations;
- the population structure researches of Unionidae species (genera *Anadonta* and *Unio*) should be initiated on 3 sites in the Neva Bay, where they are only long-lived macrozoobenthic animals. Unionidae were not mentioned among of HELCOM-CORESET long-lived macrozoobenthic species, but they are very important for the Neva Bay general condition indication.

The periodicity recommended for the indicator monitoring is once per four-five years. It is good to start as soon as possible to collect the initial data.

4.22. CUMULATIVE IMPACT ON BENTHIC HABITATS

4.22.1. Description of the indicator

The indicator measures the proportion of a benthic habitat being significantly impacted by a cumulative impact of anthropogenic disturbances (table 4.22.1). The indicator gives a result for each habitat type. The habitat data is based on the recent benthic habitat model of the EUSeaMap project and data sets on anthropogenic impacts are from the HELCOM Initial Holistic Assessment (HELCOM, 2010a). The indicator relies on reliable habitat and pressure data, but also on estimates of the weights of each pressure in the cumulative impact score, definition of a significant cumulative impact, and acceptable proportion of a habitat type being significantly disturbed (HELCOM, 2012a).

Use of the indicator in previous assessments: None

Table 4.22.1. Selected anthropogenic pressures causing physical impact on benthic habitats. The pressures are ranked according to human activities and for each pressure spatial resolution and the measured parameter are described (after Korpinen et al., 2013).

Human activity	Pressures	Description of the data
Demersal trawling fishery	Catch of demersal fish and nontarget species	Total catch or landing by demersal trawling gears in ICES rectangles (_50 km _ 50 km) was used as a proxy for the intensity. Source: national fishery authorities
Demersal trawling fishery	Abrasion of the sea floor	As above
Dredging and sand extraction	Habitat loss, siltation, noise	Point data. Amount of dredged material (in tonnes) used as a measure for the intensity. Source: national authorities
Disposal of dredged matter	Smothering	Point data. Amount of disposed material (in tonnes) used as measure for the intensity. Source: national authorities
Shipping in shallow water	Siltation, noise	Automatic Identification System (AIS) of large ships (length >25 m) in shallow waters (<15 m). Annual shipping intensity as a proxy for the pressure. Source: HELCOM
Loading of nutrients (N and P) and organic matter	Hypoxia	Polygon data. Average O2 concentration 2003–2006. Source: HELCOM
Waste water treatment plants	Changes in bottom salinity	Point data. Water flow from the plant as a proxy for the salinity change. Source: HELCOM
Bridges, oil rigs and coastal dams	Habitat loss, potential changes in hydrography	Point data. Number of installations per assessment unit. Source: HELCOM
Coastal erosion defense structures	Habitat loss, potential changes in hydrography	Length (in meters) per assessment unit. Source: European Environment Agency
Coastal nuclear power plants	Thermal change caused by cooling waters	Presence or absence per assessment unit. Source: HELCOM
Cables and pipelines	Habitat loss, thermal change, noise, electromagnetism	Length (in meters) per assessment unit. Source: national authorities
Wind farms	Habitat loss, noise	Number of turbines per assessment unit. Source: European Wind Energy Association
Beach replenishment	Siltation	Number of bathing sites per assessment unit. Source: European Environment Agency

4.22.1.1. Demersal trawling fishery

This way of fishery is not developed in Russian part of the Gulf mostly because of an absence in this area of commercial stocks of demersal fishes, peculiar to central and western Baltic.
Only trawl suitable for demersal fishing in the region belongs to the State Research Institute of Lakes and Rivers Fishery (GosNIORH) for scientific usage only. So, there is no impact from this side.

4.22.1.2. Dredging and sand extraction; Disposal of dredged matter

This way of impact is most substantial and most harmful in the area. Last decade the total amount of extracted bottom material is counted in several dozens of millions of cubic meters. It could be two relative, but some different processes distinguished as real 'sand extraction' (= removal) and a 'bottom ground replacement'. In the last case the material bieng exctracted has been returned to the sea area for building dams, new territories, beaches, etc.
Dredging work for new sea ports terminals building leads to habitat loss (irreversibly) and for siltation and noise (temporarily). As example, the littoral zone, together with macrophytes populated euphotic zone (and including the belt of *Fucus vesiculosus* – the species from regional Red List) has been lost on duration about 20 km of shoreline of the Luga Bay eastern coast.
Repair in-channel dredging of navigation routes comparably is very much less by scale.

Eastern part of the Gulf of Finland last decade as been strongly impacted by enormous bottom dradging activity. The impact of hydroengineering works can extend on appreciable distances and can have a negative influence not only on an ecosystems of adjacent regions, but also on water bodies as a whole (fig. 4.22.1).

Fig. 4.22.1. Dredging work in the Neva Bay, Strel'na, 2010 (photo by A. Antsulevich)

There are several sites in the Gulf of Finland for dredged matter disposal with strictly established borders scattered in the area and this impact is important as well (fig. 4.22.2; 4.22.4).

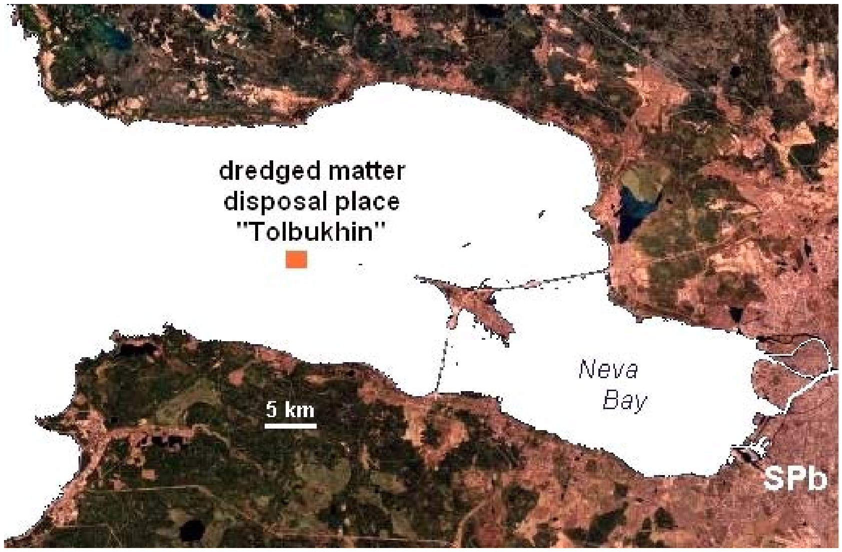


Fig. 4.22.2. Dredged matter disposal site close to light-house 'Tolbukhin', having allowed square of dump 694 hectares with the depth 13-27 m.

'Tolbukhin' is one the main dredged grounds dumping places. It is in use every year. The biggest annual volumes of the ground to 'Tolbuchin' as 3750 000 tonnes and 9 250 000 t were delivered in years 2006 and 2007 from the St.-Petersburg passenger terminal intensive building close to the city. Long tail of siltation can be observed even outside the Neva Bay when dredging work was carried out (fig. 4.22.3). General view of St.-Petersburg passenger terminal after the period of construction is presented on a photograph (fig. 2.22.8).

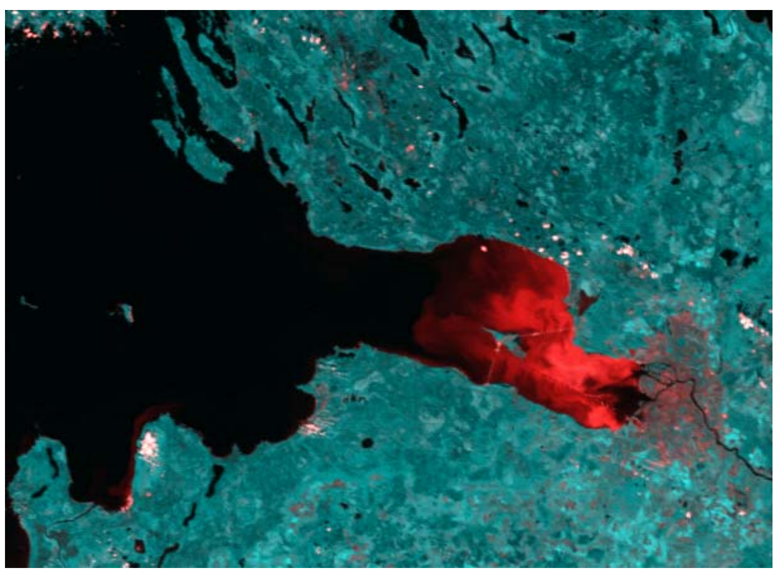


Fig. 4.22.3. Extremal siltation of the Neva Bay on satellite image 11.09.2006 (MODIS/Terra, 250 m) (after Central Research Institute of Robots Technics and Technical Cybernetics).

Fig. 4.22.4. Dredged matter disposal site in the Luga Bay (‘the Bank of Valshtein’)

The Bank of Valshtein has accepted absolutely the biggest volume of extracted materials during the period of Ust’-Luga seaport terminal constraction and the SE part of the Luga Bay bottom dredging as follows (after reports of ‘Rospryrodnadzor’ and ‘Rosmorport’ authorities):
2006 year – 6 000 000 t;
2007 year - 4 800 000 t;
2008 year – 13 200 000 t;
2009 year – 22 000 000 t;
2010 year – 240 000 t;
2011 year – 20 497 800 t;
2012 year – 1 800 000 t
2013 year – 125 110 t (just repairing dredging).

These quantities, probably the biggest ones on bottom grounds removal in the Baltic Sea last decade. Looking at these volumes it is understandable, why new-built seaport complex Ust’-Luga have became recently the biggest seaport on the Baltic Sea. However extraordinary siltation and long-term water turbidity have serious consequences for local aquatic biota and for fish community. These consequenses are not yet studied well. As just one example, the littoral zone, together with macrophytes populated euphotic zone (and including the belt of *Fucus vesiculosus* – the species from regional Red List, HELCOM, 2013b) has been lost on duration about 20 km of shoreline of the Luga Bay eastern coast (there are walls with a depth 16-18 m instead of a littoral zone).

Seasonally dredged matter disposal goes on in periods when the Gulf is free from ice coverage. Annualy the rhythm of disposal is very uneven – it depends on large dredging projects execution (fig. 4.22.5).

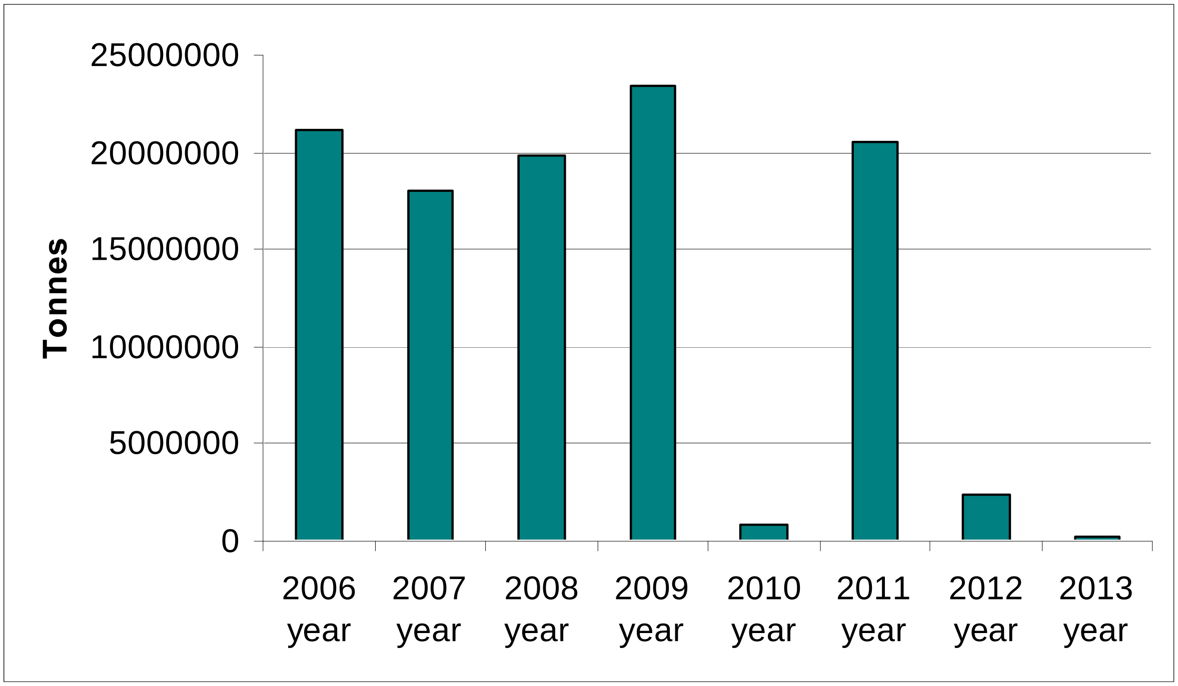


Fig. 4.22.5. The dynamics of total annual dredged matter disposal in the Russian part of the Gulf of Finland (original, from data of 'Rosprirodnadzor' and 'Rosmorport' authorities and dredging companies data).

Judging from the graph (fig. 4.22.5) the volume of dredging works in the Russian part of the Gulf of Finland have dropped down 10-100 times last two years because of the finalization of several big projects. However some new large-scale projects of bottom dredging and extracted matter disposal are under discussions within the area. Regular repearing dredging of navigation channels is comparably insignificant.

4.22.1.3. Shipping in shallow water

As it was proposed, to this impact a shipping of large ships (length >25 m) in shallow waters (<15 m) was reffered (Korpinen et al., 2013), what may be related to water turbulence caused by ship's propellers close to bottom. The Neva Bay and the great part of the easternmost Gulf of Finland are the shallow water area (<15 m). However the navigation of big ships in this area goes on exceptionally on marine navigating channels (fairways). They all were artificially dredged; the main ones to the depth 14-16 m, rarely 17 m, secondary ones - to the depth <15 m. The navigating routes are described on the map (fig. 4.22.6).

