TECHNICAL ASSISTANCE FOR CONSTRUCTION THE BREAKWATERS OF MUUGA PORT IN TALLINN, ESTONIA

Environmental Impact Assessment Report

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Contents

SECTION 1 INTRODUCTION

1.1 BACKGROUND

The State-owned company AS Tallinna Sadam[1] commissioned a group of experts from the Estonian Marine Institute at the Tartu University, Merin Engineering Consultants, Royal Haskoning and others[2], to undertake an Environmental Impact Assessment (EIA) as part of the "Planning of the Port of Muuga Breakwater" study completed by Royal Haskoning on the 9th of June 2006.

OBJECTIVES AND SCOPE OF THE EIA

This EIA aims to assess the environmental impacts, if any, of the preferred alignment and structural alternative for the new breakwater construction in the Port of Muuga. The outcome of this EIA will be presented to and discussed with the Client in order to come to a mutual agreement on the preferred layout- and structural alternatives in light of the existing natural and regulatory environment.

THE PORT OF MUUGA

The Port of Muuga was built in 1985 and is located in the Gulf of Muuga approximately 17 km east of Tallinn (Fig. 1). Today it is the main cargo port of Estonia and largest commercial port in Baltic Sea The heavy cargo trade that characterises the Port of Muuga includes vessels transporting crude oil and oil products, fertilizers and hazardous chemicals, and coal.

The Port has ISO14001 and some safety aspects. However, safety measures need to be improved to satisfy international standards. Currently, vessels entering the Port experience navigational problems which heightens the risk of accidents and collisions, especially when there are strong NW to NE winds. However, currently the only measures in place to reduce potential environmental risks, requires vessels to leave the Port for the high seas. Not only does this result in economic losses to the Port but also increases health and safety risks as vessels can be exposed to high waves of up to 4 metres in height during severe weather conditions, when they are forced to anchor in the open part of Muuga Bay.

Because of the increasing heavy traffic which characterises the Port of Muuga today, structures need to be put in place to keep vessel traffic and vessel behaviour as predictable as possible. The construction of breakwaters is seen to contribute towards increased predictability and order, and hence is seen as beneficial to those operating and using the Port's facilities. The breakwaters will increase navigational safety inside the Port of Muuga, allowing international standards to be satisfied and environmental risk, such as oil spillage, to be minimized.

[1] Also known as the Client.
[2] Estonian Maritime Academy, the Estonian Center of Geology, and others (see Table X)

1.2 BRIEF DESCRIPTION OF THE SCHEME

The Port of Muuga is currently being upgraded by the AS Tallinna Sadam, a company owned by the State of Estonia. In light of these on-going developments, this EIA has therefore taken into account the EIAs completed for other projects which comprise an overall scheme to upgrade the Port of Muuga. These EIAs allow us to identify, evaluate and assess any cumulative environmental impacts on the existing environment

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1) Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora – Habitats Directive.
2) EEC Directive79/409/EEC of 2 April 1979on the conservation of wild birds – Birds Directive.
Decision of Estonian Government from 8th May 2005 no 615-k (RTL 2004,111,1758): Proposed Natura 2000 Sites in Estonia.

This EIA is part of the planning of the breakwaters as proposed by Royal Haskoning Maritime and should therefore be read in conjunction with the following Royal Haskoning Maritime reports:

1. Layout Options Report (31.01.2006); and,
2. Planning of the Port of Muuga Breakwater, Preliminary Project Draft Report (09.06.2006).

Seven layout options were selected and described in the report by Royal Haskoning's planners. These are as follows:

1. Reference layout 006 option 1A;
2. Reference layout wide entrance 006 option 1A;
3. Modified reference layout 006 option 1B;
4. Eastern port entrance 007-2A;
5. Eastern port entrance 007-2B;
6. Budget layout 008-3; and,
7. Western Port entrance layout 009-4.

Further detail on the numerical calculations constituting the proposed layout options, can be found in Royal Haskoning's "Layout Options Report" Figures 8 – 11 ((Royal Haskoning, 2006a).

Royal Haskoning assessed three alternative technical solutions of construction of the breakwaters. The preliminary study highlighted that the composite and (piled) cellular cofferdam alternatives were both not feasible in terms of constructability and likely settlements underneath the structure. In light of this, the technical evaluation focused on the following structural constructions of the breakwaters (paragraphs - of Preliminary Project Report dated on 09th June 2006, Royal Haskoning 2006b)

1. Rubble Mound Breakwater
2. Rubble Mound Reef Breakwater
3. Piled Breakwater

Table 2 Components of the Scheme

Scheme Component	Brief Description / Characteristics
Dredging and reclamation	The amount of dredging will be approximately about 1 000 000 m^3 when combined technical solutions (Rubble Mound Reef and Piled Breakwaters) will be used (Alternatives I and II) For Alternative III the amount of dredging will be approximately less than 100 000 m^3
Reference layout 006 option 1A with entrance 300 m	• This reference layout is characterised with an entrance to Muuga Harbour along the existing approach route of 217.8º. A channel / port entrance width of 600m is included. • The length of the entrance channel inside the port up to the centre of the turning circle is some 1,500m for the larger vessels. • West Breakwater originates at the far western 90° corner of the existing breakwater surrounding the Western Basin from where it runs into a north-easterly direction till the intersection with the northern limit of the present port boundary. From this point the western breakwater turns to a south-easterly direction following the present port boundary limit. • East Breakwater originates at the root of the small spur located in the northeast part of the port and follows the present boundary of Muuga Harbour up to the port entrance. • Total length of both breakwaters in this arrangement is some 3,000m. • It has a turning circle with a diameter of 700m located just north of the West Basin, which coincides with the present turning area for the larger vessels.
Reference layout wide entrance 006 option 1A	The same as the written above except that the entrance width is 600 m (Fig. 8)
Modified reference layout 006 option 1B	The same as option 1 A except that the direction of entrance will be moved to N-S (Fig. 8, dotted line)
Eastern port entrance 007-2A	Breakwater Alignment (Fig. 9) The alignment of the West and East breakwaters is the same as for the reference layout with the main difference that the port entrance is now moved further eastward to create a more central location for the port entrance as well as to create a better and more direct approach to the eastern port facilities. The total length of the breakwaters in this arrangement is again some 3,000m. Approach Channel and Turning Circle The approach route for vessels destined for the western berths could be along a heading of some 235º with the turning circle located just north-westerly of the finger pier (same as described above). The length of the entrance channel inside the port up to the center of the turning circle is some 1,325 m for the larger vessels. This would imply that tugs would have to make fast outside the breakwaters to have sufficient time for tug fastening before the vessels arrive in the large turning area. Smaller vessels can sail further south and swing in the smaller turning circle as indicated in the drawing. In case the turning circle would be (later) relocated further south-westerly, the approach route could then be along a 240º route. In both cases the final approach would then be through the existing anchorage area located at the eastern side of the present approach channel, but would remain free of the shallow

A description and evaluation of the layout options and structural choice of the breakwaters are highlighted in Figures 8 – 11 of Chapter 2 (Royal Haskoning's "Layout Options Report" 31.01.2006).

In June 2006, the Planner and Developer were selected out the following two breakwaters layout options as basic due regard the results of multi-criteria analyses:

1. Reference layout with entrance of 600 m; 006, option 1A;
2. Budget layout (with entrance of 300 m)

Both the Planner and Developer agreed that from a cost-benefit perspective, at given water depths the following types of breakwater were the preferred construction options:

1. The Rubble Mound Reef Breakwater type at a depth of up to 12 meters; and,
2. The Piled Breakwater type deep sea will be constructed.

Dredging and dumping of the dredged material at a chosen site will be necessary because the soft soil characterizing the area up to 12 meters in depth, notably where the Rubble Mound Reef Breakwater will be built, has to be replaced. The material dredged will not be usable for filling of breakwaters and should be discharged. As the soil is not polluted the dumping into the sea spoil ground area nearby Aksi Island will planned to use.

Following receipt of the technical and cost-benefit analysis results on wave and oil-spill modeling[3], Royal Haskoning Maritime concluded that of the 7 proposed breakwater structures, the preferred lay-out option was a combination of Rubble Mound Reef-Piled Breakwater structure. These are as follows:

1. 0-Alternative, breakwaters will not be built;
2. I-Alternative, Reference layout option (Fig. 8) with rubble mount reef structural type in areas less then 12 meters in depth and piled structural type in deeper sea; and,
3. II-Alternative, Budget layout option (Fig. 10) with rubble mount reef structural type in areas less than 12 meters in depth and piled structural type in deeper sea.

Later, in August 2006 the Planners and Developer decided that the version when all breakwaters will have the structure of piled construction will also be acceptable. As result the EIA Experts evaluated this version also and the III-Alternative was added.

4. III-Alternative. Reference layout with entrance of 600 m fully with piled structural type.

In I-Alternative, two different possibilities of entrance width were considered; notably, 600 meters and 300 meters. These were evaluated separately when the impacts will be potentially differed.

The environmental impacts of each of the 7 preliminary lay-out options as presented in the Royal Haskoning Maritime draft report " Planning of the Port of Muuga Breakwater" (09.06.2006) is the same are almost similar.

[3] See Chapters 4.3 2.10 and 4.10 of which report?

1.3 THE STUDY AREA

The Port of Muuga was established in 1986 as a main grain port of former and located at the Western Coast of the Bay of Muuga (Figure 1).

Figure 1. Boundary (dotted line) of Study Area including the Port of Muuga and surrounding areas potentially affected by construction and operation of breakwaters

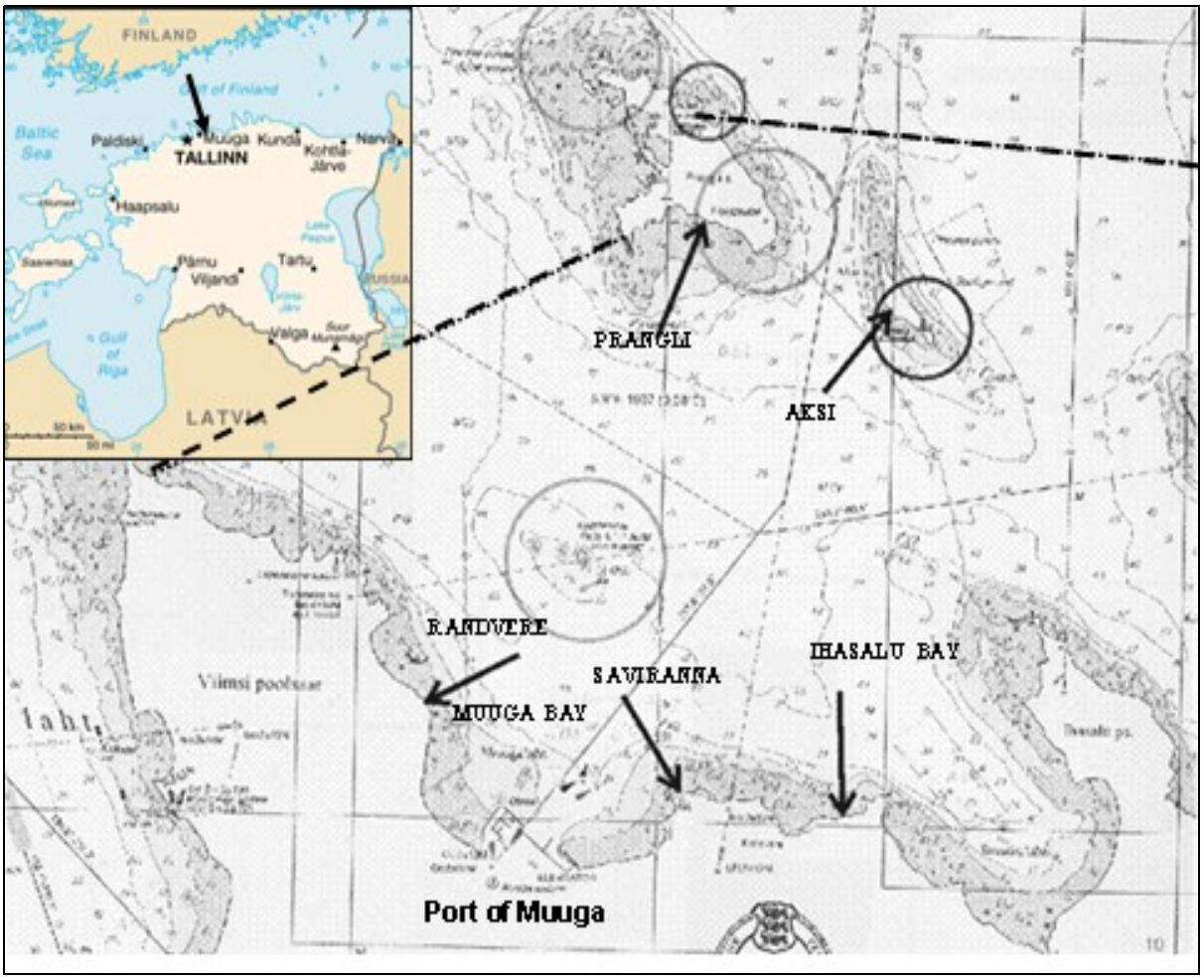
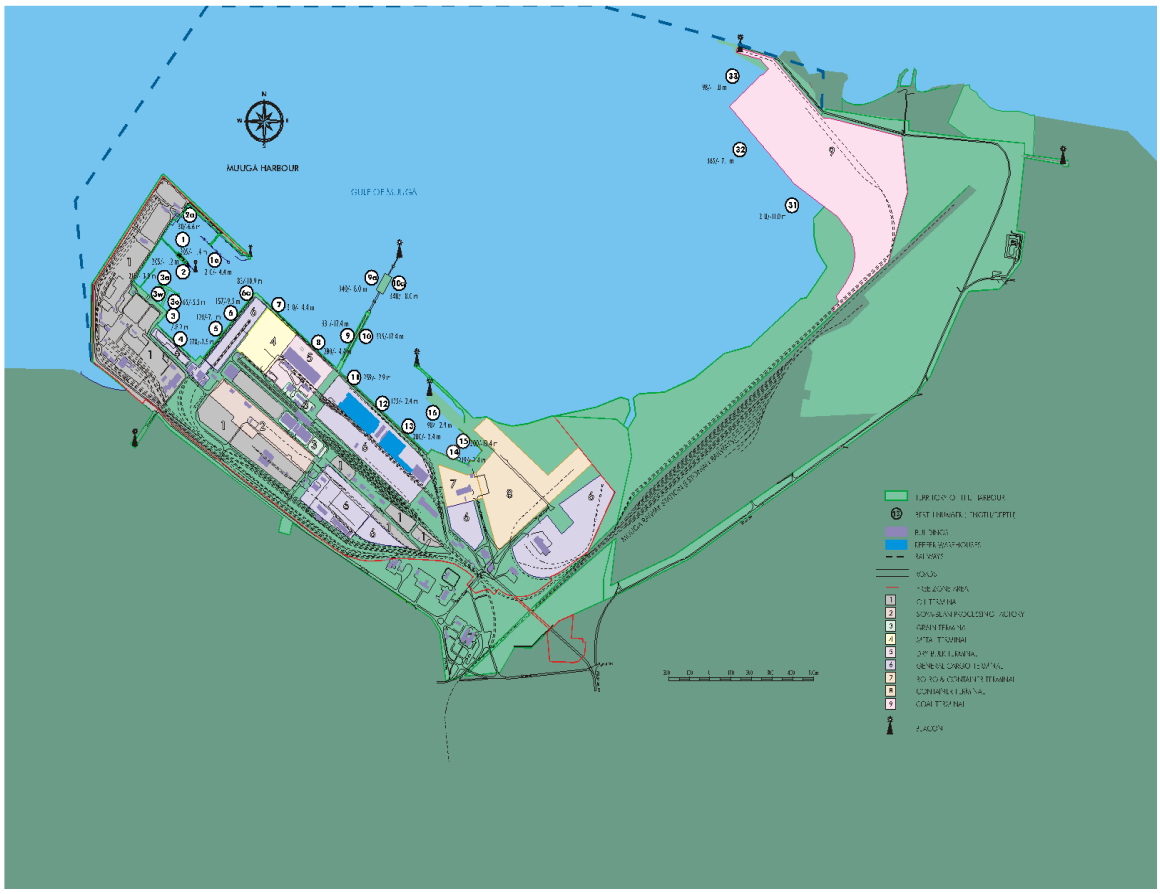


Figure 2. The Port of Muuga (2006)



The Port of Muuga (2006):
- covers an area of 449.2ha;
- aquatory 752ha;
- number of berths 23;
- total length of berths 4710 m;
- maximum depth 18 m (pier 9 and 10a);
- maximum length of a vessel 300m and maximum width of a vessel 48m;
- the largest cargo vessel may have dimension 299 164 DWT; and,
- the longest quay is 340 m, like quays No. 9a and 10a.

Terminals in the Port of Muuga include:
- 5 liquid bulk terminals + another terminal under construction
- multipurpose terminals (one of them with a reefer complex)
- Container terminal and ro-ro terminal
- Dry bulk terminal
- Grain terminal
- Steel terminal
- Coal terminal (was completed 2005)

The Port has facilities in place to load and discharge oil and oil products, general and bulk cargo, timber, reefer cargo, container and ro-ro cargo. Berths 31, 32 and 33 can be

approached through a channel 920m long, 200m wide and 17.8m deep. The construction of the new 340m long oil jetty was finished in late 2003. Water depth alongside the jetty is 18m. It allows load and discharge tankers of up to 125,000 DWT. Tankers can be loaded from two sides. The maximum capacity of the new jetty is approximately 18 million tons of oil products per year. The existing container terminal has the handling capacity of 150,000 TEU. To enlarge the annual handling capacity to 250,000 TEU, an additional quay-line is required. Plans for the 2nd phase of the container terminal include construction of two new quays and a basin between the quays.

Planned Developments in the Port of Muuga

The Port of Muuga has plans to extend its activity considerable in the future (Fig. 3).

The main characteristics of these future developments include:

- The future quay line will be situated at a distance of 250–600 m from the today's waterline.