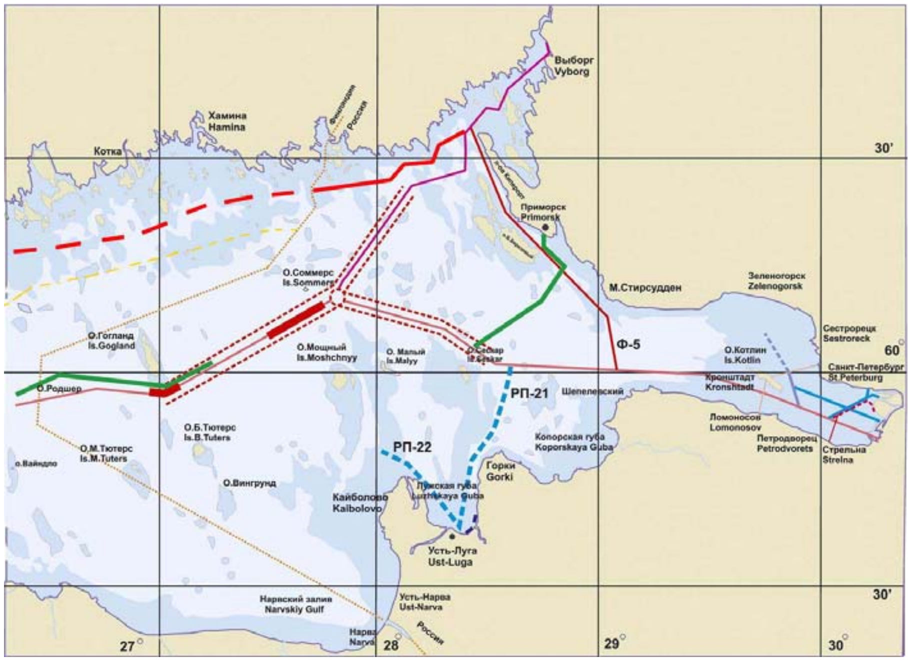


Fig. 4.22.6. Area of Adminstration of ‘Big Port St.-Petersburg’. Navigation channels, waterways, anchoring places (broadenings), main terminals (from offical web-site of ‘Big Port of St.-Petersburg’ Adminstration).

Thus when accepting the proposal of Korpinen et al. (2013), almost all navigation in the area goes on in ‘shallow waters (<15 m)’, even if it is within special navigating fairways. But we may not agree with this and to accept that shipping on narrow fairways should be regarded as impact on benthic habitats.

The amount of maritime traffic in the area is really big and have a tendency to increase from year to year (fig. 4.22.7).

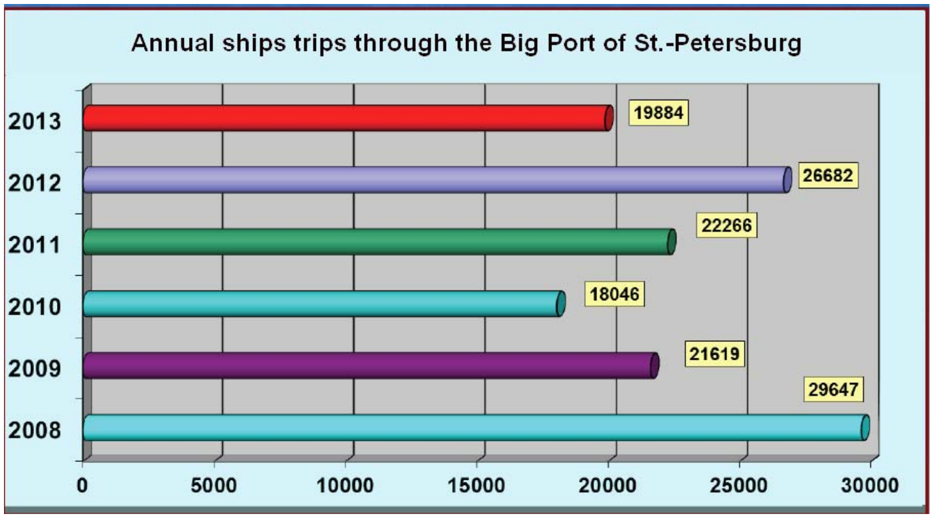


Fig. 4.22.7. Annual ships trips last six years (from data of 'Big Port of St.-Petersburg' Adminstration).

In spite of the ships trips were slightly reduced in 2013, the cargo turn-over at the same time have increased due to the bigger tonnage of cargo boats in use (fig. 4.22.7).

There are also smaller (length <25 m), but powerful vessels mooving in more shallow waters and often outside of navigating channels. The cumulative impact of shipping on benthic habitats in the area is still waiting to be adequately assessed.

Fig. 4.22.8. St.-Petersburg passenger terminal after the period of constraction in year 2012 (from archives presented by 'Big Port of St.-Petersburg' Adminstration).

4.22.1.4. Loading of nutrients (N and P) and organic matter; Waste water treatment plants

There are 14 of bigger or smaller waste water treatment plants within St.-Petersburg region, discharging totally in average 2.2 millions m^3/day. Wastewater treatment technologies and fine cleaning methods, has been implemented by Vodokanal have reduced the phosphorus concetration to acceptable level <0.5 mg/l. Such expected impact as changes in bottom salinity (Korpinen et al., 2013) may not have place in a freshwater easternmost part of the Gulf of Finland and the Neva Bay. An other possible impact as hypoxia caused by waste water has not been registered. Hypoxia in deep benthic habitats (depth >40 m) in open parts of the Gulf of Finland has natural, but not anthropogenic origin.

4.22.1.5. Bridges, oil rigs and coastal dams

There is one big Complex of Flood-Defencive Constructions (CDC) in the area. It comprising 11 of ground dams, with several controlled openings – 6 water admission gates and 2 shipping navigation gates. The CDC crossing the Gulf through the Kotlin Island (town Kronshtadt), separating the Neva Bay from the eastern Gulf of Finland (fig. 4.22.9). The construction of CDC was completed in year 2011. Total lengh is 25,4 km, the width 30-50 m. Main navigation gate C-1 have the width 200 m with water depth 16 m. All water admission gates provided with outlet valves, which are able quickly to lock the water addmission in case of flood.

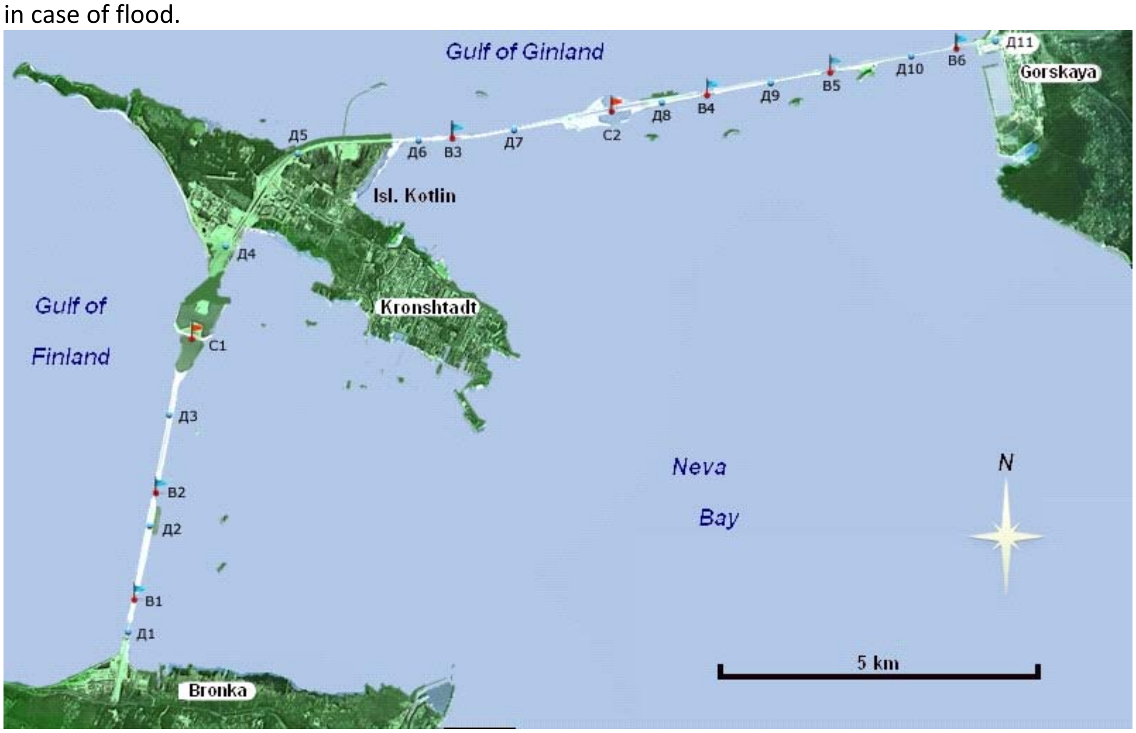


Fig. 4.22.9. Complex of Flood-Defencive Constructions of St.-Petersbirg. B1-B6 – water admission gates; C1 and C2 – navigation gates (after Directorate of CDC http://dambaspb.ru).

Six-laned highway is on the dams of CDC.

CDC, as a very large artificial body is really a cause of aquatic habitats loss and of some local changes in hydrography.

4.22.1.6. Coastal erosion defense structures

Such structures are placed on shoreline - on border between a water edge and a land. Possible habitat loss and potential changes in hydrography should be investigated locally for each construction. Erosion defense structures are locally and rather poorly developed in the Russian part of the Gulf of Finland. Mostly the employed for defence of harbors, sea-port areas and othe hydrotechnical constructions. The longest one is placed from two sides along the CDC. It has a total length about 50 km, it is made with big granit stones, but protecting not a shore, but the dams of CDC.

The lack of defense structures on sandy coasts was the reason for serious and rapid erosion processes. In autumn-winter period of 2011 year the erosion of dunes by storm was registered near village Komarovo on the N coast of eastern Gulf of Finland with irretrievable washing away of sandy matter and with coastal bench abrasion up to 10 m far just during the December (Ryabchuk et al., 2012). It was predicted that such erosion may have both climatic and anthropogenic reasons. Coastal erosion risk arising together with warm winters and ice coverage abscence repetition and with water level rise together with storms repetition. (Ryabchuk et al., 2012). On the photographs the same part of the beach near Komarovo is in July and December of 2011 (fig. 4.22.10).

Fig. 4.22.10. The same place on sandy coast near Komarovo at 10 of July, 2011 (left) and 28 of December, 2011 after warm winter strorm (after Ryabchuk et al., 2012).

4.22.1.7. Coastal nuclear power plants

There is one NPP in Sosnovy Bor at the coast Kopor'e Bay. Thermally enriched water creates the spot 3-5 km long. It leads to shifts in life cycles of plankton commuinity; evidently the similar impact may have place to benthic community as well. The area of water close to NPP may become a refuge for non-indegenous species of warm-water origin, like it was found close to Loviisa NPP in Finland (the false dark mussel - *Mytilopsis leucophaeata*; Laine, 2004).

4.22.1.8. Cables and pipelines

The biggest pipeline in the area is 'Nord Stream'. The position of it in the Gulf of Finland is described on the map (fig. 4.22.11).

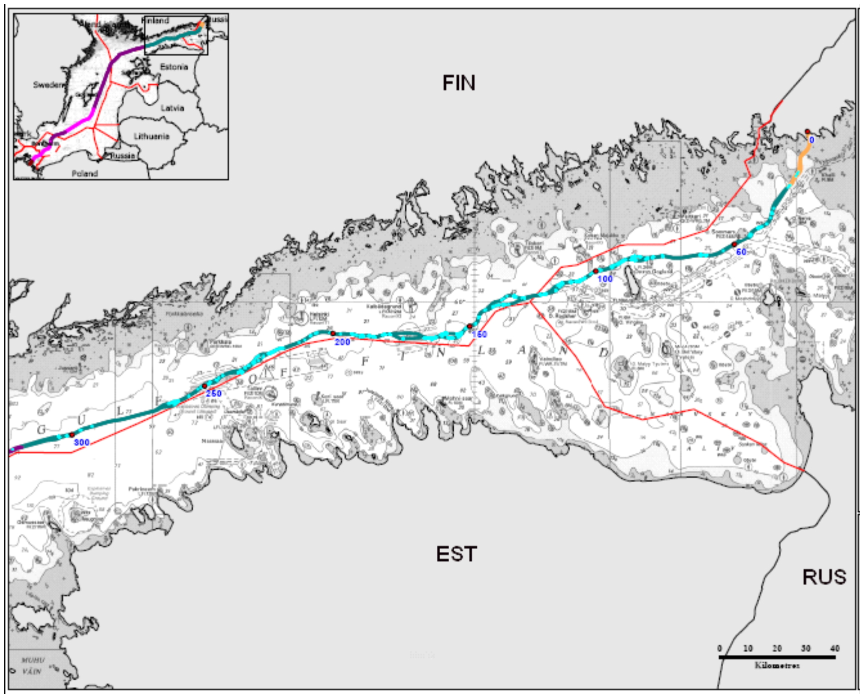


Fig. 4.22.11 . The scheme of the 'Nord Stream' pipeline position in the Gulf Finland (marked blue dots shows the free spans). (after report 'Asessment of Nord Stream project impact on environment', 2009).

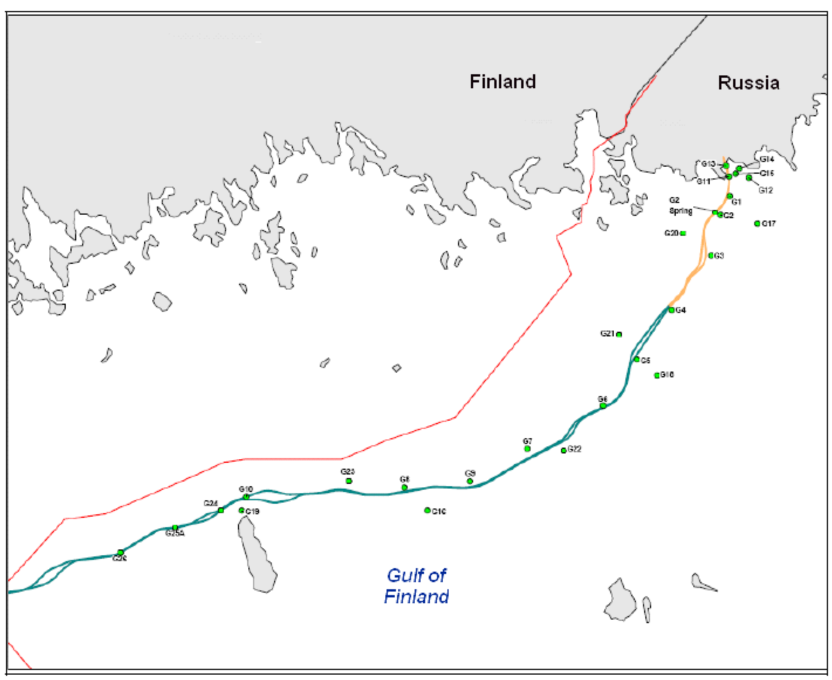
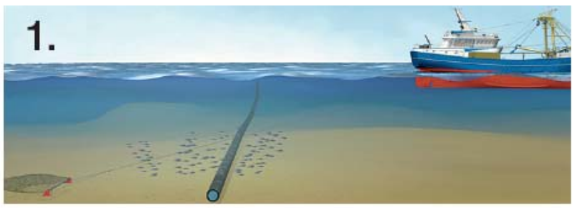


Fig. 4.22.12. Points G1- G26 – the positions of researches and environmental control stations on the 'Nord Stream' pipeline route within the Russian part of the Gulf of Finland (after 'Nord Stream AG' report 'Asessment of Nord Stream project impact on environment', 2009).

All impacts from this pipeline were well described in the working documents and reports of 'Nord Stream AG'. The work on 'Nord Stream' project is an example of international efforts for environment protection. All impacts from this pipeline were well described in the working documents and reports of 'Nord Stream AG'. The position of research and environmental control station is presented on a scheme (fig. 4.22.12). These stations were concentrated in Portovaya Harbor (Vyborg Bay) – the starting point of the pipeline. The results of fishery investigation in Portovaya Harbor were presented above, when describing the state of the indicators, based on fishery data. After the exit from Vyborg Bay the stations were evenly dispersed on the projected pipeline duration (fig. 4.22.12).

Possible impact on demersal trawling by pipeline should not occur free spans, but only at place, where are compessors installed (fig. 4.22.13).



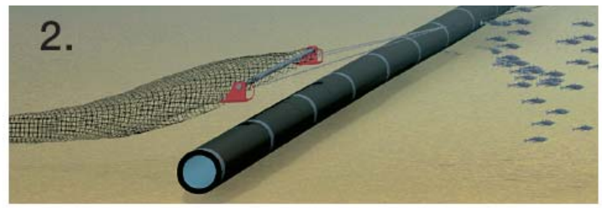


Fig. 4.22.13. **1** and **2** the ways of safe demersal trawling through the Nord Stream pipeline (after 'Nord Stream AG' report 'Asessment of Nord Stream project impact on environment', 2009).
Detailed information on environmental impacts may be found in reports and documents of 'Nord Stream AG'. Data on cables impacts to benthic zone is unavailable.

4.22.1.9. Wind farms

There are no of industrial wind farms in the Russian part of the Gulf of Finland.

4.22.1.10. Beach replenishment

The siltation may occur as temporal impact in sites of beach replenishment if the work touches a water edge and wrong size-structure of the sand was in use. Beach replenishment problems are related coastal erosion (see above) and the sand extraction from the bottom. The last brings disbalance between the processes of coastal erosion and accumulation.

4.22.2. GES boundaries

It seems the GES boundaries may be only partly expressed is terms of individual components of the 'Cumulative impact on benthic habitats' measured with tonnes, kilometres, cubic metres, number of units, etc. Count of the percentage of bottom square beeing somehow impacted is also not an adequate way of GES assessment, because actually 'somehow impacted' almost 100% of benthic habitats and the power of the all pressures estimation must be included into assessment.

So, the GES boundaries here is too difficult to quantify. Executing assessment of 'Cumulative impact on benthic habitats' we may find these habitats as sustainable or degrading.
Sustainable conditions of benthic habitats is a really GES boundary! How to identify this? All other bidiversity and hazardous substances indicators should serve as a measures of benthic habitats condition. Judging from the recent integrated situation in the Russian part of the Gulf of Finland the cumulative impact on benthic habitats is lower than GES.

4.22.3. Monitoring proposal

The indicator 'Cumulative impact on benthic habitats' seems to be one of the most complicated; it includes several independent work packages and the implementation of those needs the involvement of several differing experts. It has evident linckage to ‘Marine spatial planning’ development. The human activities and the pressures, has been reffered to ‘Cumulative impact on benthic habitats’ and quite correctly itemized by Korpinen et al. (2013), have relation to technical, constructional, maritime transport, energetic and economical development problems. That is why it is too complicated to develop the uniform method and the common shedule for monitoring of this combination of impacts (Antsulevich, 2014).

The special ‘Complex programm for coastal erosion defense of the eastern Gulf of Finland and water bodies of St.-Petersburg’ has been proposed by VSEGEI (Russian Geological Institute) for coastal erosion monitoring with usage of various methods including the satellite observations. The data on bottom dredging and extracted material disposal in the Gulf is under the control of Rosprirodnadzor (controlling authority of Minpriroda – Ministry of Natural Resources of RF). All issues related to navigation are in a competence of Rosmorport and ‘Big Port of St.-Petersburg’ (Ministry of Transport of RF). Leningrad NPP in Sosnovy Bor is drived by ‘Concern Rosenergyatom’ under the control of state corporation on nuclear energy ‘Rosatom’. Bridges, coastal dams, flood defencive barrier, pipeline and other constructions are under the supervision of several federal authorities and their regional representatives as follows:

- Ministry of Regional Development of RF;
- Ministry of Construction, Housing and Communal Services of RF;
- Emergencies Ministry of RF;
- Minisry of Energy of RF and their regional representatives.

All named authorities are kept informed about the events going on within their own field of responsibility, but none is informed enough about cumulative impact on benthic habitats. So, the main way of this composed indicator monitoring is the co-ordination and co-operation among the authorities for collection and assessment of numerous disconnected data.

Not any selected sites of the Russian part of the Gulf of Finland, but this entire area should be considered as area of monitoring and assessment for this indicator implementation.

4.23. EXTENT, DISTRIBUTION AND CONDITION OF BENTHIC BIOTOPES

4.23.1. What is 'biotope'?

The term 'biotope' is certainly the key-word in this indicator's name and meaning. The understanding and the definition of this term differs very much between modern English-speaking and Russian scientific societies and usage in special literature.

According to definition used in the indicator preparation:
'Biotope' is the functional unit comprised of a specific habitat and community' (after HELCOM, 2013c:52), what means:
biotope = habitat + biological community.

However in Russian and many other non English-speaking academic schools there is an other definition of this term as follows:
Biotope is an area of uniform environmental conditions providing a living place for a specific assemblage of plants and animals. **Biotope** is almost synonymous with the term **habitat**, which is more commonly used in anglophone countries. The subject of a **biotope** is abiotic component of an environment only.

biocenosis *a self-sufficient community of naturally occurring organisms occupying and interacting within a specific **biotope**; OR*
biocenosis a diverse community inhabiting a single **biotope** (http://dictionary.reference.com/)

Thus, sensu Russian accepted scientific understanding:
biotope + biological community = **biocenosis** &
biotope = biocenosis - biological community.

Within the work 'Red List of Baltic Sea underwater biotopes, habitats and biotope complexes' on 69 pages the term 'biotope' was in use 864 times, but the term 'biocenosis' wasn't in use at all (HELCOM, 2013c). However it is absolutely evident the term 'biotope' was used there in the same sense as the term 'biocenosis' sensu Karl Möbius (1877) originally, what also followed by recent Russian scientific society and academic school.

This inconsistency between these two senses of the same term **biotope** may bring misunderstanding among scientists, what actually already have place.

This problem have attracted an attention of Lituanian professor Sergey Olenin, who was a good student of Soviet (Russian) university (Olenin, Ducrotoy, 2006). The term ''biotope'' was introduced by a German scientist, Dahl in 1908 as an addition to the concept of ''biocenosis'' earlier formulated by Möbius (1877). Initially it determined the physical–chemical conditions of existence of a biocenosis (''the biotope of a biocenosis'').

Further, both biotope and biocenosis were respectively considered as abiotic and biotic parts of an ecosystem. This notion (''ecosystem = biotope + biocenosis'') became accepted in German, French, Russian and other European ''continental'' ecological literature.

The new interpretation of the term (''biotope = habitat + community'') appeared in the United Kingdom in the early 1990s while classifying ''marine habitats'' of the coastal zone. Since then, this meaning was also used in international European environmental documents. In the paper the evolution of the biotope notion was examined. It was concluded that the contemporary concept is robust and may be used not only for the classification and mapping but also for functional marine ecology and coastal zone management (Olenin, Ducrotoy, 2006).

OSPAR Commission (2011) operates with the term ‘habitat’, evidently in the same sense as the term ‘biotope’ is in use in HELCOM (2013c). To avoid any contradictions in the frames of the given report the term ‘biotope’ is in use in the sense of HELCOM (2013c), what is actually equal to the term ‘biocenosis’ accepted in Russian scientific literature in the same sense.

4.23.2. Description of the indicator

This indicator documents the extent and distribution of key benthic biotopes of marine ecosystems. Extent is the area of the habitat type (measured in square units, presumably in hectares) and distribution is the pattern of the habitat across the area of monitoring.

This indicator have a short name, however it is rather complicated indeed. It comprises of three evident parts:

- biotopes condition;
- biotopes distribution;
- biotopes’ extent.

Monitoring of every part needs its own approach and methods of investigations and data processing.

Habitat loss or biotopes demage and its effects on biodiversity are a growing global concern.
Baltic Sea biotopes exhibit a great diversity in function and structure. The HELCOM Underwater Biotope and habitat classification (HELCOM HUB) defines a total of 328 benthic and pelagic habitats. Of these HELCOM HUB biotopes, a threat assessment was made for 209 biotopes of which 59 were red-listed. The benthic (especially aphotic) zone was characterized by the higher proportion of red-listed biotopes compared to the pelagic zone (HELCOM, 2013c).

The indicator should describe the large scale and long-term movements on a sea floor as a general character of the ecosystem condition and its direction of the development. It has direct linkage with other HELCOM-CORESET indicators, based on benthic biota and/or benthic habitats, biodiveristy and hazardous substances data, which are linked in its own turn to the description of benthic biotopes’ (sensu biocenosis) condition.

Changes in biotopes distribution, such as range extensions or reductions, are also of interest, especially during times of climate change or major anthropogenic impacts, as they may be indicators of significant ecological changes underway.

4.23.3. State of the indicator in the Russian part of the Gulf of Finland (brief review of biotopes dynamics)

Within the Russian area of water 17 of biotopes listed by HELCOM (2013c) were registered (tab. 4.23.1). Some widely distributed in the easternmost part of the Gulf of Finland biotopes, where the communities with dominating of oligochetae are peculiar, are absent from that list. It is because by the HELCOM recommendations this taxonomic group is reffered to meiofauna; but to macrofauna should be included benthic organism left from the bottom ground washing up through the sieve of 1 mm mesh size (HELCOM, 1988). In the practice of Russian benthic researches the sieves with 0.5 mm mesh size are in use. That is why the biotopes dominated by oligochetae are considered here as ‘dominated by meiofauna’ ones according to HELCOM classification.

Biotope No 1. **AA.H3L6 Baltic photic muddy sediment dominated by Unionidae** is typical almost for all the Neva Bay (fig. 4.23.1) with exception of local and marginal parts of it (Sea port, navigation channels, sites of dredging works). Last years (2006-until recently) the existance of this biotope was endangered by long-term and large-scale hydrotechnical works for passenger’s terminal and so-called ‘Marine Facade’ construction accompanied with enormous replacements of bottom ground. The fortune of this biotope at this place is still uncertain and the decline of Unionidae bivalves is still registered.

Table 4.23.1. List of benthic biotopes recorded in the Russian part of the Gulf of Finland

№	HELCOM HUB biotope code and name	Red List category
1	AA.H3L6 Baltic photic muddy sediment dominated by Unionidae	NT
2	AA.H3P1 Baltic photic muddy sediment dominated by midge larvae (Chironomidae)	LC
3	AA.H4U1 Baltic photic muddy sediment dominated by meiofauna (Oligochaeta, Ostracoda, Nematoda)	LC
4	AA.J3N3 Baltic photic sand dominated by sand digger shrimp (*Bathyporeia pilosa*)	LC
5	AA.J3P1 Baltic photic sand dominated by midge larvae (Chironomidae)	LC
6	AB.E2T Baltic aphotic hard clay characterized by sparse epibenthic macrocommunity	NE
7	AB.F Baltic aphotic ferromanganese concretion bottom	LC
8	AB.H3L1 Baltic aphotic muddy sediment dominated by Baltic tellin (*Macoma baltica*)	LC
9	AB.H3M3 Baltic aphotic muddy sediment dominated by *Marenzelleria spp*.	LC
10	AB.H3N1 Baltic aphotic muddy sediment dominated by *Monoporeia affinis* and/or *Pontoporeia femorata*	NT
11	AB.H3P1 Baltic aphotic muddy sediment dominated by midge larvae (Chironomidae)	LC
12	AB.H4U Baltic aphotic muddy sediment characterized by no macrocommunity	NE
13	AB.J3L1 Baltic aphotic sand dominated by Baltic tellin (*Macoma balthica*)	NE
14	AB.J3M Baltic aphotic sand characterized by infaunal polychaetes	LC
15	AB.J3P1 Baltic aphotic sand dominated by midge larvae (Chironomidae)	LC
16	AB.J3N1 Baltic aphotic sand dominated by *Monoporeia affinis* and *Saduria entomon*	LC
17	AB.J4U1 Baltic aphotic sand dominated by meiofauna	LC

Note. NT – Near Threatened, LC - Least Concern, NE - Not Evaluated

New biotope of euphotic zone (No 4) – (**AA.J3N3 Baltic photic sand dominated by sand digger shrimp (*Bathyporeia pilosa*)** was found just recently by (November of 2013) and only on one statition in coastal zone of Bolshoy Tjuters Island (A.Maximov, unpublished data). Other biotopes (No 2, 3 and 5; tab. 4.23.1) are widely distributed in the Neva Bay and in coastal areas of the eastern Gulf of Finland (Ecosystema..., 2008).

It seems the biotopes No 6 and No 7 (**AB.E2T Baltic aphotic hard clay characterized by sparse epibenthic macrocommunity** и **AB.F Baltic aphotic ferromanganese concretion bottom**) in the Gulf of Finland could be united, because the aggregations of ferromanganese concretions are typical for the clayey bottom grounds in hydrodynamically active parts of deep water seafloor. Generally for this biotope the poor benthos is peculiar, what is actually impoverished variant of the usual silty bottom population. Earlier the benthos here was represented by not numerous glacial relict crustaceans *Monoporeia affinis*, *Pontoporeia femorata* and *Saduria entomon*, which were more abundant on neighbouring sites with silty ground. Recently this crustaceans replaced almost everywhere by alien polichaetan worms *Marenzelleria arctia*.

Biotope No 8 (**Baltic aphotic muddy sediment dominated by Baltic tellin (*Macoma baltica*)**
earlier was widely distributed in the eastern part of the Gulf of Finland, but in 1990-s it has decreased remarkably, probably due to the salinity reduction, hypoxia and the invasion by *Marenzelleria spp.* Last years the recovery of *Macoma balthica* population has been observed.

Biotope No 9 (**AB.H3M3 Baltic aphotic muddy sediment dominated by *Marenzelleria* spp.)** is only one expanded it distribution substantially last years, what was a result of invasion and mass development of Arctic representative of genus *Marenzelleria – M. arctia* (Maximov, 2011).
Currently this biotope have occupied the large part of the area (fig. 4.23.1) and substituted some other biotopes, which were widely distributed earlier.

One of those biotopes is No 10. (**AB.H3N1 Baltic aphotic muddy sediment dominated by Monoporeia affinis and/or *Pontoporeia femorata***). Untill the first half of 1990-s it occupied
prevailing position in the eastern part of the Gulf of Finland (Järvekülg, 1979; Kudersky, 1982; Maximov, 1997). Lately on the major part of this area of water the local populations of amphipods have perished because of hypoxia. On the bottom sites, where oxygen regime remained more or less favourable, the amphipods were forced out by alien oligochetaes *Tubificoides pseudogaster* (Maximov, Tsiplenkina, 2012). Starting from the year 2009, this biotope wasn't recorded within the Russian part of the Gulf of Finland. Its former area of distribution nowadays is occupied by the biotope No 9.