The new quays to be built (total length 2030–2050 m) allow mooring of ships with the following dimensions:

- Container ship – 50 000 DWT, 266 m x 32.3 m – 13.3 m;
- Bulk carrier – 100 000 DWT, 248 m x 37.9 m – 14.8 m;
- General cargo ship – 20 000 DWT, 170 m x 24.9 m – 10.4 m;

In the area of extension dry bulk (mainly fertilizers), metal, general cargo and container terminals will be situated.

The cargo volumes to be handled on the eastern territory of Muuga Harbour in 2010-2025 are presented in the table below, which is based on the *Economic Analysis. Traffic Forecast Muuga Harbour 2005-2025, medium scenario* composed by the Consultant.

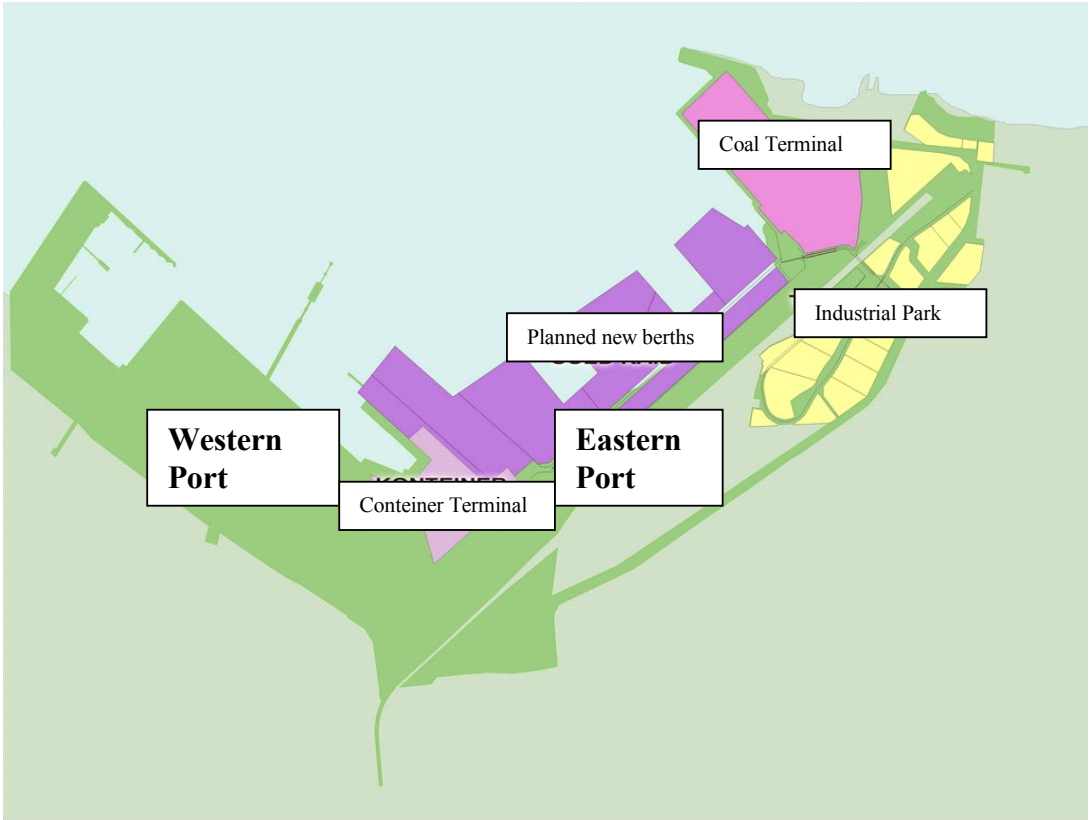
Table 2 Forecasted cargo volumes in the terminals of the eastern Muuga Port 2010-2025, million tons

	2004*	2010	2015	2020	2025
Container terminal	1.00	0.89	1.53	2.31	3.22
thousand TEU	112	77	141	219	310
Metal terminal	0.94	1.29	2.04	2.49	3.02
General cargo terminal	0.49	0.21	0.39	0.50	0.63
Dry bulk terminal (fertilizers)	2.23	0.99	1.78	2.31	2.90
Total	4.66	3.38	5.74	7.61	9.77
Coal terminal	*1.10*	*3.50*	*4.70*	*5.60*	*6.70*
Total	*5.76*	*6.88*	*10.44*	*13.21*	*16.47*

* whole Muuga Port in 2004

In the cargo volumes railway transport prevails (90–95 %), the remaining part will be delivered by motor transport.

Figure 3 Development Plan of Port of Muuga (A. Kaljurand, 2006)



The safety of navigation in Muuga Port

The safety of navigation and operation of vessels within the Port aquatory is regulated by Port Rules. These include:

- All persons operating on the territory of the harbours of Port of Tallinn shall fulfill the International Convention for the Safety of Life at Sea (SOLAS convention), incl. International Ship and Port Facility Security Code (ISPS code) and Regulation (EC) No 725/2004 of the European Parliament and of the Council of 31 March 2004 on enhancing ship and port facility security and the requirements of port facility plans prepared based on the latter coordinated by the Maritime Board.
- Entering and leaving of vessels in the Port: when entering or leaving the port, pilotage is compulsory for all vessels with the exception of vessels sailing under the Estonian flag (GT of 300 and less), technical ships and dredging vessels of the port.
- Vessels traffic in the Port aquatory: in the port aquatory the vessel shall move at minimum speed at which it can maintain maneuverability with the steer. The operating regime of the vessel's propellers shall be such that it does not endanger the vessels laying at the quay.
- The loading and discharging of oil and oil products established in annex 1 to MARPOL (Marine Pollution) 73/78 to tankers shall take place at a berth built or modified for that

purpose in accordance with requirements. If the loaded or discharged cargo, depending on its characteristics, remains floating (does not dissolve or evaporate completely), the person in charge of loading operations shall ensure quick deployment of suitable booms for the localization of pollution.

Since 2001 the Muuga Port started to introduce a quality and environmental management system, which based on the international and standards contributing greatly to the trustworthiness and transparency of the port Lloyd's Register Quality Assurance declared the Management System of Port of Muuga (as part of such system of Port of Tallinn) to be in compliance with the requirements of the international quality management standard ISO 9001:200 and the environmental management standard ISO 14001.

1.4 REQUIREMENTS FOR AN EIA

This Environmental Impact Assessment (EIA) was completed following requirements set forth in Estonian, European and international law.

1.4.1 NATIONAL LAWS AND REGULATIONS

Estonian law requires that developments satisfy those legal requirements set forth in the "*Environmental Impact Assessment and Environmental Management System Act*" (RT I 2005/15/87) and sub acts.

1.4.2 INTERNATIONAL AND EU REQUIREMENTS

At EU level, development projects must take into account those requirements set forth in the Council Directive 97/11/EEC of March 1997 amending Directive 85/337EEC of June 1985, on the assessment of the effects of certain public and private projects on the environment.

The EEC Directive 92/43/EEC of 21 May 1992 and Methodological guidance on the provision of Article 6(3) and (4) of the Habitats Directive 92/43/EEC must be taken into account to ensure that environmental impacts on Natura 2000 sites, like the Aksi Island situated 0.7-0.8 nm off the potential dumping area, as on some species specific to those habitats listed in Annex I and Annex II of the EC Habitats Directive, are mitigated or eliminated.

Appendix A lists the EC Directives and international requirements relevant to this EIA.

1.4.3 INTERNATIONAL AND NATIONAL ENVIRONMENTAL STANDARDS/GUIDELINES

The international and Estonian environmental guidelines and standards relevant to the construction of the breakwaters in the Port of Muuga, cover the following issues:

- Atmospheric emissions and ambient air quality;
- Liquid effluent discharges into the marine environment;
- Noise emissions and ambient noise levels;
- Solid waste management;

- Solid hazardous waste management;
- Operation management: health and safety, air quality and noise levels;
- Construction management;
- Other environmental management issues.

The international guidelines have been taken from the *World Bank Pollution Prevention and Abatement Handbook*.

Table 3 International Environmental Standards/Guidelines

IAIA Principles of Environmental Impact Assessment Best Practices
Environmental policies and guidelines of other US Government and multilateral
ODA
OECD Common Approaches
IUCN Guidelines for Protected Area Management
World Bank Operational Policies on Natural Habitats (OP 4.04)
World Bank Operational Policies Environmental Assessment (OP 4.01)
World Bank Operational Policies Cultural Property (WB No. 11.03)
Revised IFC / WB environmental and social standards
UN FAO Code of Conduct for Responsible Fisheries

1.4.4 INTERNATIONAL MARINE AND ENVIRONMENTAL COMMITMENTS

At the international marine level, the International Maritime Organization's (IMO) two most important technical bodies, notably the Maritime Safety Committee (MSC) and the Marine Environment Protection Committee (MEPC), require that maritime safety and the protection of the marine environment are fostered and enhanced. This is reflected, *inter alia*, in the international marine commitments listed in Table 4, to which Estonia is signatory. Table 5 lists the international environmental commitments and best practice guidelines of Estonia.

Table 4 International Marine Commitments

IMO Convention 48	CSC Convention 72
IMO amendments 93	INMARSAT Convention 76
SOLAS Convention 74	Facilitation Convention 65
Load Lines Convention 66	SUA Convention and Protocol 88
Tonnage Convention 69	OPRC Convention 90
COLREG Convention 72	SAR Convention
CLC Protocol 92	FUND Protocol
MARPOL 73/78 (Annex I/II)	MARPOL 73/78 (Annex III)
MARPOL 73/78 (Annex IV)	MARPOL 73/78 (Annex V)
UNCLOS	London Convention 72 and amendments
HELCOM	ICES

Table 5 International Environmental Conventions

Revised Equator Principles	UNESCO World Heritage Convention
Ramsar Convention	UNCLOS
UNCCD	Kyoto Protocol to the UNFCCC
CBD	Basel Convention
Stockholm Convention on POPs	HELCOM Habitat
HELCOM BSAP	HELCOM Red List

1.5 PUBLIC CONSULTATION

This EIA satisfied the public consultation requirements as set forth by Estonian law. In July 2006, the EIA Programme received full approval from the Estonian Ministry of Environment.

A public consultation was held with stakeholders and interest groups on the 21st of April 2006, to discuss the objectives and scope of the planned construction of the breakwaters in the Port of Muuga. The public consultation was successful in that the stakeholders and interest groups accepted and agreed to the construction of breakwaters in the Port of Muuga.

1.6 STATEMENT OF NEED

The Port of Muuga is characterized with environmental and safety risks due to the lack of wave breakers necessary to reduce the height of waves. Difficulties experienced by vessels during periods of elevated wind and wave height, restrict the potential for growth of container traffic and results in economic losses due to high downtime.

The current risk of environmental catastrophe is high. The Port of Muuga is characterized with the transport of crude oil, fertilizers, hazardous chemicals and coal. The risk of oil spillage into the Muuga Bay area, which neighbors Natura 2000 sites like the island of Aksi, can be reduced by the construction of breakwaters which will create a calmer water area and the enforcement of a mitigation plan which includes an oil spill response.

At present, there are practical difficulties in exporting and importing cargo via the Port of Muuga. It is anticipated that the construction of the breakwaters will result in increased potential for transshipping cargo and contribute towards a marked improvement in the following:

- Environmental Requirements;
    - Containment of Oil Spill;
    - Risk Reduction Environmental Catastrophe;
    - Water Quality inside the Basin;
- Creation of Calm Water Area;
    - Reduction of Downtime;
    - Enhancement of Safe Cargo Handling Operations;
- Ease of Ship Manoeuvring;
    - Tugs making fast;
    - Manoeuvring inside Harbour Area
- Reduction of Ice Impacts;
    - Icing of Quays
    - Icing of Vessels;
- Planning Requirements;
    - Alignment of the Approach Channel;
    - Present and Future Port Areas;
    - Design Vessels and Fleet Mix;
    - Extension of Muuga Harbour Area;
    - Phasing of Implementation;
    - Investment Costs.

Containment of Oil Spill

Substantial volumes of oil products are at present being handled in Muuga Harbour at berths located in the south-western part of the port (Western Basin and Berths 7 and 8). Recently, the finger pier was extended for accommodating large oil tankers of over 300m at Berth 9A / 10A.

Although the Western Basin could be closed in case of an oil spill inside, this is at present not the case for Berth 7, 8, 9A and 10A which are all in open connection with the Muuga Bay. The new breakwaters provide an opportunity of protecting these exposed berths in such emergency circumstances. In case of large oil pollutions the breakwater can serve as a containment ring to limit the dispersion of the spill.

Risk Reduction Environmental Catastrophe

Currently small vessels experience difficulties while manoeuvring inside the harbour area during rough weather conditions as they are fully exposed to incoming waves. The risk of arriving vessels running aground or colliding with other vessels / port structures will be reduced by implementing breakwaters.

1.7 REPORT FORMAT

This section of the report introduces the proposed scheme and the role of the EIA. Section 2 describes, in more detail, the breakwaters to be constructed in the Port of Muuga. Section 3 documents the existing environment and includes information on the collection and extent of baseline data. Section 4 explains the EIA process and the methodology used for impact identification and evaluation. Section 5 considers the construction phase as well the further exploitation phase potential environmental impacts. Section 6 describes the sustainability of the utilization of nature resources and Section 7 considers the evaluation of the alternatives and estimation the best solution of the breakwaters in terms of environmental conservation as well as of navigation and economical point of view. Section 8 consist the recommendation for monitoring needed. Section 9 describes the public hearing of EIA. Section 10 gives the findings and recommendations for mitigation measures which should be implemented.

SECTION 2 BREAKWATERS FOR THE PORT OF MUUGA

2.1 THE PROPOSED SITE

The proposed port area comprises the Port of Muuga. This Port was established in 1986 as a main grain port. It is located at the Western Coast of the Bay of Muuga at 17 km from the

Estonian Capital City Tallinn. Figure 1 illustrates the geographical setting of the Port of Muuga.

The Port of Muuga comprises a total area of 449.2 hectares (ha); a water area up to 752 ha; 23 berth of a total length of 4710 meters (m). The maximum depth is 18 m along quays No. 9a and 10a. The longest quays are Nos. 9a and 10a, up to a length of 340 m. The maximum length of a vessel that can enter the port is 300m and the maximum width of a vessel that can enter the Port is 48 m. The largest cargo vessel may have dimensions of 299 164 DWT..

Today the Port of Muuga is one of the deepest and most modern ports in the Baltic Sea region. Nearly three quarters of the cargo loaded in the Port of Muuga consists of crude oil and oil products. However, in terms of dry bulk like fertilizers, grain and coal, the Port of Muuga also operates as a major port to the Port of Tallinn.

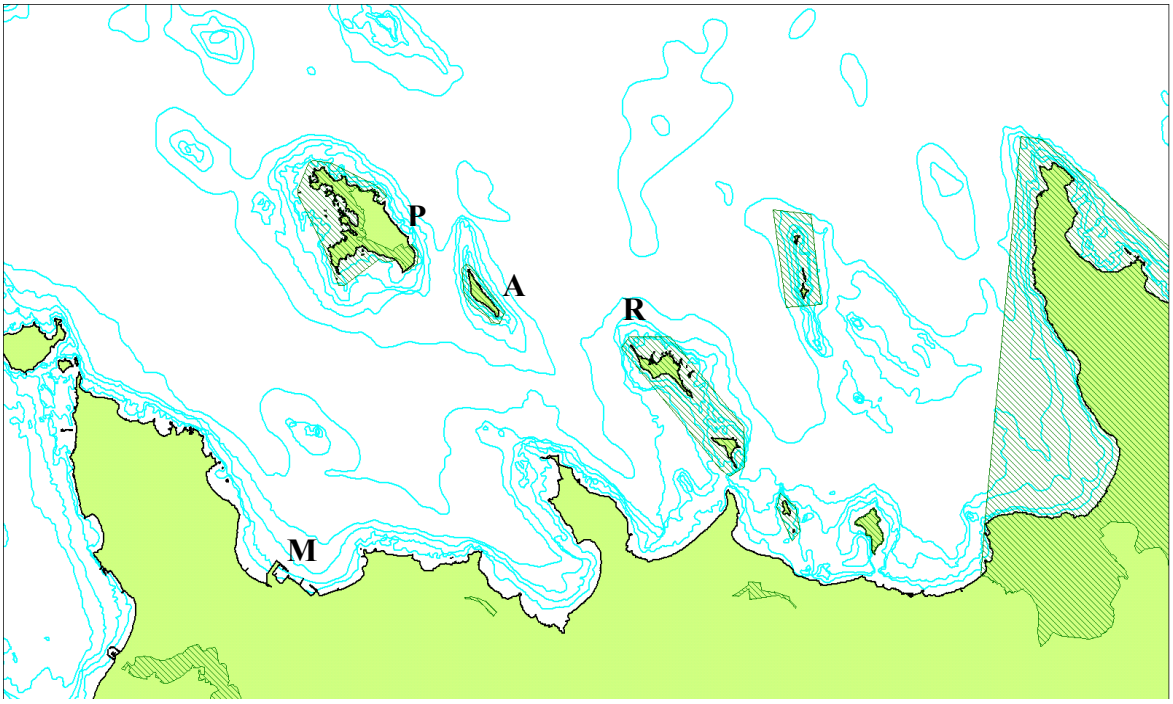
A new oil jetty of 340 meters (m) in length was constructed and completed in late 2003. The depth of water surrounding this oil jetty is 18m. This depth allows tankers of up to 125,000 DWT to load and discharge. The tankers can be loaded from both sides of the oil jetty. The maximum capacity of the new oil jetty is approximately 18 million tons of oil (MTO) products per year.

The existing container terminal has a handling capacity of 150,000 TEU. To increase the annual handling capacity to 250,000 TEU it is necessary to build an additional quay-line. Plans for the second phase of the container terminal will include the construction of two new quays and a basin between the quays.

2.1.1 THE PORT OF MUUGA

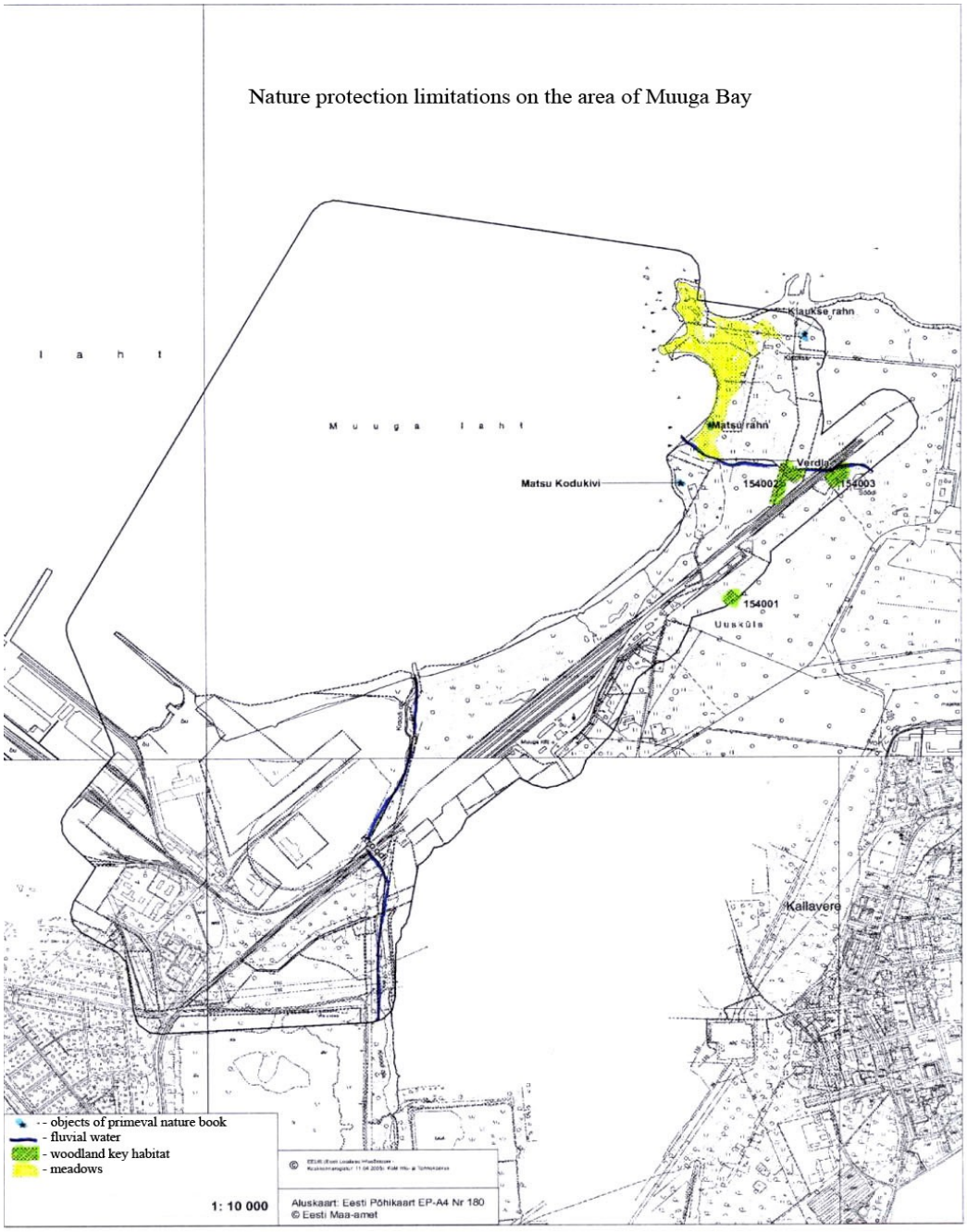
The construction of the breakwaters in the Port of Muuga will include the following Components: two breakwaters (W and E), port entrance and new turning circles, the dredging and dumping. Official dumping area is placed at E from Island Aksi (Figures 1 and 4).

Figure 4 Dotted figures are proposed Natura 2000 sites within the area potentially may affected.



P – Prangli Island; A – Aksi Island; R – Rammu Island; and, M – Port of Muuga.

Figure 5 The source: EELIS – Estonian Nature Infosystem



Source: Environmental Register. Estonian Environment Information Center. April 2005

2.1.2 HOUSING

Figure 6 The map of Muuga Port territory and surrounding areas (please note that "H" indicates the nearest houses)

Figure 7 The modified aerophoto of Muuga Port territory and surrounding areas (the planned new quays in the Eastern Port are shaded)

2.2 ALTERNATIVE BREAKWATER OPTIONS CONSIDERED

During the preliminary study of the Muuga Harbour breakwater layouts, seven different layouts were selected for detailed numerical calculations (Figures 8 – 11):

1. Reference layout 006 option 1A (Figure 8);
2. Reference layout wide entrance 006 option 1A (Figure 8);
3. Modified reference layout 006 option 1B (Figure 8);
4. Eastern port entrance 007-2A (Figure 9);
5. Eastern port entrance 007-2B (Figure 9);
6. Budget layout 008-3 (Figure 10);
7. Western Port entrance layout 009-4 (Figure 11).

Alternative technical solutions of construction the breakwaters

It was concluded during the preliminary planning that the composite- and (piled) cellular coffer-dam alternative are both not feasible in terms of constructibility and likely settlements underneath the structure. Hence the technical evaluation focuses on the next constructions of the breakwaters (Royal Haskoning, 2006b).

1. Rubble Mound Breakwater
2. Rubble Mound Reef Breakwater
3. Piled Breakwater

Figure 8 Reference layout 006-1A with entrance of 300 m (solid line) and modified reference layout 006-1B (as indicated by the dotted line)

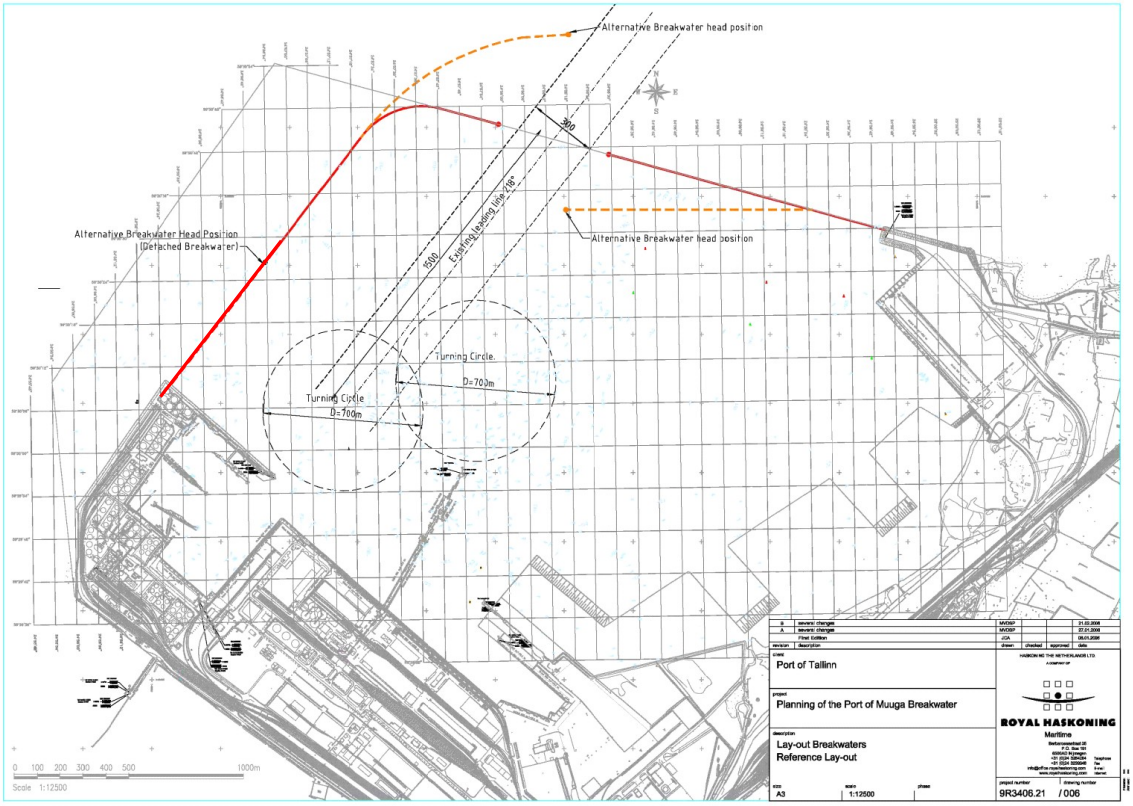


Figure 9 Eastern Port Entrance Layout 007-2A(solid line) and its modification 007-2B (as indicated by the dotted line)

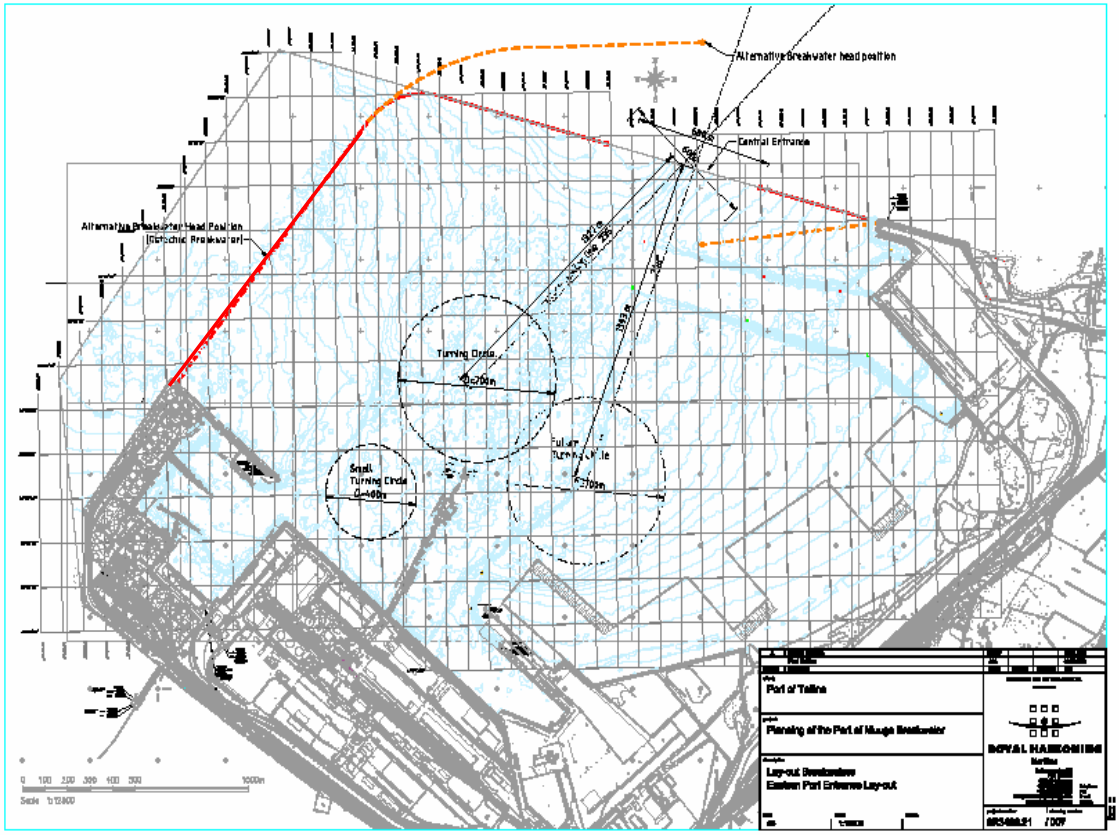


Figure 10 Budget Layout 008-3A;

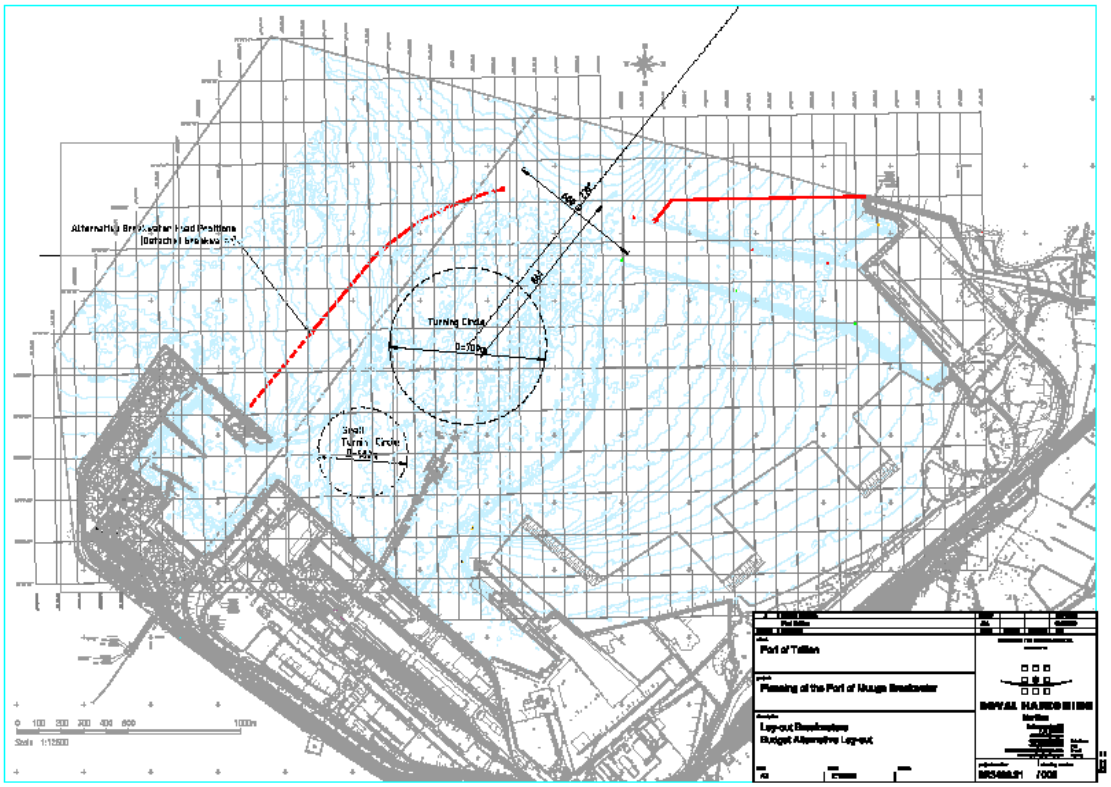
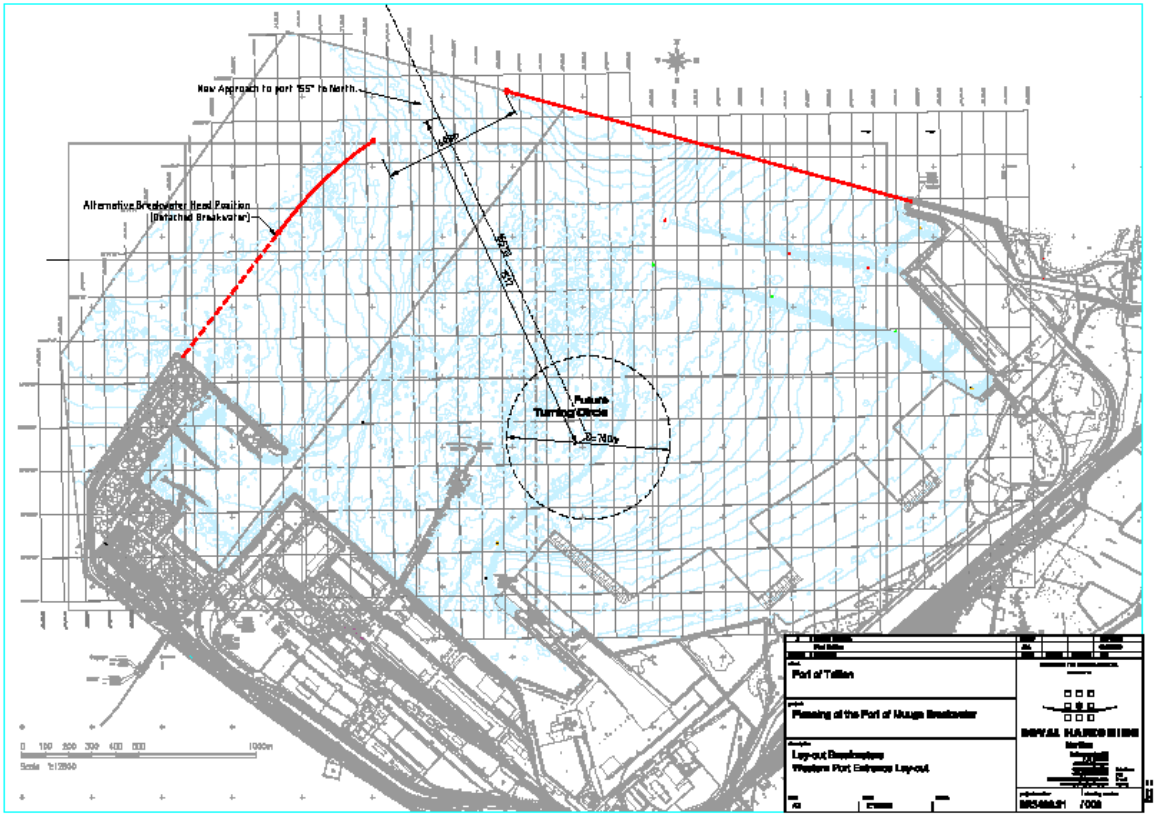


Figure 11 Western Port Entrance Layout 009-4A



Width of Entrance Channel

The required width of 4.3B is valid for a one-way approach channel, which results in a width of 4.3 x 57 ≈ 250m. The total number of channel movements of the design vessel is not known. In case a two-way channel would be required, the Planners anticipated that the channel should allow for the simultaneous transfer of the design vessel and a bulk carrier, this results in a total width of some 580 m (Appendix E, Royal Haskoning 2006b).