Biotope No 11 (**AB.H3P1 Baltic aphotic muddy sediment dominated by midge larvae (Chironomidae)** is peculiar to the most freshwater regions placed nearby Kotlin Island (Kronshtadt), Vybor Bay and the top of the Luga Bay. Last years it substitutes actively by the biotope No 9. In 2011 and 2012 years this biotope was registered only on one station near Kotlin Island (fig. 4.23.1).

The next biotope No 12 (**AB.H4U Baltic aphotic muddy sediment characterized by no macrocommunity)** is represented on the list of HELCOM with two variants: **AB.H4U1**, where meiobenthos is dominating and with **AB.H4U2**, where anaerobic organisms are dominating.
The sites of the sea floor lacking in macrozoobenthos were often registered in deep water areas during the period of 1996-2008 years (Maximov, 2003; Ekosystema.., 2008). However, events of hypoxia in the eastern Gulf of Finland are episodical and usually short-term ones. They appears in periods of summer stagnation in irregular intervals having a duration from few years to several decades. Even in periods with unfavourable oxygen conditions a saturation of demersal water layers with oxygen in autumn-winter season goes on every year by intensive convection of a water column (Eremina et al. 2012, Maximov, 2006).

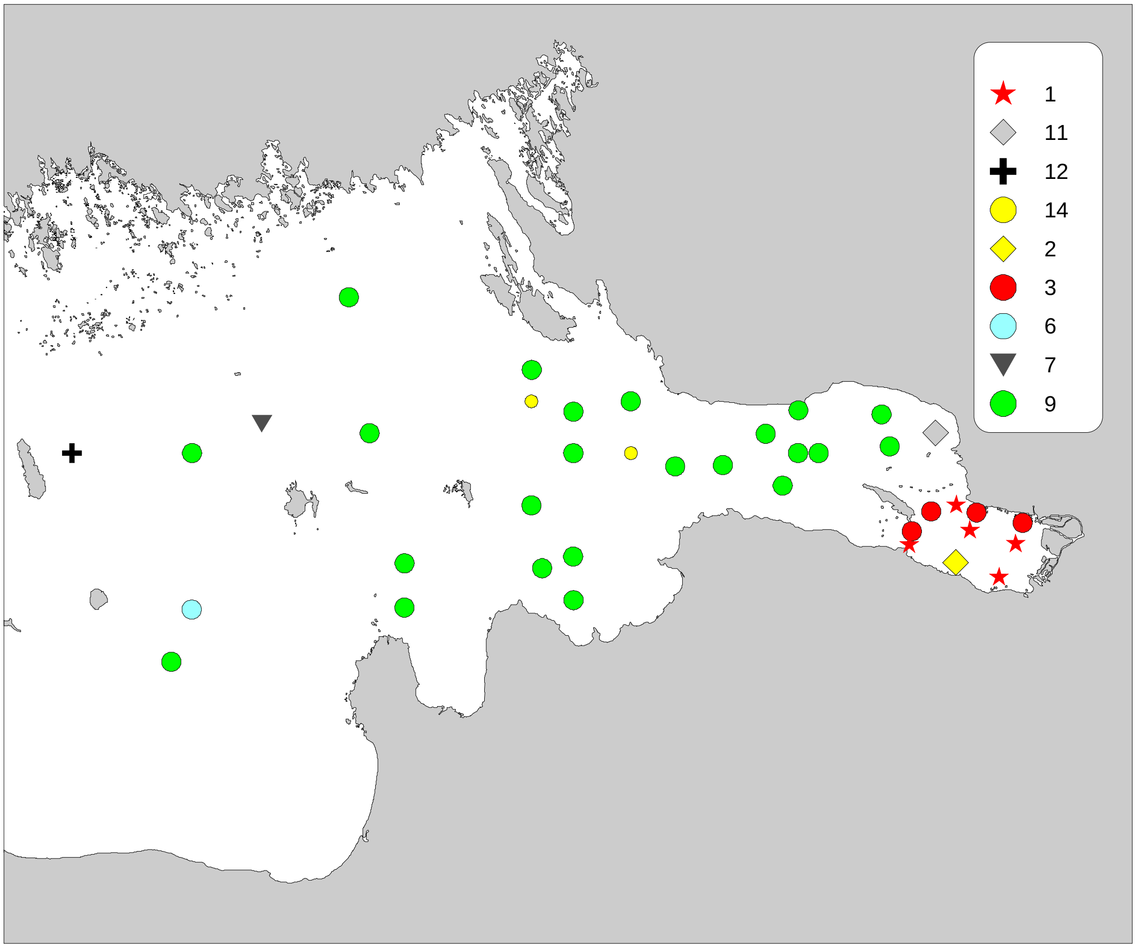


Fig. 4.23.1. Distribution of most common benthic biotopes in the Russian part of Gulf of Finland in 2011 (data of benthic survey in late July - early August). Figures denote number of biotopes as in the Table 4.23.1.

Anoxic-hypoxic conditions in a few weeks or months, cause the death of all aerobic benthic organisms, but this period is not sufficient for the development of specific fauna of more stable anaerobic habitats. Therefore the areas of eastern Gulf of Finland exposed to hypoxy remained almost lifeless (devoid of both macro-and meiofauna) for several years (Maximov, Petukhov 2011). Currently, these areas are also part of the biotope 9. They are mainly populated by polychaete *M. arctia,* which planktonic larvae are able to rapidly colonize the vacant areas of the bottom. Recently (2010-2012) the absence of benthos was observed only at certain stations at depths of about 70 m at the western border of the Russian waters (fig. 4.23.1).

Biotope No 13 (**AB.J3L1 Baltic aphotic sand dominated by Baltic tellin (*Macoma balthica*)** is a 'classic' Baltic biotope. In the eastern part of the Gulf it is especially characteristic of the vast sandbanks along the southern shores (Antsulevich, Chivilev 1992, Kudersky 1982, Maksimov, 2006). The boundaries of this habitat have not changed significantly. Although the invasion of the polychaete *Marenzelleria* (mostly *M. neglecta)* markedly changed the structure of the benthos, the dominant species *M. balthica* retained its leading position (Maximov, 2010).

In the sandy biotopes No **14-17** biological component is represented by communities of the already mentioned polychaete *Marenzelleria* spp., Chironomids, crustaceans, and oligochaetes. The last three biotopes have always been quite rare in the eastern Gulf of Finland, where sandy grounds are usually dominated by mollusks. Currently the biotopes 15-17 are being gradually replaced by biotope 14 with a predominance of polychaetes.

Two of the 17 marked biotopes are listed in the Red Book of HELCOM in category «Near Threatened». One of these biotopes (No 10) has probably already disappeared in the studied area. The biotope number 1 dominated by large mollusks from the family Unionidae, is under threat due to large-scale dredging and hydraulic works on the Neva Bay.

4.23.4. GES boudaries

GES descriptors are divided into three levels for the purposes of assessment and criteria for GES: species, habitat and ecosystem. At the habitat level there are three criteria specified in the EC guidance (Commission Decision 2010/477/EU): Distribution, Extent and Condition.
For the ***distribution*** criterion, there are two attributes listed as possible indicators: range and pattern.
Habitat (=biotope sens. HELCOM, 2013c) ***extent*** can be expressed as area and volume, where relevant.

For ***habitat condition***, three attributes are listed:

- Condition of the typical species and communities;
- Relative abundance and/or biomass, as appropriate; and
- Physical, hydrological and chemical conditions (OSPAR Commission, 2011).

An indicator of a good state of the environment in the eastern part of the Gulf of Finland can include several components: the absence or reduction of the hypoxic zones deprived of macrozoobenthos (habitat number 12 - **AB.H4U Baltic aphotic muddy sediment characterized by no macrocommunity),** as well as the stable borders to the threatened (Red Data Book in the category ‘ Near Threatened ») habitats (No 1 - **AA.H3L6 Baltic photic muddy sediment dominated by Unionidae,** No 10 - **AB.H3N1 Baltic aphotic muddy sediment dominated by *Monoporeia affinis* and / or *Pontoporeia femorata*).**

4.23.5. Indicator monitoring proposal

Taking into account high variety of biotopes and a big differences among them (for example: hard- and soft-sediment biotopes, littoral and deep water biotopes) the number of implemented methods should increase. Many aspects of these methods require expert knowledge, including optimum survey design and special instruments.

The ***quantity*** of a habitat can usually be given as area covered by the habitat, representing the areal extent. The ***quality*** of a habitat is all those features that describe the condition or state of the habitat where it occurs (OSPAR Commission, 2011).

Recently the State (official) monitoring of bottom fauna operates rather with points (reseach stations) than with areas (habitats, biotopes). The biocenosis mapping wasn’t implemented within the tasks of that monitoring. It was realized thanks to initial works of universities and academic institutions.

Extent of the typical (habitat 12) and threatened habitats (the biotopes No 1 and No 10) should be assessed annually, the rest – once every three years. In general, no specialized monitoring programs are required for this indicator. Current rating may be based on the data in the standard monitoring of the benthic macrofauna and analysis of literature. However, based on the results of the interim reports, it is advisable to organize periodically (once in five years?) special field studies aimed at the habitats endangered, rare and / or unaccounted by routine monitoring activity.

The scheme for such special additional researches may be created analogous to the routine monitoring works. Extent should be calculated in hectares, however it wasn’t done before in the Russian part of the Gulf of Finland. As many habitats are not fully mapped, a reference area should be defined that indicates the total area mapped to enable future comparisons with additional research stations.

National (or regional) level products should be developed with the needs of the various stakeholders in mind. Data access should be available through a nationally known and recognised web site (for example through the web site of North-West Department of Federal Service for Hydrometeorology and Environmental Monitoring).

4.24. TRENDS IN ARRIVAL OF NEW NON-INDIGENOUS SPECIES

4.24.1. Introduction

The introduction of alien invasive species is among the highest risks for the Baltic sea marine environment and it can cause extremely severe environmental, economic and human health impacts. This unwanted process sometimes named as 'biological pollution' (Metod. recom., 2005) on the analogy of other types of environmental pollution.

These non-indigenous species (NIS or invaders or alien species) can induce considerable changes in the structure and energy distribution of aquatic ecosystems. They may also hamper the economic use of the sea or even represent a risk for human health. Environmental impacts comprise changes of marine communities changing e.g. the structure of the food web by outcompeting original inhabitants.

Economic impacts range from financial losses in fisheries to expenses for cleaning intake or outflow pipes and structures from fouling. Public health impacts may arise from the introduction of microbes or toxic algae (Leppäkoski, 2002; Leppäkoski et al., 2002; Orlova et al., 2006).

Ballast water has been identified as one of the main vectors transporting alien species (Carlton, 1985). According to the BWM Convention, ships will be required to implement ballast water management unless an exemption, following a risk assessment, has been granted.

However in most cases, where written that 'NIS arrived with ballast waters' this statement is not really have the confirmation by direct observations. In some cases, NIS have been deliberately introduced for fishing or aquaculture, but most have been brought by ships, which can rapidly transport aquatic animals, plants and algae across the world in their ballast waters and attached to their hulls. A problem for the non-indigenous species issue is that, once a marine organism has been introduced to its new environment, it is nearly impossible to eradicate the unwanted organism, if it has established to the area.

Therefore the status of the NIS in the Baltic Sea is described by a trend of the number of new arriving NIS (HELCOM, 2012a;b; 2013a).

4.24.2. Indicator description and meaning

As indicator of trends in arrival of new non-indigenous species is considered
a number of new alien species arrivals against a baseline per fixed assessment period (periods
from two to six years were proposed; the last was accepted during HELCOM CORESET project elaboration). Every new non-indigenous species (NIS) arriving after the baseline year is counted as a new species. New NIS comprises not only established organisms but all new identified. New NIS that have already been counted will not be added to the baseline and not be added to the counts of future periods (HELCOM, 2012a;b).

Indicator is closely linked to anthropogenic pressures; it reflects mainly the impact of shipping, but it is difficult to distinguish that from other possible vectors of NIS dispersal.
Indicator directly impacted by ballast water exchange, by biofouling community transportation with ships and subsea constructions, intentional or unintentional introductions for aquaiculture or aquaria, introductions by usage of fishing nets (or trawls) in various water bodies or various regions. Indicator is linked to climate change, because the last, acting by changes of the temperature and salinity, may increase (or reduce) the number of new successful NIS introductions.

4.24.3. Methodology

Taxonomic groups in use for NIS assessments are known from microbes to vertebrates. The special agreement is needed to avoid the factor of 'development of taxonomy' in every country and region of the Baltic Sea. Otherwise the findings of new flora of fauna elements of small organisms or badly know taxa may be erroneusly regarded as new NIS arrivals. It seems the new NIS arrivals should be reffered only to more remarkable and well studied taxa of aquatic organisms and the list of them should be agreed. The habitat for NIS assesments usually doesn't matter with exception for NIS findings only on the bodies of movable ships or in a ballast water.

Special investigations of NIS should be undertaken with employment of special methods.
As well the indicator uses primarily species composition data from the conventional biodiversity monitoring programmes (Metod. recom., 2005; Zvyagintsev et al., 2009; HELCOM, 2012 a;b).

4.24.4. State of the indicator in the Russian part of the Gulf of Finland

Indicator is not implemented in regular monitoring of the area. The initial data on arrivals of new non-indigenous species was collected gradually and occasionally, when doing monitoring or special hydrobiological researches of plankton, benthos, fouling community and fishes. In some cases it wasn't in fact the registration of new species 'just arrived', but rather late registration of its occurence in the Russian waters, especially for hard bottom or fouiling communities not involved in regular state monitoring. That is why an actual time of some non-indigenous species penetration is not known exactly.

In period 2004 -2006 the Committee for Ecology of St.-Petersburg City Administration, estimating the problem of alien species, had contracted the research titled: 'Elaboration of biological pollution monitoring system for ecosystems of the Gulf of Finland' with participation of Zoological Institute Rus. Acad. Sci. (ZIN RAS), St.-Petersburg State University (SPbSU) and State Inst. of Lakes and Rivers Fishery (GosNIORH). This mutual work was the non-indigenous species monitoring in regime of elaboration and testing during three seasons, however it was stopped without prolongation until now.

The baseline study for the indicator has been already done in Russian waters for aquatic macrofauna for period until year 2012 (fig. 4.24.1; table 4.24.1) and partly for some other taxa.