Description of the Alternative Breakwater Arrangement (Royal Haskoning 2006a)
An alternative to the above arrangement has been made by shifting the head of the eastern breakwater into a south-westerly direction and by shifting the head of the western breakwater further north-easterly such that this head is due north of the eastern breakwater head. In this layout Muuga Harbour is now better protected from the predominant waves from NW and N. However, a more direct approach to the eastern berths and port basins would then not be possible anymore.

It would be possible to shift only the eastern breakwater head – in view of costs – but this would then result in less wave protection inside.

Reference Layout 006-1A (Fig. 8) with entrance of 300 m and entrance of 600 m

Breakwater Alignment

The West Breakwater in this layout originates at the far western 90 corner of the existing breakwater surrounding the Western Basin. From this point it runs into a north-easterly direction till the intersection with the northern limit of the present port boundary. From this point the western breakwater turns to a north-easterly direction following the present port boundary limit.

The East Breakwater originates at the root of the small spur located in the northeast part of the port and follows the present boundary of Muuga Harbour up to the port entrance.
The total length of both breakwaters in this arrangement is above 3,000 m for case with entrance width of 300 m and less then 3,000 m for case with entrance of 600 m.
Approach Channel and Turning Circle.

This reference layout is characterized with an entrance to Muuga Harbour along the existing approach route of 217.8º. As described in Section 3 of Preliminary Project (Royal Haskoning 2006b), a channel / port entrance width of 300 m or 600m is included.

The length of the entrance channel inside the port up to the center of the turning circle is some 1,500 m for the larger vessels.

Further, this lay-out has a turning circle with a diameter of 700m located just north of the West Basin, which coincides with the present turning area for the larger vessels.

Eastern Port Entrance Layout 007-2A and its modification (Fig. 9)
Breakwater Alignment

The alignment of the West and East breakwaters the same as for the reference layout with the main difference that the port entrance is now moved further eastward to create a more central location for the port entrance as well as to create a better and more direct approach to the eastern port facilities.

The total length of the breakwaters in this arrangement is again some 3,000m.
Approach Channel and Turning Circle

The approach route for vessels destined for the western berths could be along a heading of some 235º with the turning circle located just north-westerly of the finger pier (same as described above).

The length of the entrance channel inside the port up to the center of the turning circle is some 1,325 m for the larger vessels. This would imply that tugs would have to make fast outside the breakwaters to have sufficient time for tug fastening before the vessels arrive in the large turning area. Smaller vessels can sail further south and swing in the smaller turning circle as indicated in the drawing.

In case the turning circle would be (later) relocated further south-westerly, the approach route could then be along a 240º route. In both cases the final approach would then be through the existing anchorage area located at the eastern side of the present approach channel, but would remain free of the shallow areas at the east.

Further, the approach to the eastern berths and easterly turning area could under this alternative breakwater arrangement along a route of about 200º, thereby creating a more direct approach to this port area and reducing the maneuvering times inside the port.

Budget Layout 008-3 (Fig. 10)

Breakwater Alignment

This alternative seeks to minimize the investment costs of the breakwaters. The West Breakwater originates from a point on the existing breakwater surrounding the Western Basin opposite of Berth 1A at some 400m from the western corner and runs then in a north-easterly direction. After approximately 900m it slightly bends into an eastern direction as indicated.

The East Breakwater again originates at the root of the small spur located in the north-eastern part of the port and runs into a south-westerly direction such that an entrance channel of 600m is created.

Total length of the breakwaters in this layout is some 2,350m, which is considerably less than the total lengths as for the alternative described above. In addition the breakwaters are located in somewhat shallower water which further reduces the overall cost.

Approach Channel and Turning Circle

The approach to Muuga Harbour in this arrangement is some 218º and located easterly of the present approach to the port to create a more central approach. The turning circle with a diameter of 700m is provided just north-westerly of the extended finger pier with a smaller turning circle is located to the west side of the pier.

Western Port Entrance Layout (Figure 11)

Breakwater Alignment

The alignment of the breakwaters in this alternative is the same as in the Reference layout, be it that the port entrance (600m) is now located at the north western side of the port (Royal Haskoning 2006a).
The West Breakwater originates at the 90 corner of the existing breakwater and has a length of some 1,250m. The East Breakwater runs along the present port boundary limits and has a length of some 1,400m.
Approach Channel and Turning Circle

The orientation of the new approach channel is approximately 155º N. Such an approach route would stay clear of the Karbimadal Island and shallow areas located north of the port. The main advantage of such a channel is the more direct approach to the new eastern development.
The 700m turning area for all vessels would be located at the eastern side of the extended finger pier as indicated.

Planners preferred structural alternative *(Royal Haskoning, 2006b)*

Technical Evaluation

It was concluded during the preliminary planning that the composite- and (piled) cellular cofferdam alternative are both not feasible in terms of construct ability and likely settlements underneath the structure. Hence the technical evaluation focuses on the rubble mound-, rubble mound reef and piled breakwaters types (Royal Haskoning 2006b).

Rubble Mound Breakwater

The rock armour will most likely need to be imported from Finland. It is currently uncertain whether rock would be available in sufficient quantities if one were to build the breakwater using merely a rubble mound type breakwater.

Construction duration of the rubble mound breakwater is slightly longer than for instance the construction period of a piled breakwater, this is due to among others the requirement of soil dredging because the weak soil layers will need to be replaced with suitable fill material.

Rubble Mound Reef Breakwater

The weak soil layers will need to be replaced with suitable fill material.

Similar as for the rubble mound breakwater the rock armour (3 – 5 tons primary armour) will most likely need to be imported from Finland. It is currently uncertain whether rock would be available in sufficient quantities if one were to build the breakwater using merely a rubble mound type breakwater.

In addition large volumes of sand fill are required, but the available resources for sand fill in Estonia are limited.

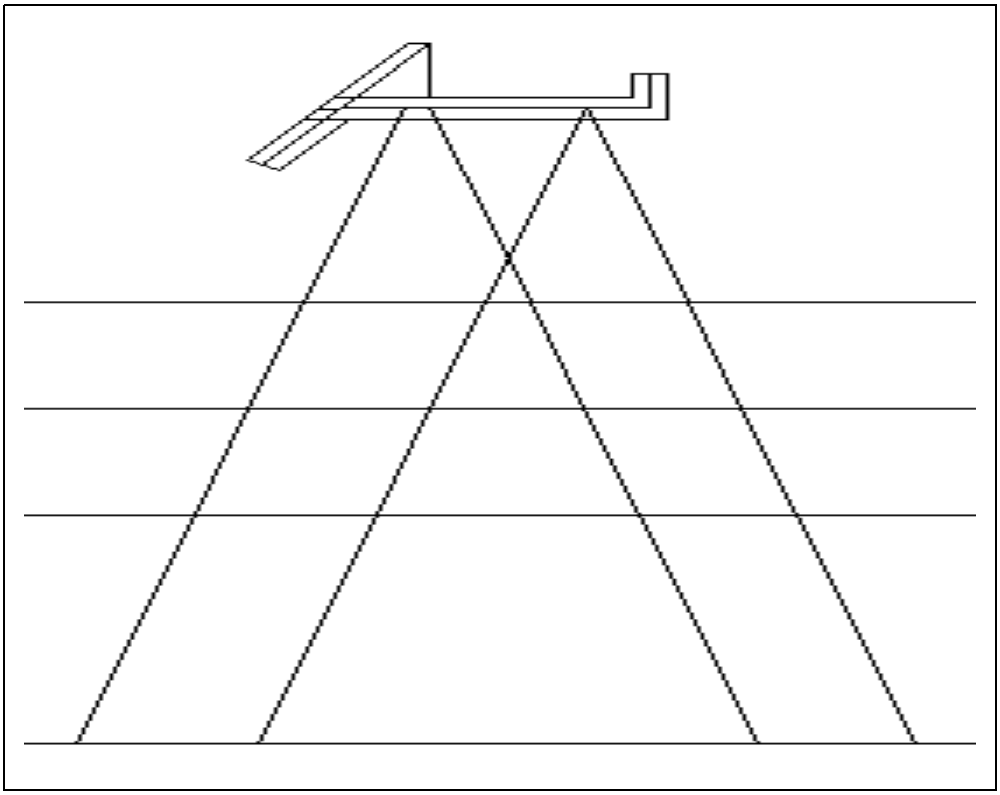
A further drawback in constructing a breakwater comprising a merely rubble mound reef type structure is the fact that the structure has a very large footprint. This is particularly unfavorable at the location of the breakwater heads. Additional measures to steeper the slopes near the port entrance are required to assure the level of wave penetration inside the basin.

Piled Breakwater

The piled breakwater is relatively expensive in shallow water areas.

Availability of construction materials is expected to be not an issue as steel piles and sheet piles are readily available in the region. A further advantage of the structure is that a piled breakwater may be incorporated relatively easy in a possible future extension of the loading jetties.

Figure 12 Typical Cross Section Piled Breakwater



SECTION 3 EXISTING ENVIRONMENT

3.1 INTRODUCTION

The following sections describe the characteristics of the existing environment within the study area. This review, which included site investigations and surveys, data collection, literature review and consultation, was undertaken to establish the location, extent and relative importance of various environmental interests. The following environmental characteristics are described:

- Water and Sediment Quality
- Geology and Geochemistry
- Hydrodynamics and Sedimentation
- Marine Ecology
- Terrestrial Ecology – Avifauna
- Fisheries
- Noise
- Air Quality
- Navigation
- Traffic
- Nature Reserves
- Cultural Heritage
- Recreation
- Climate
- Employment
- Local Community

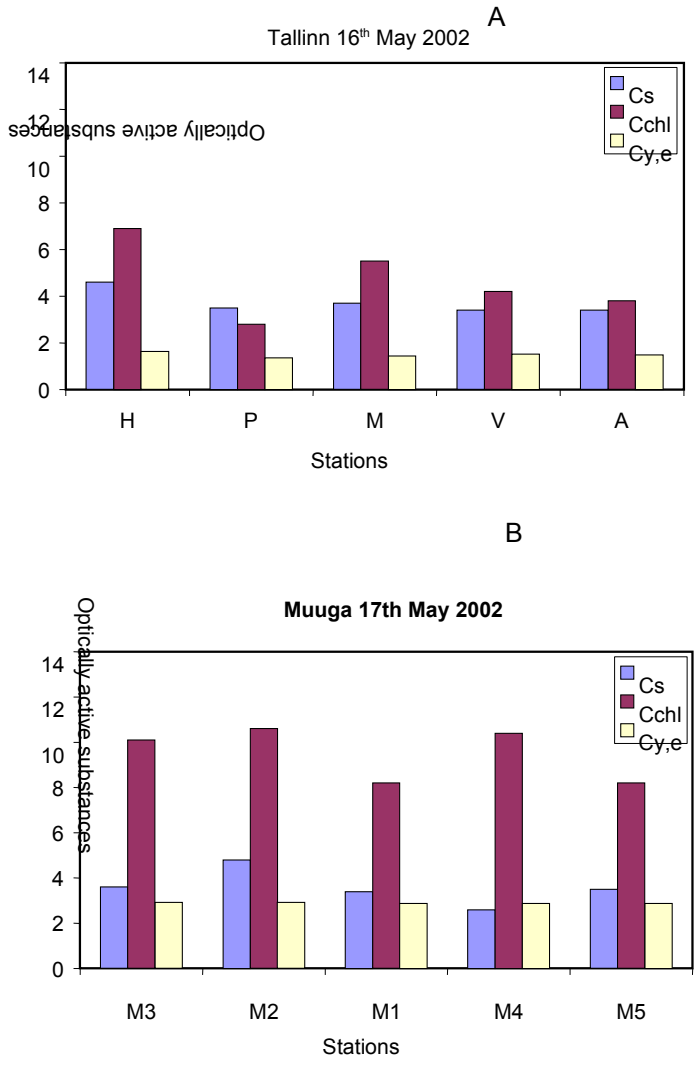
3.2 WATER AND SEDIMENTS QUALITY

3.2.1 WATER QUALITY

Water quality in the Muuga Bay has been assessed on the basis of the monitoring data from 2002-2006. The monitoring was based on the methods:

1) Ship-borne surveys to take water samples at the sampling stations and determine concentrations of optically active substances;
2) Surveys from the moving ship using “flow-through” automated high-resolution sampling;
3) Remote sensing from the satellites and specialized data processing.

Figure 13 Concentrations of optically active substances in the surface waters of Tallinn and Muuga Bays, measured on 16 and 17 May 2002.



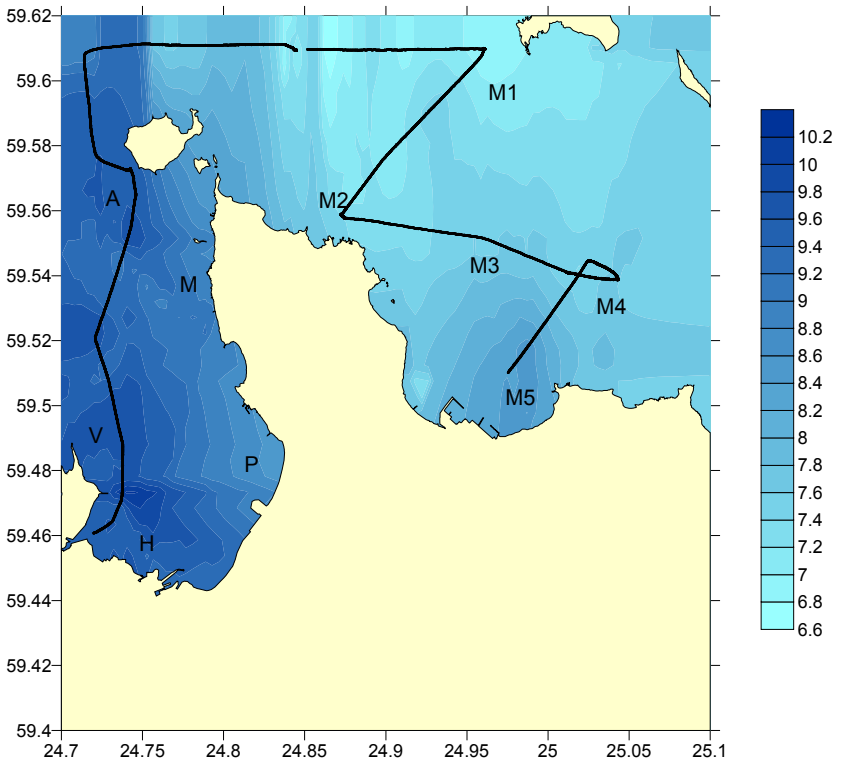
On the 17th of May 2002, we conducted high-resolution measurements of sea water optical parameters as well as of temperature and salinity. The measurements were based on the "flow-through" system (Lindfors, 2001). This system allowed us to make fast high-resolution measurements of surface waters from a ship moving at a speed of about 10 knots.

The flow-through system involves the pumping of water taken from a depth of one meter into a sensor system on-board of a vessel. These sensors measure the salinity, temperature and 18 different optical properties of sea water. The data is recorded into a database against

geographical coordinates taken with D-GPS. In this way, it is possible to establish the exact surface water quality characteristics taken at specific geographical locations.

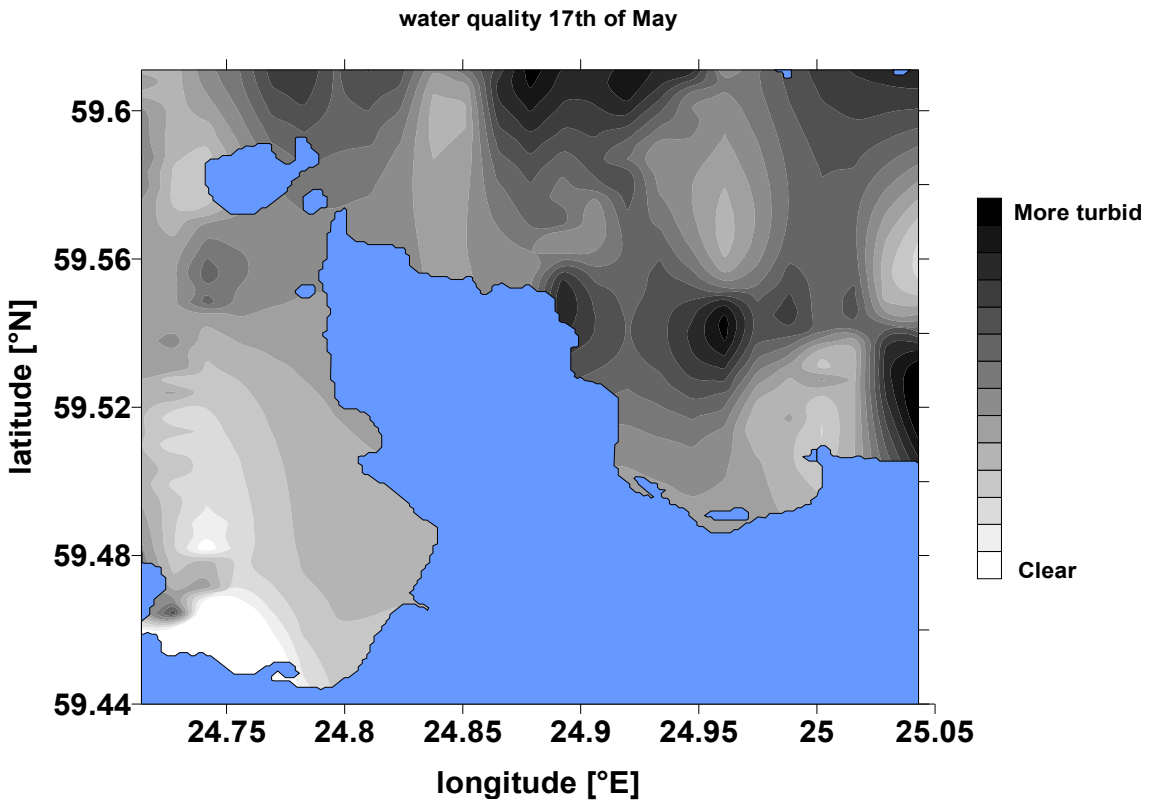
Spatial variability of water masses in the Tallinn and Muuga Bays is characterized by the sea surface temperature map, Figure 14. On 17 May 2002 showed significant temperature difference in the bays, the surface waters of Tallinn Bay were by 4°C warmer than in the Muuga Bay. This difference is explained by more effective heating in the shallow and semi-enclosed areas of the Tallinn Bay as compared to the deeper and more open regions of the Muuga Bay. In the southern part of the Muuga Bay, just near the harbor where water exchange is less intensive, the higher temperatures were recorded as well.

Figure 14 Horizontal distribution of sea surface temperature in Tallinn and Muuga bays, by the results from the survey conducted on 17 May 2002 by the "flow-through" system.



Light scattering coefficient at wavelength 555 nm well characterizes the water turbidity. Figure 15 depicts the horizontal distributions of scattering coefficient during the survey on 17 May 2002. It is evident, that scattering in the Muuga Bay is more intensive than in the Tallinn Bay. Laboratory analysis of the water samples taken at the sampling stations gave similar result. This means that concentrations of optically active substances are in the Muuga Bay somewhat higher than in the Tallinn Bay.

Figure 15 **Horizontal distribution of light scattering coefficient (wavelength 555 nm, corresponding to turbidity) of surface waters in Tallinn and Muuga Bays on 17 May 2002**



Temporal-spatial variability of water quality in the Muuga Bay

Dynamics of water quality may be effectively monitored by means of remote sensing. Data from the MODIS (*Moderate Resolution Imaging Spectrometer*) system were used, that are available from the NASA. Timing of the MODIS remote sensing satellite orbits is arranged in a way that Estonian areas are covered each day in the morning between 10 and 11 o'clock.

The MODIS sensor system registers backscattered form the sea surface light in 36 channels.

The channels are placed in the different part of visible range to cover the whole spectrum.

Suspended matter appearing in the surface layers is one primary characteristics of the water quality. By increasing the content of suspended matter, the water transparency will decrease and change the underwater light regime and therefore the whole biotic chain. Suspended matter may be divided into different categories that generally are divided as organic and

inorganic suspended matter. Organic suspended matter contains mainly phytoplankton. Inorganic part contains mainly sediments that are resuspended by currents and waves, or taken to the water column by human activities like dredging and dumping.

In the Muuga Bay, the most suitable MODIS channels for investigating the water quality are channels 1 and 2 that cover the light wavelengths 620-670 nm and 841-876 nm corresponding to the red and near-infrared range. Within these ranges, the backscattering occurs practically from all the suspended particles, both organic and inorganic. By the results from special investigations, sea surface brightness in these channels represents the suspended matter concentration in a quite confident way in a large sea area. Spatial resolution of these channels – 250 m – allows determination of necessary distribution details in coastal areas, including small bays.

Figure 16 depicts the temporal dynamics of chlorophyll in the Gulf of Finland between Tallinn and Helsinki during the ice-free season of 2002 (data from Finnish Institute of Marine Research). In such presentations, the spatial dynamics (in fact, very variable and complicated) is not shown. For the local chlorophyll dynamics we need more detailed methods.

Let us consider the temporal-spatial variability of water quality in the Muuga Bay based on the MODIS satellite images from the vegetation period of 2002, when there were no significant dredging activities during this year. It may be considered as a natural reference situation of the water quality. The brightness values acquired from MODIS sensors were transformed to the chlorophyll concentration units using the correlation method. Brightness from channel 1 was correlated with the directly measured suspended matter concentration in the Muuga Bay (Figure 17). The obtained relation was used to draw the suspended matter maps in 2002 as given in Figures 18-21). The concentration of suspended matter stays during the early spring (29 March 2002, Figure 18) in a range 2-3 mg L^{-1}. This is characteristic to the transparent waters and water quality during this period can be considered as good. Preceding winds were moderate and there was no significant resuspension of sediments in the shallow coastal areas. Also the phytoplankton spring bloom had not started yet. Water with higher suspended matter concentration appeared in the Tallinn Bay near Pirita and Miiduranna. Such situation corresponds to the scheme of wind currents at northerly and northwesterly winds. Western coast of Muuga Bay is with more transparent water. It can be also seen that in the more closed Tallinn and Ihasalu Bays the suspended matter concentrations are larger than in the wide open Muuga Bay.

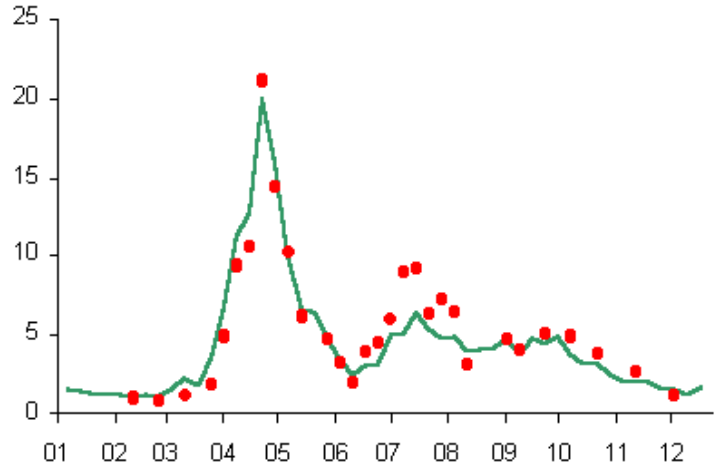
By 7 April 2002 (Figure 19) the suspended matter concentrations had increased significantly in all the coastal areas and bays, especially in Tallinn, Kaberneeme and Kolga bays. In the Muuga Bay the concentration increase was somewhat lower. Increased suspended matter concentrations are explained by the start of phytoplankton spring bloom that was amplified by the coastal upwelling processes. By the results from the Finnish Institute of Marine Research, in 2002 the spring bloom started in the beginning of April and the chlorophyll concentrations on 2-4 April 2002 was in a range 2-13 $\mu g\ L^{-1}$.

Blooms of blue-green algae occur in the Gulf of Finland (also in other Baltic Sea areas) in July. The year 2002 was one of the years of highest so far recorded bloom intensity. Figure 19 gives the suspended matter distribution on 13 July 2002. Red colors in the figure show very high concentrations of blue-green algae, where the dead algae had been accumulated

during the period of calm winds by the surface current patterns. The surface accumulations are already visible in the Tallinn Bay but not reached into the Muuga Bay. In the August (Figure 21) the water became again more transparent. On 18 August 2002 the suspended matter concentration in the Muuga Bay was again close to the early spring range 2-3 mg L^{-1}.

Water quality variables are characterized during the vegetation period with high variability, reflected in the change of water transparency. During the described above year 2002 the situation was "natural background" since the intensive construction works had not been started in the Muuga harbor. High variability of water turbidity in summer 2002 was caused by the blue-green algae bloom of exceptional intensity, raising the suspended matter concentrations from the normal values 3-4 mg L^{-1} up to 12 mg L^{-1}. Remote sensing images, used for the first time for the harbor mentoring, enabled to estimate also the spatial variability of suspension-rich waters. We may conclude that in natural conditions the wide open Muuga Bay is with more clean (less suspension-rich) waters than neighboring more closed bays of Tallinn and Ihasalu. By the regime of currents, the suspended matter occurring in the Muuga Bay is most probably transported further east to the Ihasalu Bay and the Muuga Bay receives for the replacement more clean waters from the open part of the Gulf Finland. Therefore it is important to consider in further port activities that the impact appearing during the operations would not harm neighboring bays receiving water from the Muuga Bay. Satellite images as a new tool in harbor monitoring enable tracking of human-inserted substances and also fix by back-tracking the initial source of optically active substances. Such analysis may be very helpful in finding the locations and reasons of accidental pollution.

Figure 16 Chlorophyll *a* concentration (µg L^{-1}) in the Gulf of Finland between Tallinn and Helsinki during 2002



Data from Finnish Institute of Marine Research

Figure 17 **Relation between the brightness coefficient (MODIS, wavelengths 620-670 nm) and concentration of suspended matter in the Muuga Bay (survey on 17 May 2002)**

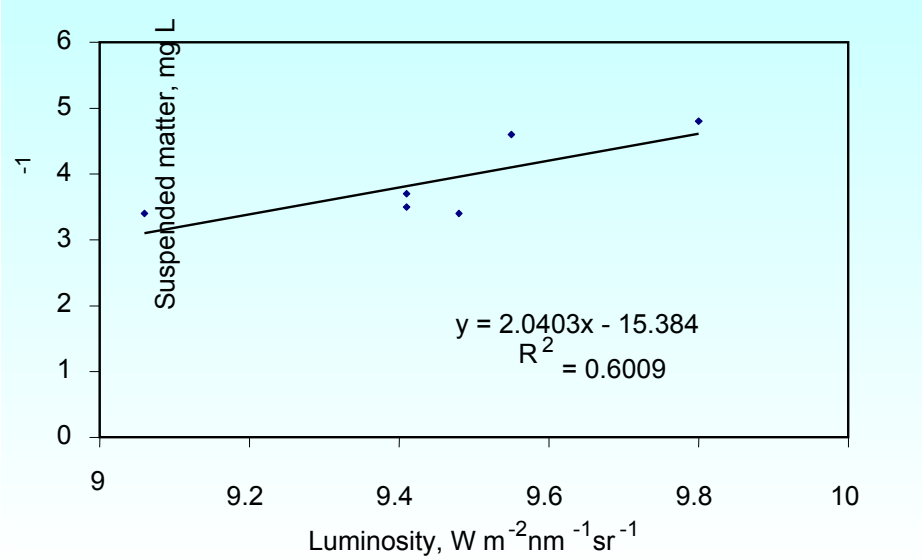


Figure 18 **Spatial distribution of suspended matter (mg L^{-1}) in the Muuga Bay by MODIS sensors 29.03.2002.**

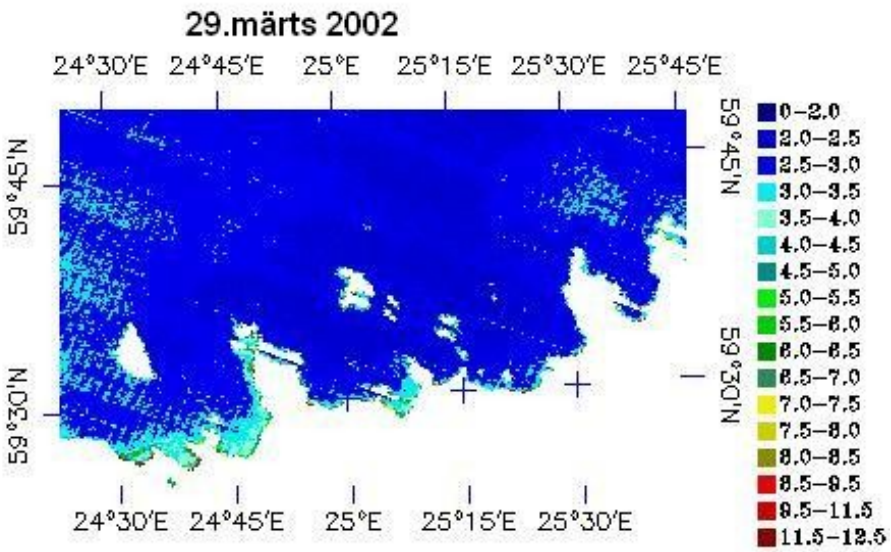

29.märts 2002
24°30'E
24°45'E
25°E
25°15'E
25°30'E
25°45'E
59°45'N
59°30'N
0–2.0
2.0–2.5
2.5–3.0
3.0–3.5
3.5–4.0
4.0–4.5
4.5–5.0
5.0–5.5
5.5–6.0
6.0–6.5
6.5–7.0
7.0–7.5
7.5–8.0
8.0–8.5
8.5–9.5
9.5–11.5
11.5–12.5

Figure 19 **Spatial distribution of suspended matter (mg L^{-1}) in the Muuga Bay by MODIS sensors 7.04.2002**

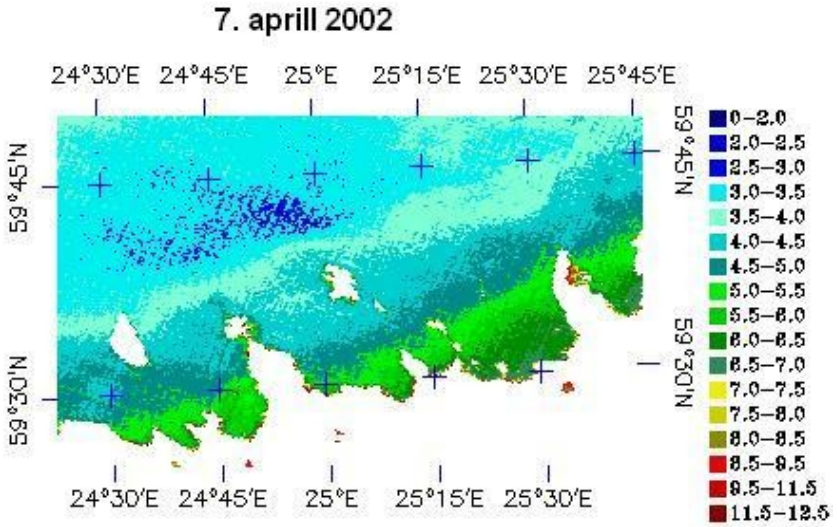


Figure 20 **Spatial distribution of suspended matter (mg L^{-1}) in the Muuga Bay by MODIS sensors 23.05.2002**

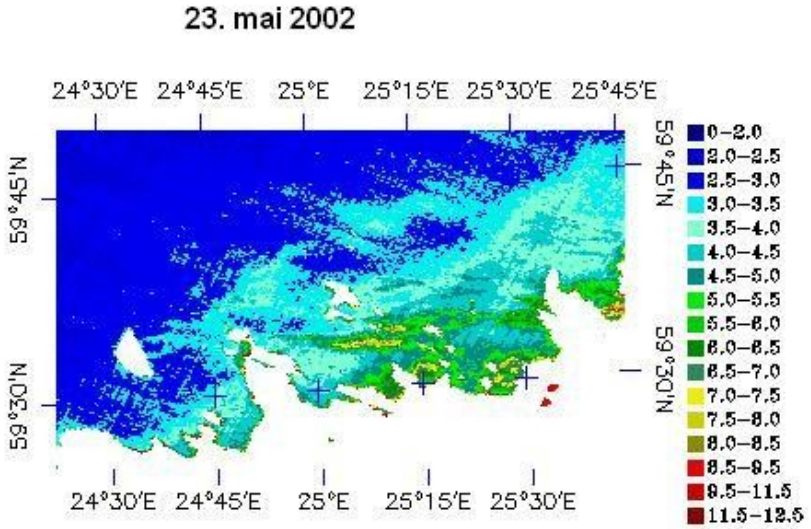


Figure 21 **Spatial distribution of suspended matter (mg L^{-1}) in the Muuga Bay by MODIS sensors 13.07.2002**

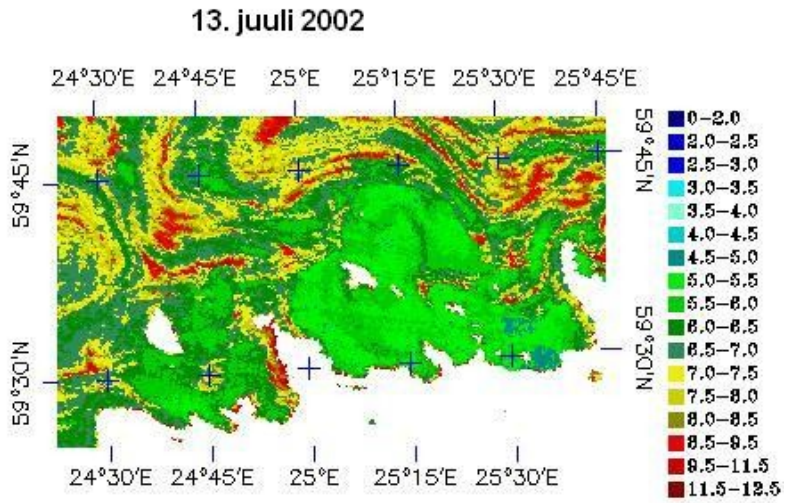
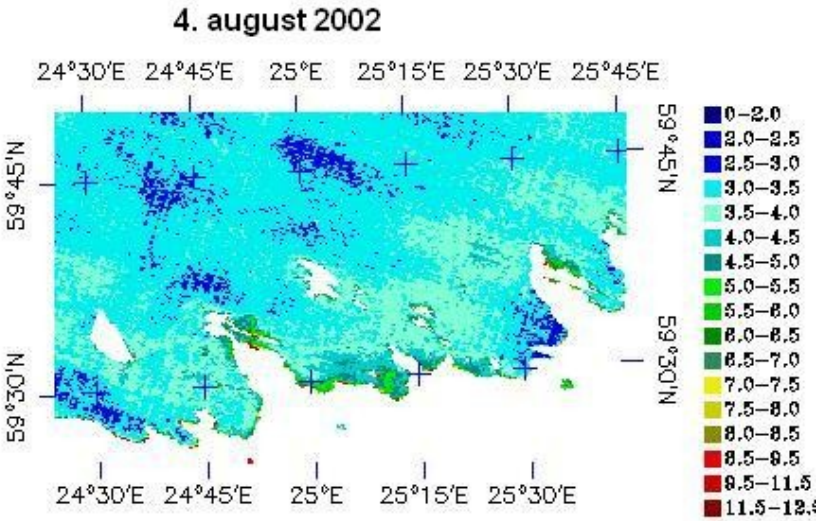


Figure 22 **Spatial distribution of suspended matter (mg L^{-1}) in the Muuga Bay by MODIS sensors 4.08.2002**



Surface water

The surface water drainage basin (catchments area) of the Muuga Bay are 64 km between Randvere main ditch in the West and Võerdla main ditch in the East, whence on the aquatory of Muuga Harbour is 47 km². The drainage basins of Võerdla main ditch and Kroodi Creek, which pass the eastern Muuga Harbour, are 13 km² and 24 km², respectively. The area of the existing quays and storage areas are ca 2.5 km² which have storm water drainage system partly.