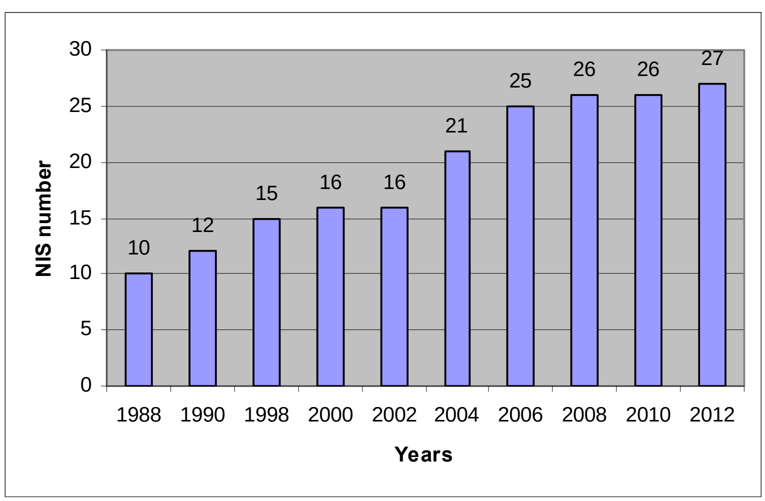


Fig. 4.24.1. Accumulated number of NIS (aquatic macrofauna only) in Russian part of the Gulf of Finland by years (after Antsulevich, 2012 with additions)

Table 4.24.1. NIS number (aquatic macrofauna only) in Russian part of the Gulf of Finland by years

Years	NIS numbers
1988	10
1990	12
1998	15
2000	16
2002	16
2004	21
2006	25
2008	26
2010	26
2012	27

Judging from these data (fig. 4.24.1; table 4.24.1), new NIS arrivals per **six years** periods were counted as follows:

- 1988-1994 – 4 arrivals;
- 1995-2001 – 2 arrivals;
- 2002-2008 – 10 arrivals;
- 2008-2012 – 1 arrival (gobid fish *Neogobius melanostomus*, Luga Bay, 2012).

Arising of new NIS number registrations started from year 2002 has two explanations – objective and subjective ones as follows:

- several new Russian seaports building and increase of navigation density;
- during the period (2004-2006) more or less intensive monitoring of NIS in the Russian waters has been supported and carried out.

Elaboration of NIS monitoring in Russian part of the Gulf of Finland was stopped together with the stop of support. However, general biodiversity monitoring (plankton and soft bottom communities) goes on annually.

Remarkable new NIS findings in the eastern part of the Gulf of Finland last decades

Dreissena polymorpha (Pallas, 1771) (zebra mussel) was firstly found in the Gulf of Finland in 1990, closely to Kotlin isl. (Kronshtadt) by SCUBA diving (Antsulevich, Lebardin, 1990). Soon it was widely found in many other areas of the Russian part of the Gulf of Finland (Antsulevich, Chiviliov, 1992). In Finland it was firstly found in 1995 near Pellinki Archipelago (by Juhani Väittinen) and near Kotka (by Alexander Antsulevich and Pentti Välipakka). In all cases were found adult mussels of age 4-6 years, so their settling (the fact of invasion!) has been occured several years earlier.

Recently *D. polymorpha* is widely distributed in the E part of the Gulf of Finland and became very abundant within this area (figs. 4.24.2; 4.24.3). The success and regularity of reproduction in new areas is very important for the zebra mussels invasion. At the beginning (1990-s years) the gaps in the eastern Gulf of Finland dreissena cohorts (annual generations) were discovered (Antsulevich et al., 2003). Evidently, last decade, thanks to warmer years (climate change?) the reproduction of the zebra mussels in this new area became regular and more successful. New studies of the zebra mussels population structure in various biotopes are needed.

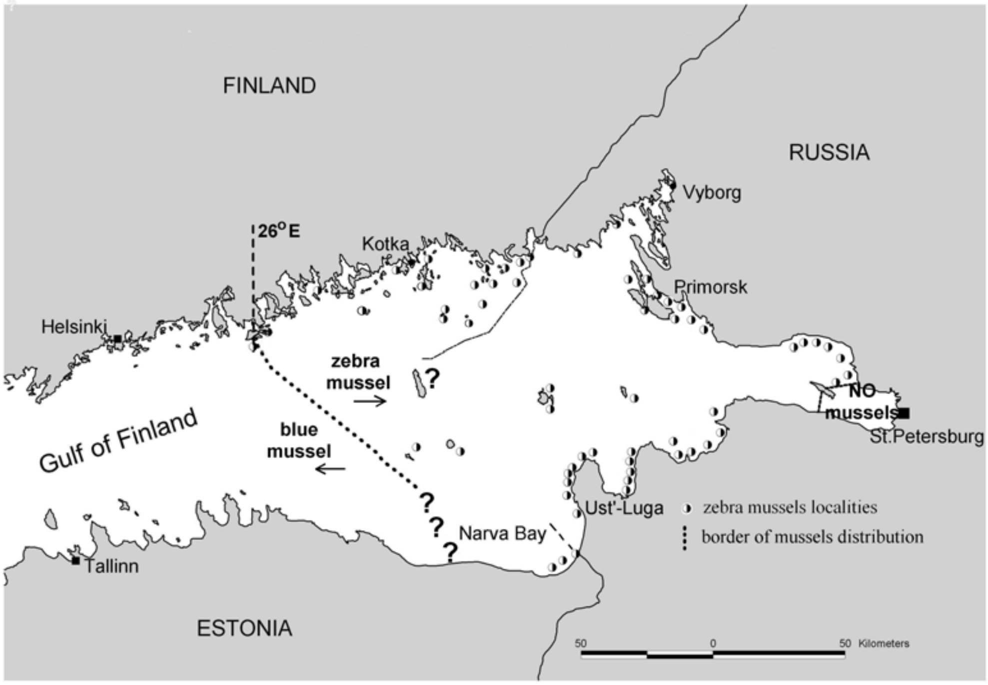


Fig. 4.24.2. The distribution of the zebra mussel (*Dreissena polymorpha*) in the Gulf of Finland (after Antsulevich et al., 2003).

Zebra mussel is absent both in Neva River and in Neva Bay. The border of zebra mussel's distribution in the Gulf of Finland caused by increasing salinity to the west. It is coincides with the distribution border of the blue mussel to the east. In the Gulf of Finland (and also some other areas in the Baltic Sea) these two species – freshwater zebra mussel and marine blue mussel have co-distribution named 'mirror antagonistic' (Antsulevich et al., 2003).

Fig. 4.24.3. Typical stone with *D. polymorpha* settlement near Primorsk from the depth 3 m (after Antsulevich, 2012).

Dreissena rostriformis bugensis (Andrusov, 1897). Single specimen was said to be found in Vyborg Bay in 2004 (Orlova et al., 2006).

Marenzelleria neglecta Sikorski et Bick, 2004 (earlier known as *M. viridis*) in 1990-s was firstly found in the Gulf of Finland western part (Norkko et al., 1993). In Russian part of the Gulf (Luga Bay and Kopor'e Bay) this species was registered in 1996 (Lyakhin et al., 1997). Starting from the next year and recently it became common and abundant in the eastern part of the Gulf of Finland (Maximov, 2003).

Eriocheir sinensis Milne-Edwards, 1854 (chinese mitten crab). The first specimen in the Gulf of Finland was registered in 1933 in Vyborg Bay (Luther, 1933). Secondly in the eastern Gulf of Finland it was recorded only in 1982 (Ruzhin, pers. com.). Recently this species is distributed in all Russian part of the Gulf, but not common and not abundant (fig. 4). More or less regularly it may be sampled by fishing nets in September during the migration via river Neva mouth, just very close to the city center of St.-Petersburg.

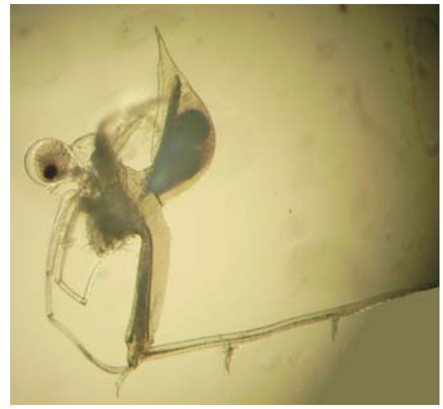


Fig. 4.24.4 (left). *Eriocheir sinensis* (chinese mitten crab) from the river Neva mouth, depth 4 m (photo by A. Antsulevich).

Fig. 4.24.5 (right). *Cercopagis pengoi* – sexual female with eggs (photo by A.Antsulevich).

Cercopagis pengoi (Ostroumov, 1894) (Crustacea; Cladocera) was firstly found in the Gulf of Finland in 1995 (Kivi, 1995; Helsingin Sanomat). In Russian part it was found in 1996 close to Finnish-Russian border and right away with substantial density (60 ind.m^{-3}). The invasion of this big predatory planktonic crustacean to the eastern Baltic should be regarded as one of the most successful and important ones in the last century. During the first years of invasion the abundance of *C. pengoi* was enormously high (sometimes over 1000 ind.m^{-3}), but gradually it has decreased to values 10-100 ind.m^{-3} in summer maximum (Antsulevich, Välipakka, 2000; 2006). Recently *C. pengoi* is common component of zooplankton in eastern Gulf of Finland and more abundant in wormer years. As it was supposed the hypoxia at the bottom in deeper zones of the Gulf of Finland may be controlling factor of *C. pengoi* abundance, by prevention of its resting ('wintering') eggs hatching (Antsulevich, Välipakka, 2000; 2006) (fig. 4.24.5).

Stenocuma graciloides (G.O.Sars, 1894) (fig. 4.24.6). Cumacea crustacean was found in the plankton of the eastern part of the Gulf of Finland of the Baltic Sea (Antsulevich, 2005). This species was never recorded before in the Baltic Sea; in the Gulf of Finland Cumacea were unknown at all. This is the next alien species of the Ponto-Caspian origin introduced into the fauna of the Baltic Sea, however untill now it was only record of it. This crustacean inhabits not densely populated biotopes of bottom and may also swim up to the surface in the water column.

Cumacea crustaceans are excellent forage both for plankton- and for bottom-feeding fishes. Negative ecological or economical consequences from this species introduction to the Gulf of Finland are not expected (Antsulevich, 2005).

Fig. 4.24.6. *Stenocuma graciloides* (G.O.Sars, 1894). The specimen and the locality (red point) of its finding (after Antsulevich, 2005).

Tenellia adspersa (Nordmann, 1845). The order of animals' nudibranch mollusks (Nudibranchia) was firstly recorded for the Russian part of the Gulf of Finland only in Luga Bay. It is represented by species *Tenellia adspersa* – the small mollusk, associated with hydroids *Cordylophora caspia* (fig. 4.24. 7) and not easily detectable on the hydroid colonies. In the Gulf of Finland fauna this mollusk is an alien species of Azov-Black Sea origin (Antsulevich, Starobogatov, 1990).

Its penetration to NE Luga Bay could happen with vessels both directly from Ponto-Caspian basin and from Baltic ports of Poland or Germany, where it appeared earlier. Some findings of this species are known earlier from waters of Finland – island Santio, close to Finnish-Russian marine border (Antsulevich, Välipakka, 2005). This species was not recorded from Baltic republics, however most likely it should be there as well. Evidently, when it will be found in Estonian water this must not be regarded as 'alien species new arrival'.

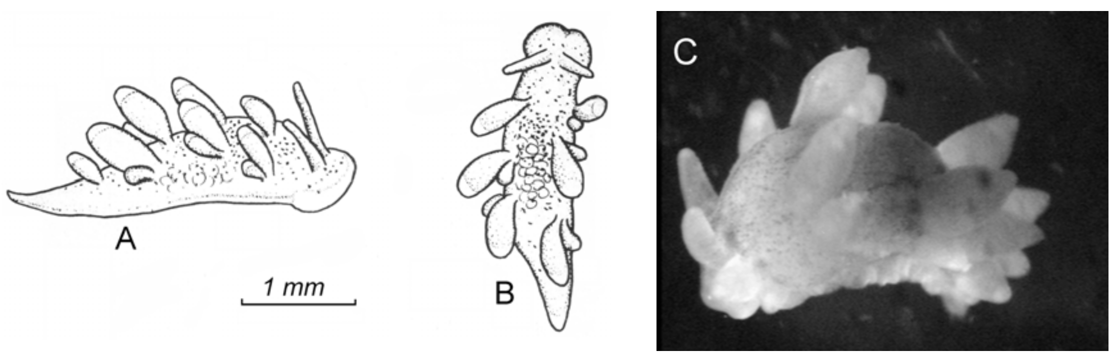


Fig. 4.24.7. *Tenellia adspersa* (Nordmann, 1845). **A** and **B** – the specimens from Caspian Sea (after Antsulevich, Starobogatov, 1990); **C** – mollusk from the Gulf of Finland (after Antsulevich et al., 2009).

Proterorhinus (?)marmoratus (Pallas, 1814) – tube nose goby. The '?' mark at specific name is added because of existance of closely related species of subspecies of this fish.

The Ponto-Caspian invasive gobiid fish *Proterorhinus* (?)*marmoratus* (tubenose goby) was recorded for the first time from the Gulf of Finland (Neva Bay) in July of 2007 by Antsulevich (2007). Recently just few years passed it started to spread itself on the E part of the Gulf and getting more common in this area (Naseka, pers. com.). Typical character of tube nose goby is elongated anterior nostrils of tube-like shape (fig. 4.24.8).

Fig. 4.24.8. Tube nose goby from the Gulf of Finland (after Antsulevich, 2007). On the right – a head of the same specimen with elongated nostrils (photo by A.Antsulevich).

Fig. 4.28.9. *Percottus glenii* Dybowski, 1877. Specimens of various age from one catch. Neva Bay, northern coast, Olgino, depth 1 m (photo by A.Antsulevich)

Percottus glenii Dybowski, 1877 (Engl.: Amur sleeper; Rus.: rotan) is the freshwater fish originating from Amur River area (Russian Far East). It was knowingly transported to Leningrad Region by hyman in the middle of last century for ornamental and scientific reasons and soon it was occurred in small fresh water bodies (ponds). Finally it migrated to the Neva Bay and some easternmost parts of the Gulf of Finland. Its distribution in the Russian part of the Gulf of Finland is patchy and confined to shallow water zones with well developed aquatic vegetation; evidently it escapes the salinity higher than 1.5-2.0 %**o** (Antsulevich, Yakovlev, 2005). These ecological peculiarities does not allowed to this species to invade waters of Estonia and Finland untill now (A.Ero; P. Vähanäki, pers. comm.).

Neogobius melanostomus (Pallas, 1814) – round goby. This species was firstly found in Russian part of the Gulf of Finland (W coast of the Luga Bay) just in summer of 2012 and one specimen only (Uspensky, 2013). The figures of this species are well-known. *N. melanostomus* demonstrates almost unique example of alien species dispersal in the Baltic Sea in opposite to all other ones from Ponto-Caspian invaders. This species firstly appeared not in Russian part of the Gulf of Finland (like many other NIS), but in waters of Poland (the Puck Bay and the port of Gdansk) by making a big 'jump' from the native Ponto-Caspian area (Sapota, Skora, 2005). Then, during almost 20 years it mooved itself gradually from the west through the waters of Lituanian and the Gulf of Riga to the east - to Estonian waters (Põllumäe et al., 2006) and to Finland (discovered in the Archipelago Sea in 2005) (Michalek et. al., 2012).

Finally it has reached the westernmost area of the Russian part of the Gulf of Finland.