The runoff of minor ditches is hindered by various pipelines, transmission lines etc established parallel to the shoreline. As a result, several land units between the Nuudi road to the coal terminal and railway station are over moist.

The **Kroodi (Maardu) Creek** is 10.8 km long, starts from Saha village of 1 km SW, flow through Lake Maardu and falls into Muuga Bay. Its flow rate is controlled by the overfill of Lake Maardu and is on the average 0.1 m³/s. The creek runs through the territory where previously intensive industrial activity was carried out and which is contaminated with industrial wastes. Through the Kroodi Creek the untreated technological wastewater of TK Eesti Fosforiit (former Maardu Chemical Plant) reached the sea. The production of mineral fertilizers in Maardu Plant has been stopped and therefore the quality of the water in the creek has improved currently. The hazardous substances in the water of Kroodi Creek have been determined in frame of State environmental monitoring.

Content of the prior heavy metals in water sample of Kroodi Creek analyzed in 2003

Area	Cd µg/l	Cu mg/l	Hg µg/l	Pb Mg/l	Zn mg/l
Kroodi Creek	0,07-0,09 (200)[1)]	0,012-0,014 (2,0)	<0,05 (50)	0,005 (0,5)	0,188-0,201 (2,0)

1) The limits of hazardous substances of the waste water directed to the water are in brackets.

A water sample has been taken from Kroodi Creek from the culvert at Maardu road and the following components were determined in its analysis (*ILAG-HPC-ESP-TALLMAC* 2006):

The determined components in Kroodi Creek water October 2005

Analyzed component	Cd	Cu	Hg	Pb	Zn	NH_4	NO_2	NO_3	POD (mgO/l)	orto-PO_4	poly-PO_4
mg/l	<0.0002	0.0217	<0.001	<0.002	0.180	9.12	2.99	19.33	8.73	0.40	<0.01

On the basis of the results of the analysis it can be concluded that there are few heavy metals in the water of Kroodi Creek – below the permitted limit. However, there is a big amount of nitrogen and phosphorus compounds. The quality of Võerdla main ditch has not been researched, but it can be concluded that there is no pollution in it, since the area has been out of active use previously.

The main sources of pollution for the creek's water are the precipitation and wastewater from the industrial area of Maardu town. According to the permission of the special water use the amount of the effluent to the Kroodi creek will be 0.97 million m³ per year (Iru Power Plant cooling water 0.32 and Maardu Boiler house 0.52 million m³/year incl.) which is about 30% of the creek mean annual runoff – 3.3 million m³/year. The total annual runoff of the effluent to the Muuga bay is about 1.6 million m³. The wastewater of Muuga Port, Maardu and Kallavere, annually 0.42 million m³ is discharged from sewage treatment plant in Kallavere trough deep sea outfall to the north direction near by Saviranna coast (east of Muuga bay).

The Kroodi Creek flow is slow from culvert near by railway to the mouth and on the bottom lies sediment layer up to 1 m. In the process of construction of Muuga Harbour the area of the mouth of Kroodi Creek has not been dredged. This area will be filled and a terminal will be built instead according to the development of eastern Port area. Thus, the contaminated bottom sediments from the area of creek's mouth will not be directly hazardous to the environment and to human health.

In the course of the Harbour extension a new channel will be excavated for the Kroodi Creek and the Võerdla main ditch will be turned into a collector. In the area of terminals and roads drainage system will be created, through which the water will reach the sea through a treatment plant. Besides, the runoff of minor ditches passing the expanded territory must be solved as well.

3.2.2. SEDIMENT QUALITY

This section addresses the quality of the sediments found in the inner part of Muuga Bay. The brief description of the sediment quality and geological structure of the area is also provided.

This description is based on the work carried out by the geologists REI Geotehnika, Unicone and IPT Projektijuhtimine, and the licensed environmental assessors Andres Kask and Jüri Kask from OÜ Altakon Grupp. Further information can be found consulting Kask et al., 2004a and 2004b.

SEDIMENT QUALITY STANDARDS IN THE PORT OF MUUGA

On the eastern and western coasts of Muuga Bay the Cambrian blue clays of the Lontova Formation crop out. At Randvere these clays are at an absolute height of +5m above sea level, in front of the coastal scarp south of Tahkumäe at an absolute height of 0 m and in the scarp higher than + 5m.

In the bay, the upper surface of the blue clays descends from -5m in the coastal zone to -46 m in the central part of the bay. The buried valley of South - North orientation in the central part of the bay is evidently connected with a buried valley of East - West orientation, which is not traceable in the contemporary relief.

The boreholes data shows that it is deeper than 100m at Merivälja. Data from a well in the territory of Uus-Muuga horticultural co-operative suggests that its depth exceeds 60m. It is not possible to determine the contours of the valley because the data available are too scanty.

The Cambrian blue clays of the Lontova Formation are 40m - 70m thick. In the territory of the port, 43m of the clay have been penetrated by drilling. The clay is variegated, greenish-blue with violetish spots, and compact. It contains 1mm - 2mm thick interlayer of dust sand or sandstone. The upper part of the clay is weathered (swelled), especially on the slopes of the buried valley. The boundary between the weathered blue clay and the undisturbed compact blue clay occurring in natural state is difficult to determine visually. The blue clay is underlain by Vendian sandstones resting upon the basement.

Geological and geochemical study no. 5 carried out in the area of wave breakers of the Port of Muuga

SOIL GEOLOGY

The Quaternary cover is formed of glacial, limnoglacial and marine sediments and varies in thickness. It is thickest in the bottom of the ancient valley. The thickness of Quaternary sediments decreases in the Western and Eastern parts of the bay.

The blue clays are overlain by violetish-grey loamy till (occasionally by sandy-loamy till) with blue clay nests and argillite and sandstone clasts. The thickness of the till is 2m to 8m, occasionally 10 meters. Its lower boundary with the blue clay is difficult to determine. In places, the till is overlain by fine- and medium-grained sand, which earlier was sometimes erroneously classified as till. In all likelihood, these are fluvioglacial sediments which have preserved only in hollows on the tills upper surface.

Prevailingly, the till is overlain by a complex of clayey soils; the lower part of which is formed of varved clays and the upper part by varved marine sediments – grayish-brown sandy loam and loam. Seldom the sandy loam comprises gravel. In the geological section, the verves are not of uniform distribution because of the cyclist of sediment accumulation. In clay soils, the boundary between the marine sediments and limnoglacial sediments is difficult to draw on the basis of sparse boreholes. The total thickness of the complex of clay soils is up to 9m.

Marine sediments are represented prevailingly by mud and sand. The mud overlies varved clays and is sandy loamy or loamy, occasionally it is covered with very fine (dust) organic-rich sand. In the central part of Muuga Bay the mud layer is up to 16m thick.

In the western and eastern parts of the bay the mud is overlain by a layer of yellowish-brown dust sand, which comprises interlayer with thin plant remains or muddy interlayer and mollusk shells. The thickness of this sand layer varies. In the area of the port sand was removed during the dredging; the sand layer has preserved only in the peripheral parts of the region. During earlier investigations (1982—1985), the sand layer reached even 9m in thickness.

A great amount of fill, prevailingly sand, has been dumped into the sea in the area of constructions. However, splinters and limestone lumps also occur. The fill also comprises marine sand pumped from the bottom of the bay. In the area of quays, the natural structure of bottom sediments has been disturbed by construction works and here redeposit sand and mud occur in the upper layers.

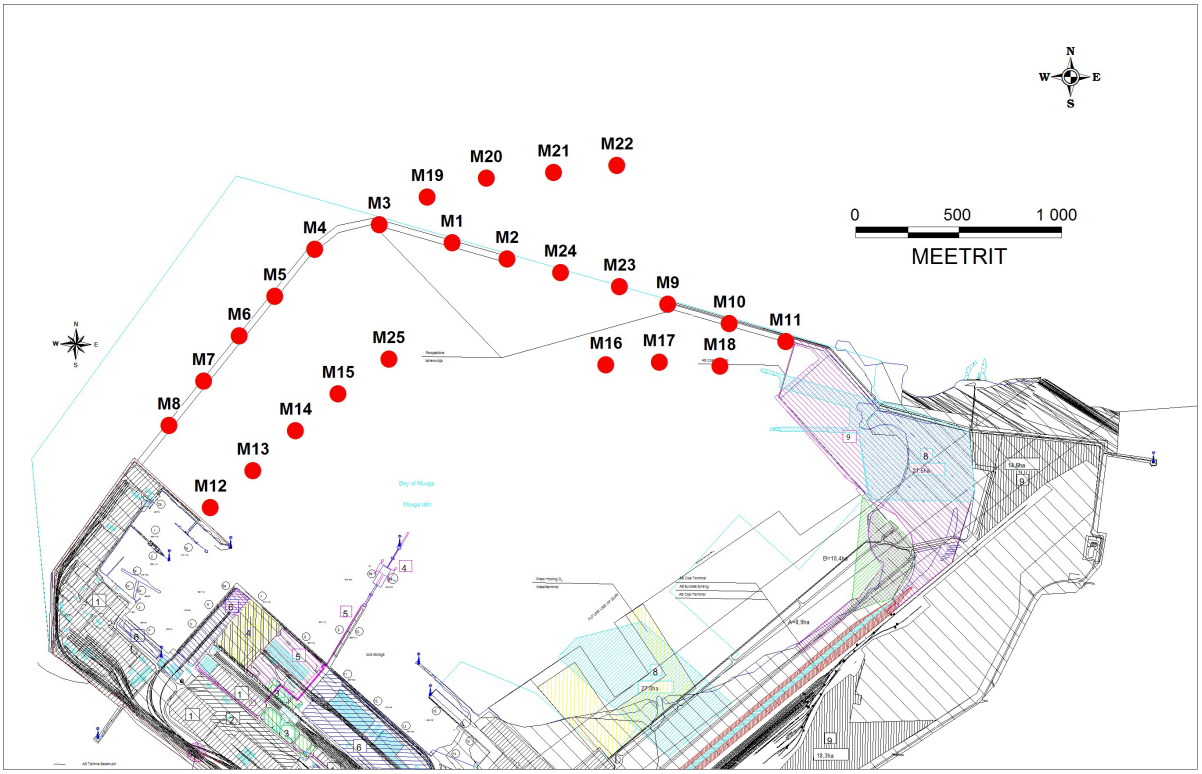
SEDIMENT QUALITY ASSESSMENT

Twenty-five samples were taken during the current EIA from the area of planned breakwaters (Table 6). Sediment samples were taken from the upper layers at 0.50m on the sea floor. At this depth, fine-grained sand was found which comprises silt and pelite particles in which the content of arsenic, cadmium, chromium, cobalt, copper, mercury, nickel, lead, zinc, and oil products were determined.

The content of oil products and heavy metals was determined at an accredited test-laboratory of the Geological Center of Estonia and headed by M. Kalkun (Registration No. L093). In the laboratory, the sediment samples were dried and portions of certain weight were taken for analysis.

Cadmium, copper, chromium, cobalt, nickel, zinc and lead were determined in the aqua regia extract by the atom-absorption method. Since the target value of cadmium in the soil is 1 mg/kg, for the determination of this element a method with the lowest measurable limit 1mg/kg was used. Arsenic was determined by X-ray fluorescence analysis. For the determination of oil products, the samples were extracted in hexane and the contents were obtained by weight analysis.

Figure 22 Map illustrating EIA sediment samples taken of the sea bottom



3.2.3. SEDIMENT QUALITY OF THE PORT OF MUUGA

Limit pollutant concentration values have been established for the soils to be dredged, as required by the Estonian Ministry of the Environment and stated in national law Decree No.

12 Limit concentration values of hazardous substances in soils and groundwater of the 2nd of April 2004. This Decree follows Article 12 of the Law on Chemicals.

The results of this analysis were compared with the established boundary values. The target value illustrated in Table 6 is the concentration of hazardous substances found in the soil. If the value is equal to or lower than the Estonian soil standards, the state of the soil is good; i.e., the sediment quality does not pose a threat to human health or the environment.

The limit value is the concentration of hazardous substances found in the soil. If the limit value is high, the contaminated soil is hazardous and therefore dangerous to human health and the environment.

The results obtain show that the state of the soil is found to be satisfactory if the determined value of hazardous substance is between the target value and limit value.

Table 6 Observed values of heavy metals and oil products in sediments sampled in the Port of Muuga (mg/kg)

B	L	Sample	Interval, m		As	Cd	Cr	Co	Cu	Hg	Ni	Pb	Zn	Oil prod.
24.96766	59.51224	M1	0,00	0,50	<5	<1,0	5,7	<4,0	10,3	0,002	3,55	11,8	27,2	<25
24.97236	59.51152	M2	0,00	0,50	8	<1,0	8,6	7,75	**96,7**	**0,005**	10,1	23,5	**132**	90
24.96143	59.51301	M3	0,00	0,50	5,9	<1,0	7,44	6,4	21,2	**0,005**	5,42	**33,6**	48,7	50
24.95591	59.51194	M4	0,00	0,50	9,1	<1,0	7,44	5,71	22,4	0,004	6,82	16,8	53,3	40
24.95250	59.50990	M5	0,00	0,50	5	<1,0	8,06	4,4	20,5	0,004	10,2	12,6	31	59
24.94945	59.50817	M6	0,00	0,50	<5	<1,0	7,59	5,6	14,1	0,004	8,93	10,7	28	<25
24.94640	59.50620	M7	0,00	0,50	7,7	<1,0	**11,3**	8	17,1	0,004	12,8	12,6	32	48
24.94346	59.50429	M8	0,00	0,50	<5	<1,0	5,74	4	11,2	0,004	6,02	8,87	20	<25
24.98611	59.50955	M9	0,00	0,50	5	<1,0	5,28	4,4	17,4	0,002	6,5	9,34	31	<25
24.99140	59.50872	M10	0,00	0,50	<5	<1,0	<4,0	4	19,7	0,002	<3,0	13,6	32	<25
24.99622	59.50794	M11	0,00	0,50	5,6	<1,0	<4,0	<4,0	18,6	0,002	<3,0	8,87	36	<25
24.94699	59.50070	M12	0,00	0,50	5,3	<1,0	<4,0	4,8	23,6	0,002	5,05	14,5	36	<25
24.95063	59.50232	M13	0,00	0,50	6,2	<1,0	<4,0	<4,0	21,4	0,002	<3,0	7,92	42	58
24.95427	59.50405	M14	0,00	0,50	6,1	<1,0	<4,0	4	20,8	0,003	4,56	8,87	36	40
24.95791	59.50567	M15	0,00	0,50	<5	<1,0	7,59	4	24,5	0,002	6,02	12,6	46	50
24.98083	59.50692	M16	0,00	0,50	**10,2**	<1,0	9,44	**8,8**	27	0,002	**12,8**	14,5	68	33
24.98541	59.50704	M17	0,00	0,50	7,2	<1,0	6,6	7	19,2	0,002	12,3	10,2	29	55
24.99058	59.50687	M18	0,00	0,50	9,2	<1,0	6,67	4,8	20,3	0,002	6,02	8,87	28	<25
24.96554	59.51421	M19	0,00	0,50	7,3	<1,0	7,59	<4,0	15,7	0,002	5,05	14,5	28	<25
24.97060	59.51505	M20	0,00	0,50	<5	<1,0	7,59	6,4	17,7	0,002	8,45	10,7	32	<25
24.97635	59.51529	M21	0,00	0,50	5,1	<1,0	5,74	4,6	14,4	0,002	7,48	7,5	28	45
24.98176	59.51559	M22	0,00	0,50	<5	<1,0	5,74	4	17,7	0,002	8,93	16,4	30	35
24.98200	59.51033	M23	0,00	0,50	6,1	<1,0	9,44	4	17,4	0,001	8,93	8,87	32	30
24.97695	59.51093	M24	0,00	0,50	6,5	<1,0	5,74	4	16,3	0,002	8,93	18,3	32	**195**
24.96226	59.50716	M25	0,00	0,50	6,1	<1,0	5,74	4,4	48,1	0,002	8,93	15,4	64	<25
Limit value					20	1	100	20	100	0,5	50	50	200	100
Target limit for dwelling zone					30	5	300	50	150	2	150	300	500	500
Target limit for industrial zone					50	20	800	300	500	10	500	600	1500	5000
Max observed value in current investigation					**10,2**	**-**	**11,3**	**8,8**	**96,7**	**0,005**	**12,8**	**33,6**	**132**	**195**

B – E longitude, L – N latitude

3.2.4. THE GEOCHEMISTRY OF SITE

Depending on the type of land use, limit values of the concentration of pollutants have been established for industrial and residential areas. We are dealing with an industrial area; i.e., a port aquatory and shipping lane. For this reason, the content of polluting substances in the bottom sediments must not exceed the limit values established for industrial areas. These are as follows and elaborated in Table 6

- The highest content of arsenic is 10.2 mg/kg in sample M16, less than the target value (20 mg/kg). The content of arsenic is in all sediments below the target value.
- The content of cadmium is below the target value in all samples.
- The highest content of chromium is 11.3 mg/kg, which is much less than the target value (100 mg/kg). The content of chromium is in all samples below the target value.
- The highest content of cobalt is 8.8 mg/kg in sample M16, which is less than the target value (20 mg/kg). In all samples cobalt is below the target value.
- The highest content of copper is 96.7 mg/kg in sample M2, which is a bit less than the target value (100 mg/kg). Copper is in all samples below the target value.
- The highest content of mercury is 0.005 mg/kg, which is considerably less than the target value (0.5 mg/kg). Mercury is in all samples below the target value.
- The highest content of nickel is 12.8 mg/kg in sample M 16, which is less than the target value (50 mg/kg). Nickel is in all samples below the target value.
- The highest content of lead is 33.6 mg/kg in sample M3, which is below the target value (50 mg/kg). Lead is below the target value in all samples.
- The highest content of zinc is 132 mg/kg in sample M2, which is below the target value (200 mg/kg). Zinc is in all samples below the target value.
- The content of oil products is in sample M24 between the target value (100 mg/kg) and the limit value (500 mg/kg) established for residential areas.
- In the area where sample M 24 was taken, the state of the soil is satisfactory in terms of oil products. In the area where the remaining samples were taken the state of the dredged soil is good.

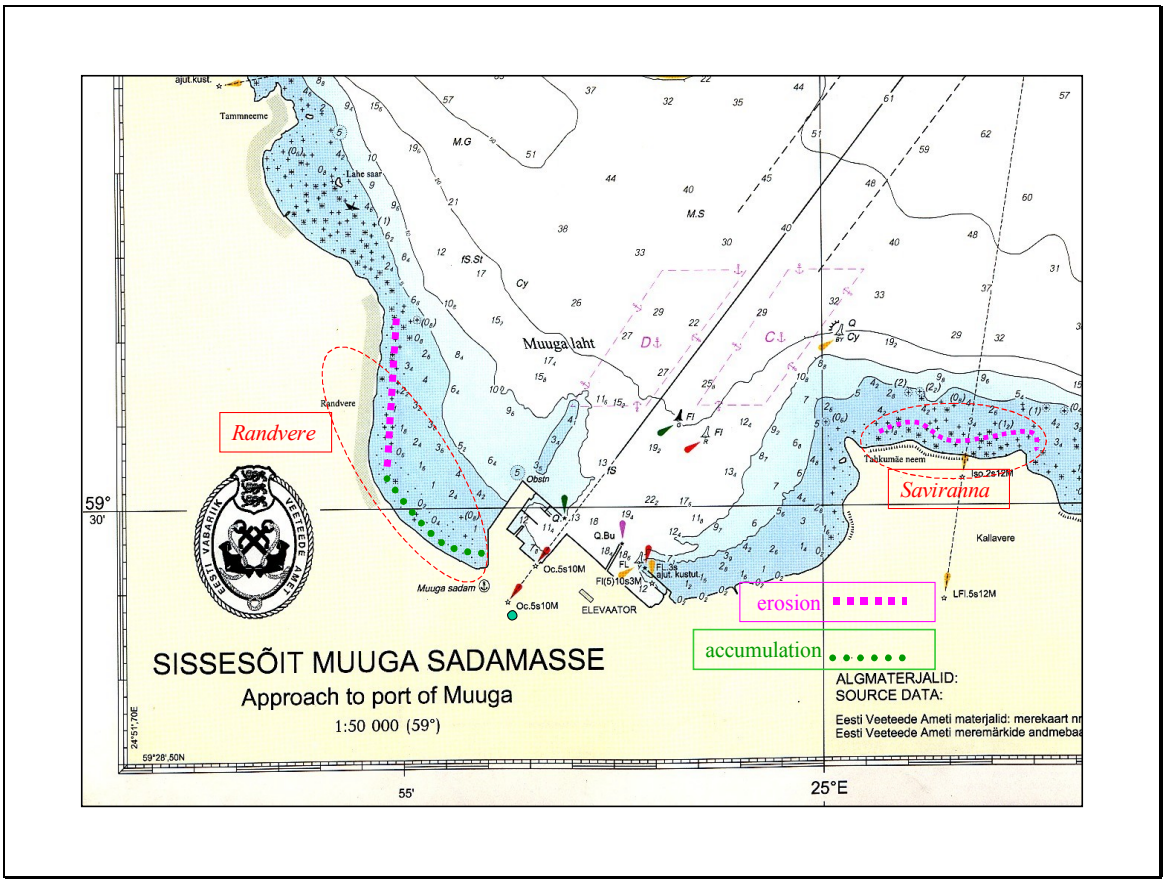
3.3. SAVIRANNA CLIFF

East from Muuga Harbour coal terminal area, within so-called Saviranna cliff, coastal researches and monitoring have been made in 2004 and 2005.

Starting from the so-called offshore outfall harbor, located ca 150 m east from the Coal terminal, until a small cape on Saviranna village the changes caused by natural shore processes are the most intense.

The total length of the coast section in aerial perspective is approximately 1.5 kilometers. The eastern part of the observed coast is located within Rebala heritage protection area.

Figure 24 Locations of erosion and accumulation areas monitored.



3.4. MARINE ECOLOGY

3.4.1. SENSITIVE AREAS AND MARINE PROTECTED AREAS

Aksi and Prangli islands – during dumping phase. It is necessary to write about the islands to ensure that any impact has been assessed. Also stress that there will not be any additional or cumulative impacts on Tahkumae Cape

Not far from the Muuga Port located islands Aksi and Prangli, what has the goal to protect the habitats types included in Annex I of Directive 92/43/EEC. But this Natura 2000 (SPA) site potentially and significantly may be affected during the breakwaters construction only by dumping in Aksi Spoil Ground area. However, due regard that the depths of this dumping area are above 50 m and that the slope of Island Aksi is very sharp (the depth raised about 80 m per nautical mile), the spreading of suspended matter up to coast of this island is with law probability.

During the further exploitation of the Muuga Port no any impacts on mentioned Natura 2000 site caused by the breakwaters, will expected.

However some species, included in Annex I of Directive 79/409/EEC, might be potentially affected and the merit of those impacts will be assessed below (see 5).

Species, which habitats places will be protected include:

1) Mammals like the Grey seal *(Halichoerus grypus);*
2) Fish species like the Bullhead *(Cottus gobio)*, Baltic salmon *(Salmo salar)* and also River lamprey *(Lampetra fluviatilis)*;
3) Mussels and bivalves like the *Unio crassus* and *Vertigo angustior*; and,
4) Several species of protected birds, included in Annex I of Directive 79/409/EEC, like the swan (*Cygnus Cygnus*)*, Branta leucopsis, Calidris alpina, Limosa lapponicus, Pandion haliaetus, Porzana porzana, Sterna albifrons, Sterna caspia* and *Sterna paradisaea* can be affected.

<u>Bullhead</u> is very rare species in coastal waters of the Gulf of Finland and was never been caught within the fish monitoring (since 1994) in Muuga Bay. So, the impacts are theoretically possible, but the probability of those impacts is close to zero.

<u>River Lamprey</u> is spawning in Jägala River (see 3.4). Due to the biology of River lamprey the impacts on reproduction of lamprey is not expected. Regarding the mature specimen of lamprey the potentiality of harmful impacts should be close to zero.

<u>Baltic Salmon.</u> The Jägala River was earlier one of the most important spawning river of salmon. However due to building the Electric Plant in 1930s and high pollution rate caused by Kehra Pulp Mill Factory during the second half of 20th century, since the 1950th the spawning of salmon in this river was not fixed. The situation changed recently, the factory in Kehra was not polluted the river during last decade and the water in river became almost clean. In 2000th the stocking of salmon's smolts into the Jägala River was started and today it

was preliminary estimated that the spawning of salmon in this river is possible again. The breakwaters construction can concur with some sediments suspension (see 5). However, the sediments suspended will not spreaded to the estuary of Jägala River where the postsmolt of salmon should be pervade the osmoregulation. So, the impacts on reproduction of salmon will be unbelievable. However, it should be attended, that some impacts on mature salmon migrated in the Jägala River for spawning, will potentially be possible. But, in the sea the salmon should easily change it migrations routes and so, those impacts will be also not marketable.

Birds species, mentioned above are today used the sea area what will be enclosed by breakwaters for resting and feeding, but not actively. Also, as it can be highlighted the birds get accustomed relatively quickly with new environment including new ports and can feeding even inside the port basins. The more actual should be the indirect impacts on protected birds, what consists in decreasing the abundance of zoobenthos within the area enclosed by breakwaters and also in the nearest areas outside breakwaters (see 5).

‘

Conclusions

During the construction of breakwaters in the Port of Muuga, the probable negative impacts on the Natura 2000 sites are expected to be close to zero.
Concerning the SPA, the negative impacts on salmon and river lamprey as well on birds included in Annex I of Directive 79/409/EEC are possible, but they will probably be not marketable.

The mentioned negative impacts don’t affect the key species and habitats of pSCI Natura 2000 as well, as the integrity of its.

There will not be significance impacts on Natura 2000 objects caused by the further exploitation of breakwaters irrespective of Alternative realized.

3.4.2. NATURE RESERVES

PROTECTED HABITATS

There are not any Natura 2000 sites within the area potentially affected during the construction and further exploitation of the Muuga Port breakwaters.

However not far (about 7 nautical miles) from the Muuga Port located islands Aksi and Prangli. There were stated by the decision of Estonian Government from 8th May 2005 no 615-k (RTL 2004,111,1758) a proposed Prangli Special Conservation Area (pSCI), what included the Eastern part of Prangli Island and all Aksi and Rammu islands territories (Figures 1 and 5). Furthermore, the potential dumping are will be at the distance of 0.7-0.8 nautical miles from the Aksi Island.

The objective of the Estonian Government is to protect habitat types listed in Annex I of the Habitats Directive (HD) 92/43/EEC. This will include sea floor of up to 5 meters in depth as well as habitats listed in Annex I, like:

- Coastal Lagoons (1150), Reefs (1170);

- Boreal Baltic islets and small islands (1620);
- Boreal Baltic coastal meadows (1630);
- Embryonic shifting dunes (2110);
- Shifting dunes along the shoreline with *Ammophilia arenaria* ("with dunes") (2120);
- Fixed coastal dunes with herbaceous vegetation ("grey dunes") (2130);
- Decalcified fixed dunes with *Empetrum nigrum* (2140);
- Wooded dunes of the Atlantic, Continental and Boreal region (2180);
- Dry sand heaths with *Calluna* and *Empetrum nigrum* (2320);
- Juniperus communis formations on heaths or calcareous grasslands (5130); and,
- Alkaline fens (7230).

The potential dumping are will be at the distance of 0.7 nautical miles from the Aksi Island.

PROTECTED SPECIES

It may be that some species included into the Annex II of the Habitats Directive 92/43/EEC will potentially be affected during the construction and operation of the breakwaters due to potential troubling by suspended sediments and/or some needs for changing of usual migratory routes. These species include:

- Mammals like the Grey seal *(Halichoerus grypus)*;
- Fish like the Bullhead *(Cottus gobio)*, River lamprey *(Lampetra fluviatilis)* and the Baltic salmon *(Salmo salar)*; and,
- Mussels and bivalves, like the *Unio crassus* and *Vertigo angustior*.

Muuga Bay and Ihasalu Bay are the important feeding areas of species of fish like the whitefish *(Coregonus lavaretus)*, which are protected under national law (Category II species). Sea trout *(Salmo trutta trutta)* are also protected under national (Category II species). Sea trout is not a rare species and present in both. It spawns in Jägala river.

PROTECTED AVIFAUNA

A number of protected birds included in Annex I of the Habitats Directive 79/409/EEC will also be affected by the construction and operation of the breakwaters in the Port of Muuga, including:

- *Cygnus Cygnus*;
- *Branta leucopsis*;
- *Calidris alpine*;
- *Limosa lapponicus*;
- *Pandion haliaetus*;
- *Porzana porzana*;
- *Sterna albifrons*;
- *Sterna caspia*; and;
- *Sterna paradisaea*.

The area could potentially be affected during the construction of the breakwaters in Port of Muuga, especially during:

1. the dredging and dumping of dredged material; and,
2. the operation of the port.

PROTECTED AREAS AT THE NATIONAL LEVEL

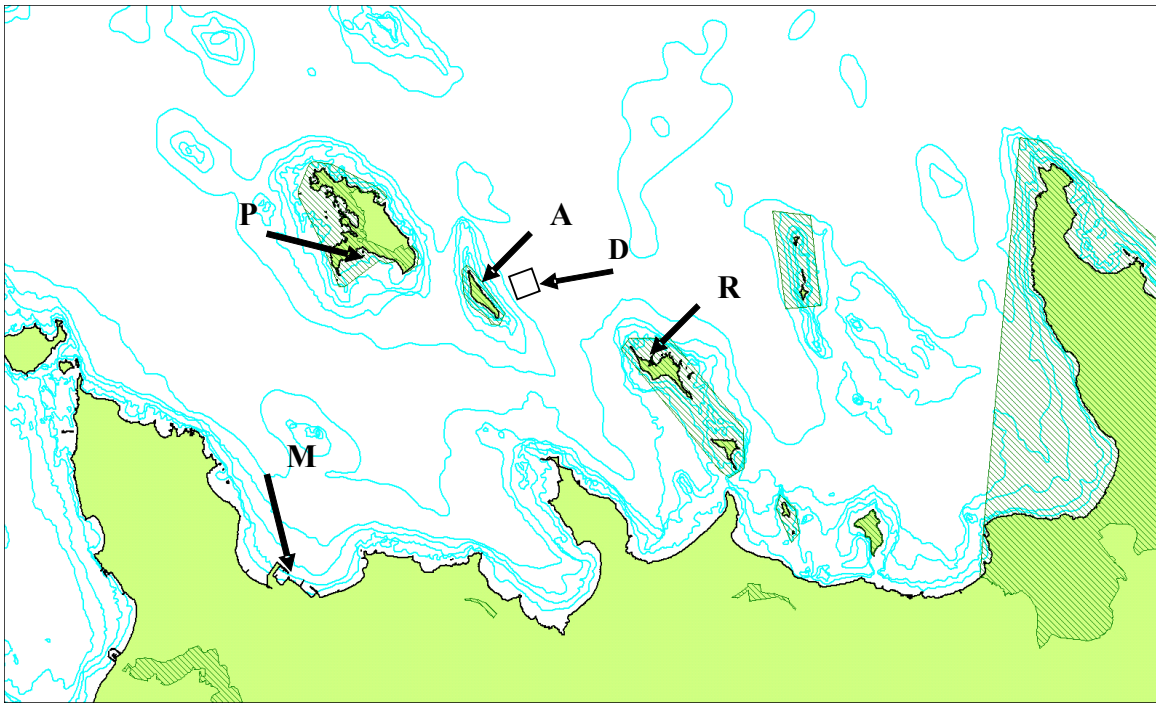
As stated in the Decision No. 441 of the Estonian Government 30th of December 1999, the the Prangli Land Protection Area was established. This protected area includes the Eastern part of Prangli Island and all Aksi Island as well, as the surrounding of both the shallow-water sea areas of 250 m and by terrestrial part it is enveloped with Natura 2000 site, mentioned above.

PROTECTED AVIFAUNA IN THE NATURA 2000 SITES

Both the Prangli and Aksi islands are regularly visited by migratory birds. The birds choose to rest along the shoreline of Ihasalu Bay to East from the Muuga Port and along the Western coast of the Ihasalu peninsula (2.8, Kuus and Kalamees 2003).

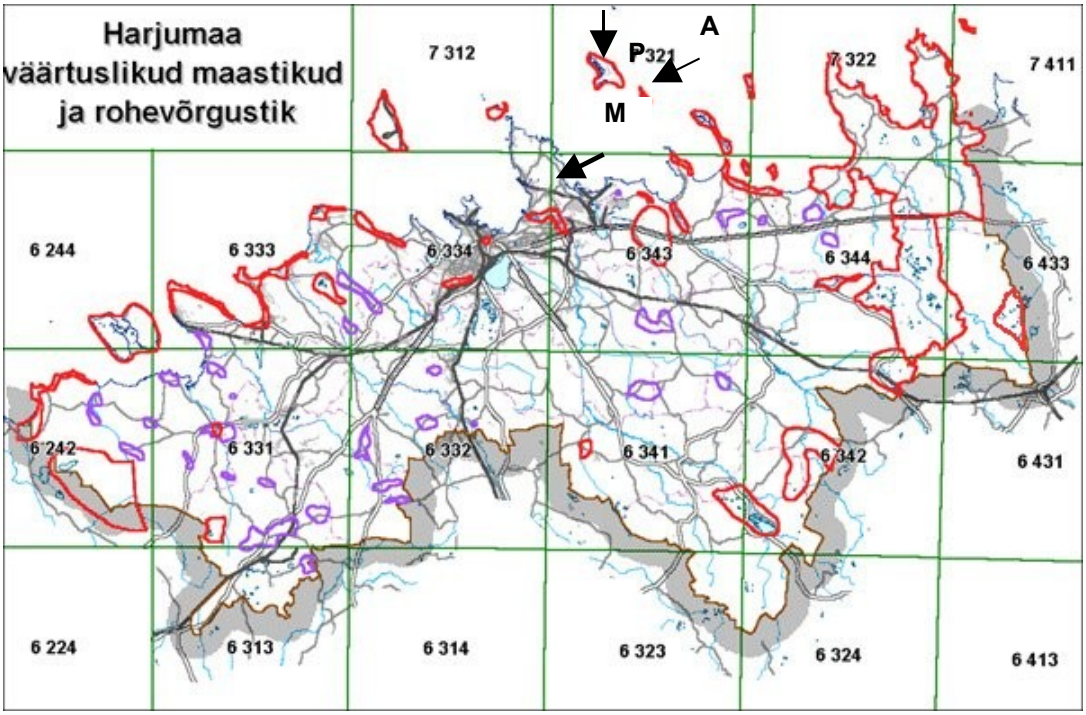
The location, where dredged material is discharged and that is in use for dumping of dredged material by Developer and already has been used many times for those purposes, is located at relatively small distance from island Aksi, about 0.7 nautical miles (Fig. 25.).