4.24.5. GES criteria and boundaries

Because of numerous vectors of NIS arrivals we are unable to control this process absolutely and everywhere. The criteria for good environmental status and boudaries for this were taken here as it was elaborated by HELCOM CORESET alien-species group: **NIS introduced by human activities are at the levels that do not adversely alter the ecosystem** (Table 4.24.2). The ultimate goal is to minimize man made introductions of non-indigenous organisms to zero. The boundary between GES and sub-GES is 'no new introductions of NIS per assessment unit during a six year assessment period' (HELCOM, 2012a).

Table 4.24.2 (after (HELCOM, 2012a).

NIS introduced by human activities are at the levels that do not adversely alter the ecosystem		
GES criteria	**Proposed GES indicators**	**Relation to biodiversity criteria**
1.1 Abundance and state characterisation of NIS, in particular invasive species.	1.1.2 Trends in abundance, temporal occurence and spatial distribution in the wild NIS (notably in risk areas) in relation to the main vectors and pathways of the spreading of such species.	Not directly applicable. Invasive species might change the biodiversity by filling in niches previously not occupied by 'native' species in the young Baltic ecosystem. **State indicator** of NIS. **Pressure indicator** on other biodiversity components.
1.2. Environmental impact of invasive NIS.	1.2.1 Ratio between invasive NIS and native species and native species in some well-studied taxonomic groups (e.g. fish, macroalgae, mollusks) that may provide a measure of change in species composition (e.g. further to the displacement of native species).	Habitat / Community condition. Population distribution, size and condition.

4.24.6. Proposals for indicator monitoring in the Russian part of the Gulf of Finland.

As it was already proposed the indicator should be assessed every six years, but data should be collected continuously, i.e. every year (HELCOM, 2012a;b); here wse propose assessment of data evey four years with continuous investigations. Regular biodiversity monitoring still promise to be the main data supply for NIS arrivals registration. However some special researches (like artificial substrata for fouling organisms attraction) and SCUBA diving surveys in sea ports area are reasonable as well (Metod. recom., 2005; Zvyagintsev et al., 2009).

In the Russian part of the Gulf of Finland 3-4 of the biggest for the Baltic sea-ports are situated. Besides the numerous terminals, there is enormous ancoring place is in the central part of the Gulf, where dozens of large cargo vessels are wating for terminal access or for a transit to the Arctic region via Baltic

Sea – White Sea canal. It means the major part of the small Russian Gulf of Finland waters can be considered as a one huge sea-port area and a sampling for NIS could be undertaken almost everywhere. Russian sea-port areas is increase every year very rapidly. By now no peculiarly good sites could be specified, because the discovered NIS were actually found everywhere (from central parts and a big depth to coastal shallow waters) and no map for such planned monitoring sites is enclosed here.

Herein all the proposals of HELCOM like 'port survey protocol', 'survey design' and 'sampling / monotoring frequency', 'site selection', 'environmental data', 'field sampling' and 'human pathogens' (HELCOM, 2013) are well-known in Russia and they accepted entirely with modifications because of the difference in conditions. With some exceptions all these surveys and especially the special NIS methods are the novelty for the routine State environmental monitoring and they may be involved only with additional finacial support. Such support for the research season of 2014 is expected by Zoological Institute of Rus. Acad. Sci. from the government of St.-Petersburg.

Thus, for NIS monitoring (new NIS arrivals assessment), the data have to be collected annually as frequently and as wide as possible; the assessment itself proposed to be done every six years (HELCOME, 2012 a;b; 2013) or every four years, as proposed here, because of the unpredictable dynamics of this process. General biological monitoring (biodiversity total assessment) can be used as the basis for primary data collection. Taxonomic composition of NIS should be examined as completely as possible. However for assessment purposes it is reasonable to select only remarkable and well studied taxa. Otherwise (if somebody will use also poorly known organisms) it could be just a competition of taxonomists qualification instead of the real NIS arrivals assessment.

5. WAYS AND PROBLEMS OF IMPROVEMENT OF RUSSIAN CAPACITY TO PARTICIPATE IN OPERATIONALIZATION OF HELCOM-CORESET INDICATORS

5.1. Introduction

Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention) was signed in 1974 by representatives from seven countries of the Baltic region (Denmark, Finland, the German Democratic Republic, the Federal Republic of Germany, Poland, Sweden and the USSR). This convention is the first international agreement on regional adoption of restrictive measures to all sources of pollution entering the marine environment (terrestrial, marine and atmospheric). The Convention entered into force on May 3, 1980, after ratification by all states of the Baltic Sea region.

Geopolitical changes that have occurred in the early 90s, have necessitated the revision of the Convention. Updated Helsinki Convention (1992) was signed by the old and the newly formed countries and the European Community at the Diplomatic Conference in April 9, 1992, and entered into force after ratification by January 17, 2000. On October 15, 1998 the Government of the Russian Federation has issued a Decree №1202 on the ratification of the Helsinki Convention.

During 40 years of its existence, HELCOM developed and adopted more than 200 recommendations for governments of the states participating in the Convention, organized and continuously developed the integrated environmental monitoring of the Baltic Sea. The ongoing project HELCOM CORESET is a substantial novelty in this regard. It is focused on development of the series of new indicators to assess the quality of the marine environment, intended to be introduced in the practice of environmental monitoring in the countries participating in HELCOM.
In this regard, the start of the practical application of the HELCOM indicators requires the submission of key legislative and regulatory principles for the organization of monitoring system in the Russian Federation.

5.2. The environmental monitoring system of the Russian Federation

In Russia, monitoring as a system of regular observations on the anthropogenic impact, assessment and prediction of the state of the environment considering the natural background fluctuations began to emerge about 50 years ago. Back in 1964, the stations of the Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet) organized the first regular observations of atmospheric pollution of rivers and lakes. Those observations subsequently became the basis for the formation of national monitoring network measurements acting at present.

Current goals and objectives of the water monitoring are described in the legislative and other normative legal acts of the Russian Federation, including the Decrees of the Government. The most important of these documents are listed below.
- Federal Law of 10.01.2002 № 7-FZ (as amended on 12.03.2014) 'On Environmental Protection'
- Government Decree of 09.08.2013 № 681 'On the state environmental monitoring (state monitoring of the environment) and state data bank for the data of the state environmental monitoring (state monitoring of the environment)'.

The keystone law in system of the Russian environmental legislation is the Federal Law of 10.01.2002 № 7-FZ 'On Environmental Protection'. Among other aspects of environmental protection, it establishes the terms and basic principles of the Russian state environmental monitoring. Thus, this law (Article 1) introduced the concept of 'state environmental monitoring (state monitoring of the environment)' as 'integrated observations of the environment, including the components of the environment, natural ecological systems, the processes and phenomena in it, evaluation and forecasting of the changes in the environment.'

According to Article 63 of the said Act, ‘State environmental monitoring (state monitoring of the environment), is carried out within *a single system of state environmental monitoring (state monitoring of the environment)* by federal executive authorities, state authorities of the Russian Federation in accordance with their competence by the laws of the Russian Federation, *through the creation and operation of monitoring networks and information resources within the subsystems of the unified system of state environmental monitoring (state monitoring of the environment),* as well as the establishment and operation *of the state data bank by the federal executive authority authorized by the Government of the Russian Federation. ‘*

In turn, a unified system of the state environmental monitoring (state monitoring of the environment) (Article 63.1) includes 15 subsystems (Table 5.2.1), the organization and functioning of which is determined by the Regulations on the state environmental monitoring (state monitoring of the environment) and state data bank for the data of the state environmental monitoring (state monitoring of the environment), approved by the Government Decree of the Russian Federation of 09.08.2013 № 681.

Said Regulations govern the implementation of the state environmental monitoring (state monitoring of the environment), the organization and functioning of the unified system of the state environmental monitoring (hereinafter - unified monitoring system).

According to the Regulations the state environmental monitoring is implemented by the Ministry of Natural Resources and Ecology of the Russian Federation, the Ministry of Agriculture of the Russian Federation, the Federal Service for Hydrometeorology and Environmental Monitoring, the Federal Service for State Registration, Cadastre and Cartography, Federal Forestry Agency, the Federal Agency for Subsoil Use, the Federal Water Resources Agency, the Federal Agency for Fisheries, and executive authorities of the Russian Federation by the establishment and operation of monitoring networks and information resources within subsystems of the unified monitoring system, as well as the creation and operation of the state data bank by the Ministry of Natural Resources and Ecology of the Russian Federation (Official letter...; Annex # 8.1)

Table 5.2.1. Subsystems of the state environmental monitoring (state monitoring of the environment) and the federal executive bodies responsible for their functioning.

№	Subsystem	Legislative and regulatory acts of the Russian Federation governing the functioning of the monitoring subsystem	Responsible federal executive bodies
1	State monitoring of the state and pollution of the environment (air, soil, surface water bodies (including hydrobiological indicators), the ozone layer of the atmosphere, the ionosphere and near-Earth space)	Government Decree of 06.06.2013 № 477 ‘On the implementation of the state monitoring of the state and pollution of the environment’ (together with the ‘Regulations on the state monitoring of the state and pollution of the environment’)	Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet)
2	State monitoring of the atmospheric air	Federal Law of 04.05.1999 № 96-FZ (as amended on 23.07.2013) ‘On atmospheric air protection’	Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet)
3	State monitoring of the radiation situation on the territory of the Russian Federation	Federal Law of 21.11.1995 № 170-FZ (as amended on 02.07.2013) ‘On the use of atomic energy’	Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet), as well as the

			State Nuclear Energy Corporation Rosatom
4	State monitoring of land	Government Decree of 28.11.2002 № 846 ‘On approval of the Regulation on the state monitoring of land’	Federal Service for State Registration, Cadastre and Cartography (Rosreestr) (except agricultural land); Ministry of Agriculture of russian Federation (Minselhoz) - the state monitoring of agricultural land
5	State monitoring of wildlife	Order of the Ministry of Natural Resources and Environment of the Russian Federation of 22.12.2011 № 963 ‘On approval of the procedure of state accounting, state cadastre and monitoring of wildlife’ (registered with the Ministry of Justice on 14.03.2012 № 23473)	Ministry of Natural Resources and Environment of the Russian Federation (Minprirody)
6	State forest pest monitoring	Order of the Ministry of Natural Resources and Environment of the Russian Federation of 09.07.2007 № 174 ‘On approval of the organization and implementation of pathology monitoring’ (registered in the Ministry of Justice on 23.07.2007 № 9880)	Federal Forestry Agency (Rosleshoz)
7	State monitoring of forest reproduction	Federal Law of 12.03.2014 № 27-FZ ‘On amendments to certain legislative acts of the Russian Federation on the implementation of federal state forest inspection (forest protection) and the implementation of measures for the forest protection and reforestation’	Federal Forestry Agency (Rosleshoz)
8	State monitoring of subsoil condition	Order of the Ministry of Natural Resources of the Russian Federation of 21.05.2001 № 433 ‘On Approval of the Procedure for State monitoring of subsurface condition of the Russian Federation’ (registered with the Ministry of Justice of 24.07.2001 № 2818)	Federal Agency for Subsoil Use (Rosnedra)
9	State monitoring of water bodies	Government Decree of 10.04.2007 № 219 (as amended on 05.06.2013) ‘On Approval of the Regulation on the implementation of state monitoring of water bodies’	Federal Water Resources Agency (Rosvodresursy) with the participation of the Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet) and the Federal

			Agency for Subsoil Use (Rosnedra)
10	State monitoring of water biological resources	Government Decree of 24.12.2008 № 994 (as amended on 22.10.2012) 'On approval of the Regulation on the implementation of state monitoring of water biological resources and the application of its data'	Federal Fisheries Agency (Rosrybolovstvo)
11	State monitoring of the internal sea waters and the territorial sea of the Russian Federation	Federal Law of 31.07.1998 № 155-FZ (as amended on 02.03.2014) 'On the internal marine waters, territorial sea and contiguous zone of the Russian Federation'	Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet)
12	State monitoring of the exclusive economic zone of the Russian Federation	Federal Law of 17.12.1998 № 191-FZ (as amended on 02.03.2014) 'On the exclusive economic zone of the Russian Federation'	Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet)
13	State monitoring of the continental shelf of the Russian Federation	Federal Law of 30.11.1995 № 187-FZ (as amended on 02.03.2014) 'On the continental shelf of the Russian Federation'	Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet)
14	State environmental monitoring of the unique ecological system of the Lake Baikal	Federal Law of 01.05.1999 № 94-FZ (as amended on 28.12.2013) 'On the protection of the Lake Baikal'	Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet)
15	State monitoring of hunting resources and their habitats	Order of Ministry of Natural Resources and Ecology of the Russian Federation of 06.09.2010 № 344 (as amended on 10.11.2011) 'On approval of the Regulation on state monitoring of hunting resources and their habitats and the use of its data' (registered with the Ministry of Justice on 08.10.2010 № 18671)	Ministry of Natural Resources and Ecology of the Russian Federation (Minprirody)

It should be noted that the four of the federal agencies from the above list are structures of Minprirody, namely Roshydromet, Rosvodresursy, Rosnedra, Rosselhoz, Rosrybolovstvo, belong to the Ministry of Agriculture of the Russian Federation (Minselhoz), while the Federal Service for State Registration, Cadastre and Cartography (Rosreestr) is subordinated to the Ministry of Economic Development of the Russian Federation, which significantly reduces the number of recipients for the discussion of prospects of practical use and implementation of HELCOM, or any other, indicators.

Moreover, paragraph 4 of the Regulation on the state environmental monitoring, approved by the Government of the Russian Federation of August 9, 2013 № 681, states that 'the overall coordination of the organization and functioning of the unified system of monitoring is implemented by the Ministry of Natural Resources and Ecology of the Russian Federation.'

Thus, **all the prospects of implementation of the HELCOM indicators in the practice of public ecological monitoring should be addressed and resolved in the Russian Ministry of Natural Resources,** which, according to the Regulations of the Ministry of Natural Resources and Ecology of the Russian Federation, approved by the RF Government Decree of May, 29 2008 № 404, 'organizes and within its competence ensures meeting the obligations arising from international treaties of the Russian Federation on issues within the scope of activities of the Ministry.'

5.3. Ways and problems of introducing new indicators into the environmental monitoring system of the Russian Federation

Most of the proposed HELCOM indicators including indicators for biodiversity and hazardous chemicals are new for the current practices, Russian Ministry of Natural Resources, including the Roshydromet as the main organizer and performer subsystems monitoring the Russian part of the Baltic Sea and its catchment area (Table 1, item 1, 9, 11, 12, 13), will be required considerable institutional and methodical effort, as well as material costs for their practical implementation.

First of all, for example, the introduction of indicators for hazardous substances is associated with a time consuming procedure not only for the development of national measurement techniques (NMT), but their metrological support in order to comply with the integrity and the required accuracy of measurement results of indicators of environmental pollution, the reliability of the measurement information obtained during the state monitoring, as required by GOST R 8.589-2001 (State Standard of the Russian Federation. State system for ensuring the uniformity of measurements. Metrological ensuring. General principles). As a result, the newly developed NMT must be registered in the Federal Register of NMT used in the fields of state metrological control and supervision. NMT admitted to use in environmental pollution monitoring, in addition must be registered in the Federal list of measurement techniques allowed for use during environmental pollution monitoring (RD 52.18.595-96) - guidance document of Roshydromet.

These principles of compliance and accuracy of measurements in order to obtain comparable results apply not only to indicators of chemical pollution, but also to biodiversity indicators, the use of which in the framework of the state environmental monitoring should be regulated by methodological guidelines of appropriate department of the executive branch of the federal level.

There is a big reserve of highly qualified laboratories and individual experts is in the institutions of Russian High School (leading universties) and of Russian Academy of Science. The involvement of these institutions into the monitoring process and indicators development may improve substantially the Russian capacity to participate in operationalization of those indicators. For this reason some parts of monitoring work could be delegated (offered) by Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet) together with part of funds, instructions, licenses and other necessary technical documentation to selected institutions. The distinctions in departamental affiliations and separated budgets are the main barriers on this way.

Research institutions of St. Petersburg of different departmental affiliation can significantly facilitate preparation for implementation of the proposed indicators. They can take on obligations to develop projects of all kinds of guidance documents for future indicators, including approaches to setting standards to assess water quality and, most importantly, the basis for *environmental and economic feasibility* of their use is in practice of environmental monitoring of the Russian part of the Baltic Sea. Such activities would have been more than helpful and could be implemented, for example, within the framework of current agreement on cooperation of 27.04.2011 № 127 between the Federal Service for Hydrometeorology and Environmental Monitoring and the Russian Academy of Sciences.

However, participation in the implementation of state environmental monitoring, especially with the use of indicators for hazardous substances, research institutions or any other legal entities and (or) individual entrepreneurs requires a license issued by the licensing authority in the field of hydrometeorology and related fields, i.e. Roshydromet, in accordance with the Government Decree of the Russian Federation of 30 December 2011 № 1216 defining the licensing procedure in this area. Otherwise, the results obtained by research institutions can not be placed in a state data bank and thus be recognized by the state environmental monitoring data either within Russia or abroad.

Thus, the proposed HELCOM indicators can be put into practice by the state environmental monitoring. However, it is possible only after a thorough ecological and economic expertise of their feasibility, selection from a list of indicators of priority indicators for the Russian part of the Baltic Sea, including the eastern Gulf of Finland, creation of technical standards and logistical base for their application and allocation of financial resources for that purpose.

An other, but just additional, way is applications for grants implementing the indicators. The combined team from SPbSU (biologists and chemists) had applied for budget grant for hazardous substances HELCOM indicators surveys in marine biota for 2014 year. Unfortunately that grant wasn't given, but the application itself is a correct way to move forward.

5.4. Russian experts network creation for participation the projects of HELCOM, related to indicators development and implementation (BASE, CORESET II et al.)

The experts are the highly skilled bearers of special knowledge, what differs the word 'expert' from the word just 'the specialist'. The participation of Russian experts in HELCOM projects always was extremely limited. For example in HELCOM-CORESET project from 56 participants was only one Russian expert - Alexander Antsulevich (HELCOM, 2012a;b). The reason of it was not in the lack or in the limited number of experts in Russia, but in the organization of work, including the stimuli for experts to do this job. This problem still not resolved completely and it is the responsibility of the Russian authorities.

When executing this project by St.-Petersburg State University in frames of the HELCOM-BASE project 27 of experts from various leading institutions (mostly from SPbSU) were involved (the list of them is on the second page of the given report). This is actually the big step to the experts network creation for participation the projects of HELCOM, related to indicators development and implementation. On the base of this list of experts and after the personal negotiations with everyone by SPbSU project manager the group of 14 experts has been proposed and pushed forward for the participation the new ongoing HELCOM project CORESET II (Table of Russian experts; Annex # 8.3). It is a most abundant representation of Russian experts whenever has been in the history of HELCOM-Russia colaboration, what is in full accordance with the main tasks and with the Terms of Reference of the project HELCOM-BASE and of the Contract between HELCOM and SPbSU.

6. CONCLUSIONS

Several conclusions may be extracted from the given report content as follows:

1. HELCOM-CORESET indicators most fully and multilaterally describe the environment, using so-called 'holistic approach'.

2. The whole set of indicators (over 40 of them together with CORESET II list) is implemented in none HELCOM country recently and Russia is not an exception.

3. All components of actual Russian state environmental monitoring are already belong to HELCOM-CORESET indicators, but they are about 10% from the indicator's scope. Other indicators are new - either partly (there is some data available or/and some efforts have been undertaken) or sometimes even completely (no data available).

4. From the list of hazardous substances indicators only the metals and hydrocarbons (and partly PCB) have been monitored more or less satisfactory.

5. There is no officially accepted analytical method for PFOS and TBT in the Russian Federation and few laboratories offering these measurements.

6. The contamination of biota, especially one by complicated organic substances, is a serious gap in a knowledge of biological resources condition.

7. It should be noted that studied area has substantial differences from the main Baltic Sea basin and even from the western part of the Gulf of Finland by flora and fauna content because of the lower salinity, what brings regional difficulties to implementation of some indicators.

8. Some indicators ('Population growth rates, abundance and distribution of marine mammals', 'Abundance of waterbirds in the breeding season', 'Abundance of waterbirds in the wintering season', 'Reproductive disorders: malformed amphipod embryos', 'Trends in arrival of new non-indigenous species') were used in the Russian part of the Gulf of Finland not bad and long ago. However, these investigations were not included into the State environmental monitoring system and they were based only on intial activity of the researches, who plan such works themselves and have no strict obligations to do this. Thus these works may be stopped and any time.

9. The indicator 'Proportion of large fish in the community' in the Russian part of the Gulf of Finland is incomparable with one in the western Baltic area; it should be modified or substituted for other similar parameter, based on locally common fish species.

10. Some of indicators are composed. Indicator 'Cumulative impact on benthic habitats' seems one of most complicated ones and compised 14-15 of various impacts acting cumulatively, but independently; this indicator assessment needs several experts working together.

11. LMS (lysosomal membrane stability) indicator is in use for medical purposes, but it wasn't implemented for environmental assessments in the Russian part of the Gulf of Finland.

12. Just two indicators, based on seals, are impossible to monitor, because of the lack of material (dead seals).

13. There are no technical (staff qualification, equipment presence, etc.) preventions to implement almost all indicators in Russian part of the Gulf of Finland.

14. There are two main clusters of problems to introduce the indicators into practical official monitoring in Russia as follows: organizational and financial.

15. The official involment of leading universities and academic institutions into the State environmental monitoring practice is a shortest way to the HELCOM-CORESET indicators implementation in Russia.

16. The problems of analytical methods and laboratories licensing to contribute to the harmonisation of assessment methods, of the interactions among of the institutions of different authorities and the departamental separation of their budgets are still remains, what needs a coordination, official procedures and agreements.

17. As follows from Russian legislation, 'the overall coordination of the organization and functioning of the unified system of monitoring is implemented by the Ministry of Natural Resources and Ecology of the Russian Federation.'

Thus, all the prospects of implementation of the HELCOM indicators in the practice of public ecological monitoring should be addressed and resolved in the Russian Ministry of Natural Resources, which, according to the Regulations of the Ministry, approved by the RF Government Decree of May, 29 2008 № 404, 'organizes and within its competence ensures meeting the obligations arising from international treaties of the Russian Federation on issues within the scope of activities of the Ministry.'

18. When executing this Contract between HELCOM and St.-Petersburg State University in frames of the HELCOM-BASE project 27 of experts from various leading Russian institutions (mostly from SPbSU) were involved. On the base of this list of experts the group of 14 experts has been proposed and pushed forward for the participation the new ongoing HELCOM project CORESET II, what is a most abundant representation of Russian experts whenever has been in the history of HELCOM-Russia colaboration.

19. Evidently, all indicators may not be implemented at once and immediately. The introduction of the indicators will serve to the harmonisation of assessment methods in the whole Baltic Sea region and this way will promote the the Baltic Sea Action Plan (BSAP) development and realization.

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Annex # 1

МИНИСТЕРСТВО ПРИРОДНЫХ РЕСУРСОВ И ЭКОЛОГИИ РОССИЙСКОЙ ФЕДЕРАЦИИ (Минприроды России)

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на № ______ от ______

А.Е.Анцулевичу,

199178 Санкт-Петербург. 16 линия , 29,
Кафедра ихтиологии и гидробилогии СПбГУ

О мониторинге в Балтийском море

Уважаемый Александр Евгеньевич!

В ответ на Ваше обращение от 24.02.2014 по вопросу об экологическом мониторинге в Балтийском море и Финском заливе сообщаем следующее.

В соответствии с постановлением Правительства Российской Федерации от 10 апреля 2007 г. № 219 "Об утверждении Положения об осуществлении государственного мониторинга водных объектов" организация и осуществление мониторинга российской части Балтийского моря и Финского залива проводятся Федеральным агентством водных ресурсов, Федеральным агентством по недропользованию, Федеральной службой по гидрометеорологии и мониторингу окружающей среды и Федеральной службой по надзору в сфере природопользования с участием уполномоченных органов исполнительной власти субъектов Российской Федерации, а также соответствующими научными институтами, в том числе Федеральным государственным бюджетным учреждением «Государственный океанографический институт имени Н.Н.Зубова».

Данные мониторинга водных объектов района Балтийского моря, направляемые в Комиссию по защите морской среды Балтийского моря (ХЕЛКОМ) Хельсинкской конвенции, основываются на полученной из указанных агентств и служб Минприроды России информации.

С уважением,

Директор Департамента
международного сотрудничества Н.Р.Инамов

ПБТретьякова 84992547947

Annex # 8.2. HELCOM – CORESET - BASE indicators in the Russian part of the Gulf of Finland. Facts in brief.		
	Hazardous substances and their effects	
1.	**Polybrominated biphenyl ethers (PBDE): BDE-28, 47, 99, 100, 153 and 154**	There is no regular monitoring of PBDE in the Russian Federation. Data on PBDE in the Russian part of the Gulf of Finland are scarce. Available data is summarized; data were obtained as a result of independent research.. In the bottom grounds the sum of 6 indicator congeners may reach up to 1.19 ng/g, BDE-47 clearly is a major contributor into the poluttion. PBDE is a relevant indicator. No data is available for biota samples. Monitoring scheme is proposed.
2.	**Hexabromocyclododacene (HBCD)**	There is no regular monitoring of HBCD and no official information on production or use of this chemical in the Russian Federation. HBCD was not detected in natural waters (Fig. 1, 5 samples, LOD – 0.4ng/L), in sewage water (3 samples, LOD – 0.4ng/L) or in WWTP effluent (3 samples, LOD – 0.4ng/L). HBCD was detected in WWTP sludge. HBCD is a relevant indicator, though its significance appears to be secondary in comparison with PBDE. Available data is not sufficient for conclusions on the status of this indicator in the Russian part of the Gulf of Finland. GES boundary proposed by CORESET is currently 167 µg kg^{-1} fish ww and for sediment 170 µg kg^{-1} dw. This can be taken as provisional quality status for the Russian part of the Gulf of Finland as well. Monitoring scheme is proposed.
3.	**Perfluorooctanesulphonate (PFOS)**	There are no known local producers of PFOS. There is no official analytical method for PFOS in the Russian Federation. PFOS was found in two (of 5) water samples: near Strelna – 1.7 ng/L, in the Neva mouth – 2.4 ng/L. In other samples PFOS was not detected beyond LOD, 0.5ng/L. No data is available on PFOS in biota. PFOS is a relevant indicator. Monitoring scheme is proposed.
4.	**Polychlorinated biphenyls (PCB) and dioxins and furans: CB-28, 52, 101, 118, 138, 153 and 180; WHO-TEQ of dioxins, furans +dl-PCBs**	PCBs have been monitored in the Russian Federation and monitoring data was reported on numerous conferences, seminars and international meetings. There exists some historical data on PCB level in the Gulf of Finland as well. In water samples maximal concentration of the six proposed congeners was 6 ng/L at Tolbukhin island, of which 2.6 ng/L was PCB-28. The minimal concentration (0.2ng/L) was found in Neva water upstream of St.-Petersburg. Both Dioxins and PCBs are relevant as indicator for Russian Federation. There are internationally agreed «safe levels» of dioxins in fish or sediment. These can be suggested as GES boundaries. Sediment: 0.85 ng / kg dw (Σ PCDDs+PCDFs). As concentrations of PCDD/PCDFs are very low in water, it is wise not to monitor their concentration in water at all – as indicator parameters. Monitoring of this indicator can be likely accommodated into existing monitoring activities of 'Sevmorgeo' (institution of Ministry of Natural Resources of RF).
5.	**Polyaromatic hydrocarbons and their metabolites: US EPA 16 PAHs / selected**	'Sevmorgeo' is carrying monitoring of the shelf and has made some of the data publicly available. In 2009 high sediment levels of PAHs was found in sediments of the St. Petersburg and Vyborg harbours (in the

	metabolites.	range 3000 – 4500 mg/kg at some stations), and significant levels near Primorsk (500 – 1000 mg/kg). Benzo[a]pyrene was detected in 96% of sediment samples taken along the waterway Ladoga lake – Neva river - Eastern part of the Gulf of Finland. No information is available on PAH metabolites. PAHs are relevant as indicator for Russian Federation. PAHs are being monitored on a regular basis, but majority of data is not in public domain. Monitoring of this indicator can be likely accommodated into existing monitoring activities.
6.	**Metals (lead, cadmium and mercury)**	Heavy metals are monitored in a water and bottom sediments of the Gulf of Finland by 'Sevmorgeo'. Safe levels are determined by hygienic and fishery standards. The data is variable and the concentrations are often linked with dredging works. Existing scheme of monitoring is described and supported.
7.	**Tributyltin (TBT) and imposex**	There is no official analytical method for TBT in the Russian Federation and there are few laboratories offering TBT measurements.However, tributyltin chloride can often be detected in sediments of the Russian part even by direct GC-MS analysis. TBT is a relevant indicator. Monitoring program does not exist, but proposed herein.
	Biodiversity and food webs	
8.	**Lysosomal Membrane Stability – a general stress indicator**	Lysosomal membrane stability indicator is in use for medical purposes, but it wasn't implemented for environmental assessments in the Russian part of the Gulf of Finland. Monitoring scheme is proposed.
9.	**Fish diseases – a fish stress indicator**	No really regular monitoring is exist. However some scattered historical data and recent data are available, mostly on coastal fishes parasites (roach, perch and three-spined stickleback). Relevant indicator. Monitoring proposal is given.
10.	**Micronuclei test– a genotoxicity indicator**	MNT was not implemented for environmental asessment in the Russian part of the Gulf of Finland. It is cosidered as more or less acceptable indicator. An other, considered as better genotoxicity indicator - ana-telophase analysis in biomonitoring in order to make in-depth assessment of the pressure on aquatic ecosystems. Recommendations for monitoring using both of methods are given.
11.	**Reproductive disorders: Malformed eelpout and amphipod embryos**	Eelpout as a marine fish inhabits close to the perifery of the Russian part of the Gulf of Finland and it is rather rare in the region. No monitoring of its reproductive disorders is exist. There are two studies only are known on **s**keletal deformities and fluctuating asymmetry of an eelpout. Malformed amphipod embryos have great potential for the sediment toxicity tests in estuarine and marine areas. Such kind of works is in progress recently and promise to become a regular monitoring. Three species of gammaridean amphipods *Gammarus tigrinus*, *Pontogammarus robustoides* and *Gmelinoides fasciatus* were used as test species in initial work. The results and monitoring proposals are given.
12.	**Population growth rates, abundance and distribution of marine mammals**	Rather regularly monitored indicator. Both historical and quite new data are available and provided here on the Russian part of the Gulf of Finland. Grey seals are more or less widely distributed (estimated abundace is about 500 individuals). Ringed seals are less numerous and endangered (about 100 individuals). Both of species are pressed out

		from the SPb area to the perifery of the region. Monitoring schemes are proposed.
13.	**Pregnancy rates of marine mammals**	Therefore under the current conditions and regarding high conservation status of Baltic ringed seal and grey seal we don't consider this particular indicator to be applicable in the Russian part of the Gulf of Finland at the moment.
14.	**Nutritional status of seals**	Therefore under the current conditions we don't consider this particular indicator to be applicable in the Russian part of the Gulf of Finland at present.
15.	**Number of drowned mammals and waterbirds in fishing gears**	The is no of monitoring of the indicator. The data on the indicator are not available and doubtfully reachable. Few facts are known just qualititatively, but it is impossible to estimate it quantitavely. Some ideas for monitoring are proposed.
16.	**White-tailed eagle productivity**	There are some data available, based on 1-2 nests observations. Total amount of nests in the Russian area is not bigger than five. **White-tailed eagle is the least abundant species among all of animals of the Gulf of Finland!** The data and monitoring proposal are given.
17.	**Abundance of waterbirds in the wintering season**	Regularly (annually) monitored indicator. Long-term data sets are available. The reduction of the number of mallards in winter last two decades corresponded to the autumn decline, which depends directly on reproductive success in breeding and migrating birds. The weakness of the indicator in Russia: this kind of studies is not included into the State monitoring system. The data collected initially by group of scientist without regular support, often using enthusiasm only, which is not unlimited.
18.	**Abundance of waterbirds in the breeding season**	Regularly (annually) monitored indicator. Long-term data sets are available. Rather big amount of acting ornithologists. The available data are not sufficient yet to make conclusions because up to 2010 the data were collected irregularly, except for the Kurgalsky Reef for the Great Cormorant (the numbers of breeding pairs are available for 1993-1999, 2005-2012). To monitor the indicator 'Abundance of waterbirds in the breeding season' it is necessary to provide surveys of the islands of the Gulf of Finland twice a breeding season (for parameter 'abundance' – number of breeding pairs).
19.	**Number of waterbirds being oiled annually**	No monitoring is exist. Just some isolated facts are know without quntitative estimation. No serious oil leakage accidents are knonw untill now. Only partial usage of the indicator is possible for the Russian part of the Gulf of Finland (for nesting birds and summer surveys). Assessment of winter birds oil pollution should be excluded because of several reasons. Data collection and interpretation are complicated. The relevance of the indicator and its self-descriptiveness are not so evident. Usage of the indicator and the design of the monitoring are discussed. Proposal for monitoring is given.
20.	**Abundance of key fish species**	Rather intensive monitoring goes on, however it has non-regular spatial and temporal schemes (often dependent on commercial contracts existance and placements). The data is available, but poorly published. Some unpublished data are presented in the given report. Fishery research institute belongs to its own authority – the Ministry of Agriculture, what brings some difficulties to interactions. Thanks to the 'Gulf of Finland Year -2014' the cooperation should get over the difficulty.

21.	**Abundance of fish key functional groups**	No special monitoring for this indicator is exist. However available data can be extracted from the data of previous indicator. It was actually done in the given report for abundance of key functional groups: cyprinids and piscivores. No special monitoring for this indicator is needed, but just a usage of general fishery monitoring data for calculations.
22.	**Proportion of large fish in the community**	The indicator is currently limited to the area where the Baltic International Trawl Survey (BITS) is operated and this area is strongly dominated by cod (*Gadus morhua*). Due to the salinity gradients the species community in the northern part of the Baltic and especially in its easternmost part are not comparable to the western part. However the data on regional fish size-structure for the Russian part of the Gulf of Finland is exist and it is presented in the given report. The indicator in the Russian part of the Gulf of Finland is incomparable with one in the western Baltic area; it should be modified or substituted for other similar parameter, based on locally common fish species. Such proposal is given. The data of existed fishery monitoring should be used.
23.	**Abundance of sea trout spawners and parr**	The indicator is represented by two independent variables – abundance of parr in the river and abundance of spawners. Abundance of smolts of this species has also been monitored during the last 12 years in the basin of the river Luga There is no monitoring of abundance of sea trout spawners, both in the rivers and the marine part of the Gulf of Finland on the territory of the Russian Federation. The monitoring of several rivers of the Gulf of Finland catchment area was proposed.
24.	**Abundance of salmon spawners and smolt**	Currently, the populations of Atlantic salmon remain in 4 rivers flowing into the Gulf of Finland on the territory of the Russian Federation. In the two rivers - the Neva and Narva - populations are supported solely by the activities of salmon hatcheries. Monitoring of the smolt abundance in the natural population of Luga river had been conducted over the last 12 years. The number of smolts of natural origin ranges from 2000 to 8000 individuals and remains stable at a low level. Abundance of smolts in the salmon populations from the Neva River had been monitored from 2005 to 2008. The number of smolts in these years ranged from 20000 to 30000 reared individuals. There is no regular monitoring of the number of spawners in the salmon rivers on the territory of the Russian Federation. In the rivers smolt production should be assessed using smolt trapping. The smolt productivity assessment in the marine part of the Gulf of Finland is difficult and unrealistic, because of the high cost of such studies and the lack of conventional procedures for their implementation.
25.	**Zooplankton mean size and total abundance**	The indicator is the subject of long-term regular monitoring. The data, also historical ones, are available. There are at least two monitorings of it: an official one (carried out by Roshydromet Service) and initial departamental one (carried out simultaneously by other institutions). They are independent, but similar by results. Zooplanktom mean size wasn't a subject of any monitoring, but this important character may be calculated from known data on density and biomass without additional researches and expenses. That was done for the given report. Existing monitoring scheme (stations number, sampling frequency) is good enough and it does not need any changes.

26.	**State of the soft-bottom macrofauna communities**	The indicator is one of the oldest (about one hundred years old) beeing monitored within the Russian part of the Gulf of Finland. There are long-term data available, showing dramatic changes in the soft-bottom macrofauna communities; it is presented in the report. These changes are connected with water pollution and euthrophication, bottom ground contamination, hypoxia, alien species arrival and other pressures. Some of these changes were found reversable. GES boundaries are discussed. Monitoring proposal is given.
27.	**Lower depth distribution limit of macrophyte species**	The indicator wasn't implemented, however its relevancy is evident. Anyway, there are some scattered data exist from the Russian part of the Gulf of Finland. The special expedition of SPbSU was undertaken in summer of 2013 to support the indicator. Available data (including newest ones) are presented in the report. Monitoring schemes, methods and maps were proposed.
28.	**Population structure of long-lived macrozoobenthic species**	The attention to this topic was paid, however it wasn't used as general indicator for environment. In the Russsian part of the Gulf of Finland just few taxa may be considered as long-lived macrozoobenthic species: Unionidae bivalves (genera *Anadonta* and *Unio*), *Macoma balthica* and *Dreissena polymorpha. Saduria entomon* seems doubtful long-lived one. The population structure of the zebra mussel only has been well studied 10-15 years ago, what needs to be repeated. Some weaknesses of the indicator were noted. Recommended periodicity for the indicator monitoring is once per 4-5 years.
29.	**Cumulative impact on benthic habitats**	Quite new indicator. Impact on benthic habitats was not assessed cumulatively earlier. This indicator seems to be one of the most complicated ones and compised 14-15 of various impacts acting cumulatively, but independently; this indicator assessment needs several different experts working together. The first attempt of it is presented in the report. The GES boundaries here is too difficult to quantify. It is too complicated to develop the uniform method and the common shedule for monitoring of this combination of impacts as one indicator.
30.	**Extent, distribution and condition of benthic biotopes**	The difference between understanding of the term 'biotope' accepted by HELCOM and by Russian (also in other countries) scientific societies is demonstrated. Within the Russian area of water 17 of biotopes listed by HELCOM (2013c) were registered. The distribution and dynamics of those are shown and illustrated. The GES boundary is discussed. The aprroaches and the scheme of monitoring are proposed.
31.	**Trends in arrival of new non-indigenous species**	In spite of these trends have no official status of general environmental indicator in Russia, the investigations of this topic in the Russian part of the Gulf of Finland are intensive and have a long-term background data. The data is abundant and widely published. That was partly presented in the given report. The status of the NIS is described by a trend of the number of new arriving NIS with recommended periodicy of registration once per 6 years. GES is none arrivals. The monitoring is quite similar to general hydrobiological monitoring with some peculiar methods in addition.

Annex # 8.3.

The table of Russian experts for participation the HELCOM - CORESET II project, proposed in frames of this work execution for nomination by the Ministry of Natural Resources of the Russian Federation

TASKS (Indicators)	Role	Candidates to CORESET-II Activity Exerts from Russia
Biomass of microphagous mesozooplankton (absolute and relative) (ZEN-MARMONI)	TML & TMA (team leader & team lead. assistent)	
Proportion of cyanobacteria in summer phytoplankton biomass (GES-REG)	TMA	PhD, Ekaterina Voyakina, SCRCES RAN, sen. sci., katerina-voyakina@rambler.ru TMA ONLY; PhD , Andrey Sharov. SCRCES RAN, sen. sci., sharov_an@mail.ru
Cyanobacteria biomass index	TMA	PhD, Ekaterina Voyakina, SCRCES RAN, sen. sci., katerina-voyakina@rambler.ru TMA ONLY
Spring bloom index (MARMONI)	TMA	PhD, Ekaterina Voyakina, SCRCES RAN, sen. sci., katerina-voyakina@rambler.ru TMA ONLY; PhD , Andrey Sharov. SCRCES RAN, sen. sci., sharov_an@mail.ru
Concentration of silica and chlorophyll a	TML & TMA	
Distribution of seabirds	TML & TMA	
Mean maximum length (MML) of the fish community	TML & TMA	
PCB and dioxins for safe fish to eat	TML & TMA	
Occurrence, origin and extent of significant acute pollution events	TML & TMA	
Alkylphenols (nonylphenol and octylphenol)	TML & TMA	
Acetylcholin-esterase inhibition	TML & TMA	

Macrophyte depth distribution	TML & TMA	PhD, Nickolaj Kovaltchouk (Bot. In-t RAN) nickkovaltchouk@rambler.ru
Biomass ratio of opportunistic and perennial macroalgae	TML & TMA	? PhD, Nick Kovaltchouk (Bot. In-t RAN) nickkovaltchouk@rambler.ru
Cladophora length	TML & TMA	PhD, Yulia Gubelit (Zool. In-t RAS) <gubelit@list.ru>
Blue mussel cover	TML & TMA	No blue mussel cover in Rus. GoF (with exception for few specimens found at Rus-Est border)
Fishing effort by specific gears	TML & TMA	
Integrated status of contaminants in fish species	TML & TMA	
Fishing mortality in the fish stocks	TML & TMA	
White-tailed eagle productivity	TML	Pchelintsev Vasiliy (SPbSU) ; vapis@mail.ru TMA PREFERABLY
Abundance of sea trout spawners and parr	TML	
Abundance of salmon spawners and smolt	TML	
Trends in arrival of new non-indigenous species	TML	PhD, Dr.Sci. Marina Orlova (Zool. In-t RAS) marina_orlova2012@gmail.com
Polybrominated biphenyl ethers (PBDE): BDE-28, 47, 99,100, 153 and 154	TML	
Hexabromocyclodocecane (HBCD)	TML	
Perfluorooctane sulphonate (PFOS)	TML	PhD, Yana Russkikh, SCRCES RAN, sen. sci., yanarussk@gmail.com TMA ONLY

Polychlorinated biphenyls (PCB) and dioxins and furans: CB-28, 52, 101, 118, 138, 153 and 180: WHO-TEQ of dioxins,furans –dl-PCBs	TML	PhD, Larisa Khoroshko, SCRCES RAN, sen. sci., lkhoroshko@list.ru TMA ONLY
Metals (lead, cadmium and mercury)	TML	Prof., PhD, Dr.Sci. Sergey Ermakov (Director for Science, In-t of Chemistry of SPbSU) ermakov.sergey@chem.spbu.ru; Prof., PhD, Dr.Sci. Alexander Rybalko (Dept. of Geology, SPbSU); alek-rybalko@yandex.ru
Radioactive substances: Caesium-137 in fish and surface waters	TML	
Tributyltin (TBT) and imposex	TML	PhD, Zoya Zhakovskaya, Head of Dept., SCRCES RAN zazhak@hotmail.com TMA ONLY
Extent of benthic biotopes (indicator split in to at CORESET II 1/2014)	TML	PhD, Daria Ryabchuk, (Rus. Geol. In-t), sen. sci. daria_ryabchuk@mail.ru
Distribution of benthic biotopes (indicator split in to at CORESET II 1/2014)	TML	PhD, Daria Ryabchuk, (Rus. Geol. In-t), sen. sci. daria_ryabchuk@mail.ru
Pharmaceuticals: Diclofenac, EEA2 (+E1, E2, E3 + in vitro yeast essay)	TML	Ekaterina Chernova, scientist, SCRCES RAN S3561389@yandex.ru TMA ONLY
Lysosomal Membrane Stability – a toxic stress indicator	TML	
Fish Disease Index– a fish stress indicator	TML	

Micronucleus test – a genotoxicity indicator	TML	PhD, Dr.Sci, Prof. Eugene V.Daev, (Dept. Genetics & Biotechnology, Faculty of Biology, SPbSU) mouse_gene@mail.ru
Reproductive disorders: Malforme eelpout and amphipod embryos	TML	PhD, Nadezhda Berezina (Zool. In-t RAS) na-berezina@rambler.ru Nadezhda.Berezina@zin.ru
Ratio of diatoms and dinoflagellates	TML	
Ratio of autotrophic and heterotrophic organisms	TML	
Frequency and intensity of cyanobacterial blooms (MARMONI)	TML	
Seasonal succession of functional phytoplankton key groups (MARMONI)	TML	
Phytoplankton diversity (MARMONI)	TML	
Zooplankton species diversity	TML	PhD, Larissa Litvinchuk (Zool. In-t RAS) llitvinchuk@yahoo.com
Biomass of copepods (absolute and relative) (ZEN-MARMONI)	TML	PhD. Larissa Litvinchuk (Zool. In-t RAS) llitvinchuk@yahoo.com
Zooplankton-phytoplankton biomass ratio (ZEN-MARMONI)	TML	

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