Figure 25 Proposed Natura 2000 Sites regarding Port of Muuga and dumping place location



Index: P - Prangli Island; A - Aksi Island; R - Rammu Island; M - Port of Muuga and D – dumping place

Figure 26 Protected landscapes and relevant green areas in Harju County

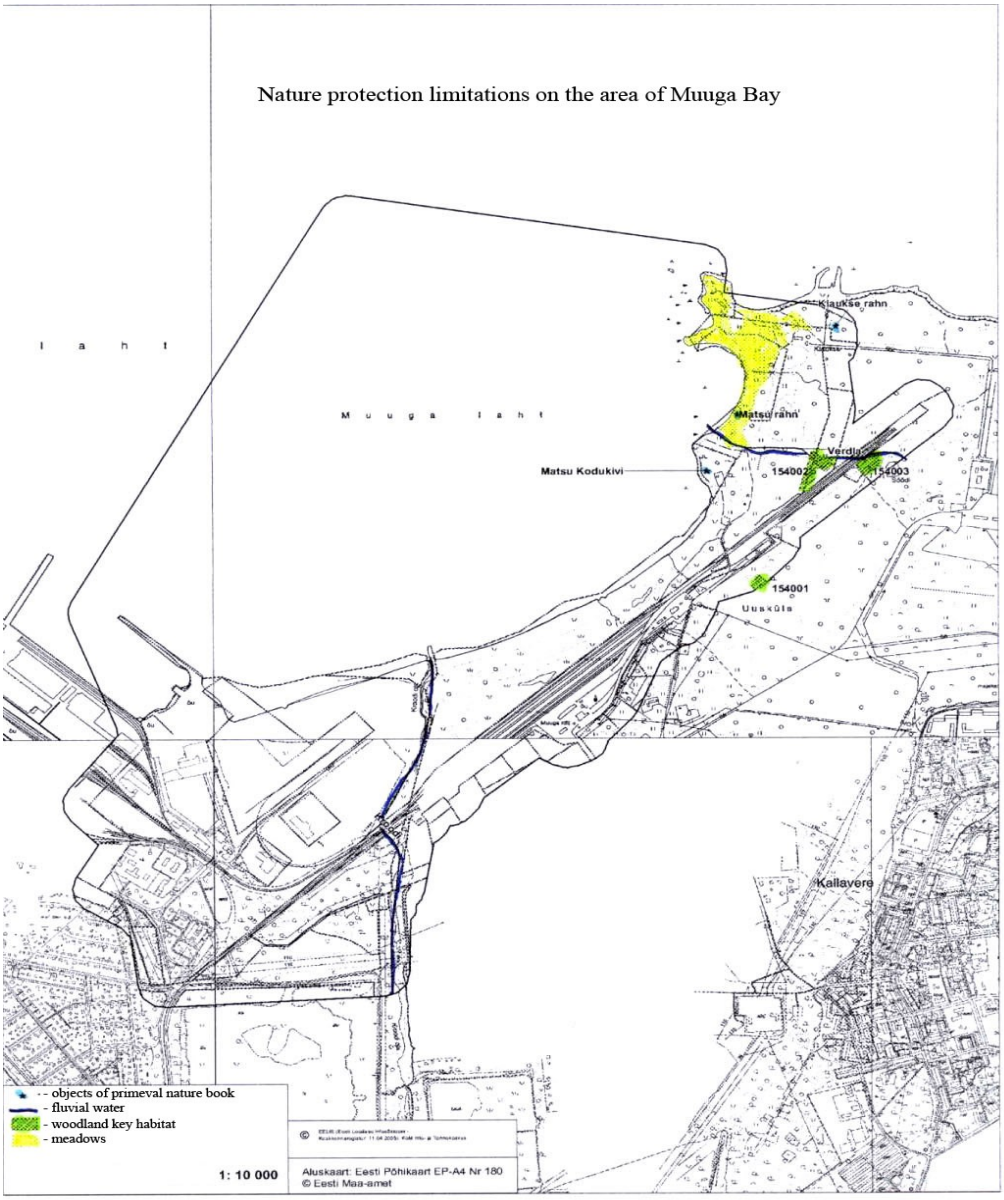


M - Muuga Port, A – Aksi, P – Prangli (Harju Maavalitsus, 2003)

3.5. TERRESTRIAL ECOLOGY

On the eastern coast of Muuga Bay, east of Kroodi Creek up to Tahkumäe Cape there are **meadows** flooded by the sea and covered mainly by reed (Fig. 27.).

Figure 27 County-level protected areas in the neighborhood of the Port of Muuga



Thematic planning of the Harju County

According to the thematic planning *Environmental conditions guiding the settling and land use* of the Harju County, in the area bordering with Muuga Harbour in the east on Tahkuneeme Cape, there is a small green corridor (K9) of county importance (Fig 27). According to the above thematic planning, the whole territory of the Island Aksi is also stated as the protected area of county importance. Besides, this island is included in Natura 2000 network (see 3.1).

3.5.1. ORNITHOLOGY

The following is a survey of the bird life in the Muuga Bay area based mainly on the observations by Meelis Uustal. The species abundance and composition is described. Attention is focused on the potential impact the wave breaks planned to be constructed in the Muuga Port may have on the birdlife and on the possibilities to mitigate their impact.

Material and methods

To study the birdlife in the Bay of Muuga, observations were carried out in June 2004, April, June—September 2005 and April 2006. During these observations, all bird species occurring in the area northwest of the port and in the area between the port and the coal terminal were recorded. The data on the birds wintering in the area were obtained through the observations conducted in the beginning of April 2006 (that year the spring was late) and from the report „Mid-winter waterfowl counting – 2004" compiled by L. Luigejõe.
All the bird species related to the coast or open sea and recorded during the cause of many years in the area of Muuga Bay were summarized and are presented in the Table. The table shows also the status of each species (nesting, migrant, feeding visitor, protection status; see Appendix 1).

Description of birdlife in the Muuga Bay area

The birdlife in the coastal waters of the southeastern part of the Viimsi Peninsula, which is situated west and northwest of the Muuga container terminal, is rather rich in species. The area is characterized by rich plant communities. There occur both gentle coasts and reed-beds that offer good nesting and feeding possibilities. Coastal bird species are mostly related to the near-shore sea areas where the water is shallow (max 1—1.5 m) and where they can feed on the roots of aquatic plants, invertebrates and fish. During the nesting period, representatives of the following species have been registered in the area: mallard, shoveled, pintail, she duck, grey heron, common coot, arctic tern and little tern.

Single pairs of common gull, herring gull and arctic tern nest on the roofs of the terminals and buildings in the Port of Muuga. These birds find their food mainly in the coastal waters northwest of the port.

The area between the container terminal and the coal terminal is poorer in stopping waterfowl because the feeding conditions are not particularly good there. The coast is covered mostly with fine sand and splitters and it is mainly used by herring gulls and, to a lesser extent, by laughing gulls and sea gulls, who stay there for night and fly to feed on Jõelähtme dumping ground, in the sea and the surrounding area in the morning.

During the nesting period the area accommodates stably 200—300 gulls, but after the end of nesting period (August—September) the number of gulls staying there for night may reach even 3000.

The area between the coal terminal and Saviranna is relatively poor in waterfowl species. Only single non-nesting gulls, ducks and mute swans feed in the area.

The area between Saviranna and Koljunuki is much richer in vegetation and provides better feeding and nesting conditions for birds. Mallards, shelducks, arctic terns and a great number of common gulls stop here.

The most common open sea species are diving ducks – long-tailed duck, golden eye and eider who stay at the places where the bottom fauna is rich. They feed on mollusks their main feeding objects being *Mytilus edulis* and *Macoma balthica.* In winter time, from November till March, the coastal area is poor in birds and depending on the severeness of the winter, the coastal waters are mostly covered with ice. The number of waterfowl who wintered in the Muuga Bay area between Leppneeme and Koljunuki in 1993—2003 and in 2006 is presented in Table 7. The table shows that the most abundant winterer's were long-tailed ducks, mute swans and mallards. The importance of Muuga Bay for wintering species increases in severe winters when Muuga Bay stays (longer) ice-free. In such winters the number of birds gathering in Muuga Bay and particularly in the area of Muuga Port may be even greater than shown in Table 8.

Table 7 The bird species recorded in Muuga Bay in 2004—2006 and their status

	Liik	*Teaduslik nimetus*	*Protection status*	*Breeder*	*Feeding visitor*	*Passage migrant*
1	Cormorant	*Phalacrocorax carbo*			*	
2	Great crested grebe	*Podiceps cristatus*			*	
3	Grey heron	*Ardea cinerea*			*	
4	Mute swan	*Cygnus olor*		*	*	
5	Whooper swan	*Cygnus cygnus*	II category, Bird Directive			*
6	Barnacle goose	*Branta leucopsis*	III category, Bird Directive			*
7	Shelduck	*Tadorna tadorna*	III category	*	*	
8	Gadwall	*Anas strepera*			*	
9	Mallard	*Anas platyrhynchos*		*	*	
10	Pintail	*Anas acuta*	II category		*	
11	Shoveller	*Anas clypeata*			*	
12	Tufted duck	*Aythya fuligula*			*	
13	Eider	*Somateria molissima*			*	
14	Long-tailed duck	*Clangula hyemalis*			*	*
15	Velvet scoter	*Melanitta fusca*			*	
16	Goosander	*Mergus merganser*			*	
17	Red-breaster merganser	*Mergus serrator*			*	
18	Marsh harrier	*Circus aeruginosus*	III category		*	
19	Osprey	*Pandion haliaetus*	I category, Bird Directive			*
20	Water rail	*Rallus aquaticus*	III category	*	*	
21	Spotted crake	*Porzana porzana*	III category, Bird Directive		*	
22	Common coot	*Fulica atra*		*	*	

23	Oyster catcher	*Haematopus ostralegus*			*	
24	Little ringed plover	*Charadrius dubius*	III category	*	*	
25	Ringed plover	*Charadrius hiaticula*	III category		*	*
26	Red knot	*Calidris canutus*			*	*
27	Curlew sandpiper	*Calidris ferruginea*			*	*
28	Broad-billed sandpiper	*Calidris alpina*	II category, Bird Directive		*	*
29	Snipe	*Gallinago gallinago*			*	*
30	Bar-tailed godwit	*Limosa lapponicus*	III category, Bird Directive		*	*
31	Common curlew	*Numenius arquata*	III category		*	*
32	Redshank	*Tringa totanus*	III category		*	
33	Laughing gull	*Larus ridibundus*			*	
34	Common gull	*Larus canus*		*	*	
35	Herring gull	*Larus argenatatus*		*	*	
36	Sea gull	*Larus marinus*			*	
37	Caspian tern	*Sterna caspia*	II category, Bird Directive		*	*
38	Arctic tern	*Sterna paradisaea*	III category, Bird Directive	*	*	
39	Little tern	*Sterna albifrons*	III category, Bird Directive		*	

Table 8 Winter abundance of sea birds at Randvere and Tahkumäe observation sites of Muuga Bay in 1993-2003 (Luigujõe 2004[4]) and in 2006 (M.Uustal)

Species	*Scientific name*	*Abundance (min-max)*

[4] Luigujõe, L. 2004. Kesktalvine veelindude loendus -2004. Eesti Ornitoloogiaühing. Tartu.

Long-tailed duck	*Clangula hyemalis*	201 - 1500
Goldeneye	*Bucephala clangula*	2 - 350
Mute swan	*Cygnus olor*	202 - 540
Whooper swan	*Cygnus cygnus*	0 - 10
Goosander	*Mergus merganser*	3 - 60
Velvet scoter	*Melanitta fusca*	1 - 10
Mallard	*Anas platyrhynchos*	110 - 450
Herring gull	*Larus argentatus*	600 - 1000

3.6. MARINE ENIRONMENT

3.6.1. FISHERIES

In present case, the noticeable part of Muuga Bay planned to dissociate by breakwaters from the potential fish feeding and reproduction area. However, this area is not virgin already today because the twenty years exploitation of the one of the largest port in the Baltic Sea. Regular fish monitoring in the Muuga Bay began in 1994 with goal to estimate the impacts of the Port of Muuga on fish communities and fishery. As result, we have now quiet a long-time and good data of local fish stocks dynamics and biodiversity, including the changing of fish reproduction capacity in Muuga Bay.

Totally 34 species of marine, brackish waters and freshwaters species of fish and 2 of lampreys were caught in area potentially affected. 24 species of fish and river lamprey can be specified as commercially important (Table 9).

Table 9 Fish species within the area affected by the construction of the breakwaters of Port of Muuga

Species	Muuga Bay	Coastal sea of Aksi Island
Merekalad / marine species		
Räim / Baltic herring	xx *	xx
Kilu / sprat	x	xx*
Tuulehaug / garpike	x	-
Lest / flounder	xx	xx*
Tursk / god	-	x
Emakala / eelpout	x	x
Siirdekalad / migratory species		
Merisiig / whitefish	x	x
Meritint / smelt	x*	x

Angerjas / eel	-	-
Lõhe / salmon	x	-
Meriforell / sea trout	x*	-
Vimb / vimba bream	x*	x
Mageveekalad / freshwater species		
Ahven / perch	xx*	x
Koha / pikeperch	-	-
Kiisk / ruffe	-	--
Särg / roach	xx*	x
Säinas / ide	-	-
Teib / dace	-	--
Linask / tench	-	--
Koger / crucial carp	-	--
Hõbekoger / gibel carp	x	--
Luts / burbot	-	--
Haug / pike	x*	-

x - common; xx - abundant ; * – present during spawning season; – rare; -- not present

Marine species

Baltic Herring (*Clupea harengus membras L.)*

Herring traditionally has been one of the most important commercial fish species in the Baltic Sea. Herring catches have been fluctuating between 30-40 thousand tons in Estonian waters during then recent decades. From that amount 10-13 thousand tons were taken by trapnet fishery in coastal areas. One of the most important regions of herring coastal fishery has been the Gulf of Finland, where annual landings have amounted to 15 000-20 000 t in 1980s and to 7 000 - 8 000 t in most recent years. The decrease in landings was caused by fluctuations in stock size but also by the overexploitation of the herring stock. The spawning of herring take place almost everywhere in the Estonian coastal sea up to depths of 15 (20) meters. The spawning started in spring (usually in April) after the water temperature reached + 6 ^{0}C and continues until 14 – 16 ^{0}C. The hard sea bottom covered with gravel and red and brown algae (*Furcellaria, Ceramium, Polysiphonia, Sphacelaria and Pilayella*, see 2.6.1.) and having good water exchange is the most suitable for herring spawning (Raid, 1985, 1991, 1998). The mean production of herring larvae with length above 10 mm reached 133-156 * 106 per 1 km^2. The duration of the period of non-activity larvae is about two weeks and usually finished in first decade of July. Due regard, that about 90 % of those larvae dead before reaching the maturity and taken account the mean weight of matured specimens, the total production of spawning stock by each 1 km^2 of spawning grounds was estimated to be equal to 400 tons (Raid 1985).

Flounder *(Platichthys flesus)*

Besides to the relatively abundant Baltic herring, entering the coastal sea of Muuga Bay for spawning, flounder is the second commercially most important species. It is believed that also flounder is using the Muuga Bay and the area of Aksi Island for spawning however the

location of potential spawning grounds is unknown (Mikelsaar, 1957, E. Ojaveer jt., 2003). Flounder is fished mainly by passive gears (traps, gill nets) in coastal sea, and in Muuga the annual flounder catches have been recently about 4 000 – 5 000 kg (Table 2.7.2). The main food objects of flounder are Macomab b*althica* and *Mytilus edulis* and because the catches of flounder within areas being impacted by dredging/dumping and others hydro-engineering activity are usually good, as it was many times during the monitoring in Muuga Bay, also (see 2.6.2 and 2.7.2).

Turbot, *Psetta maximus L*. is not abundant species in Muuga Bay and not fished directly. But, as very high marketable fish species, the by-catch of turbot may have sometimes an importance for fishermen incomes.

Others economically most valuable marine fishes of the Baltic Sea, as **sprat (*Sprattus sprattus*)** and **cod *(Gadus morhua),*** are rare in the Muuga Bay coastal sea at present, due to unfavorable environmental conditions for those species (low salinity due to long time absence of significant inflows from the North Sea into Baltic Sea). However, in more depths areas in the open part of Muuga Bay as well as within the area of Aksi Island, the sprat fished actively by trawls. Also, when the salinity increase and cod stocks abundance arise the cod can be abundant within the area discussed. So, in early 1980s the annual trawl catches of cod in the Gulf of Finland have been more then 10 000 ton's.

Commercially important freshwater and migratory fish species

Baltic Salmon, *Salmo salar L*.

Goldwater migratory fish, known as genetically very fixed to its spawning river. Jägala river was earlier one of the most important salmon spawning river in Estonia, but after the hydroelectric power station was built, the salmon could not swim up to the spawning grounds and this local stock of salmon was destroyed. Recently, the Jägala river became cleaner and it was decided to recover the current salmon population. In this reason, the stocking of salmon smolts organized in May during recent years. Today, some specimens of salmon have been found to enter the river for spawning in late autumn. But not yet any data about the efficiency of the salmon spawning in Jägala river are available. Salmon is the species, included into the Annex II of the EU Habitat Directive (see 3.5.).

Sea trout, *Salmo trutta trutta L.*

Goldwater migratory fish but not so highly, as salmon. Sea trout has also genetic memory. For spawning trout entered into some river, even a small, in August-November. Before it, the mature specimens concentrated in shallow water nearby spawning rivers mouth. Despite the pollution of Jägala river, sea trout has been continued the using of this river for spawning in second half of last century, also.

Whitefish. *Coreogonus lavaretus lavaretus (L.).*

Whitefish is coldwater semi-migrating species, which likes the sea areas with clean water and high concentration of oxygen. Spawning grounds located in shallow areas with land sea bottom and free of algae. Due to eutrophication the many areas of Estonian coastal sea became not usable by whitefish for spawning. There may be some spawning grounds of whitefish in Prangli Island coastal sea and Kaberneeme and Kolga Bay. Spawning is taken place in October-November and then the eggs will be developed till to spring, In this case, the normal oxygen concentration is needed in all winter time and also when the sea is covered by ice.

Whitefish is under the National protection as species of category II in Red Book of Estonia.

Perch. ***Perca fluviatilis L.***
Spawning grounds can be found in almost all coastal waters of Ihasalu Bay, and in Muuga Bay the reproduction areas are located in shallow waters small bays nearby Randvere. The time of spawning depend on water temperature (between + 8– 15 ^{0}C), and usually begin at the end of April. The eggs of perch are developed at the bottom algae and the suspended sediments concurred with dredging and dumping usually should not be marketable dangerous for perch reproduction efficiency. The locality is very typical for perch distribution. Perch fished in mostly by traps, fykenets and gill nets during the all period, free of ice cover. The market interests and prices of perch have been high since the beginning of 1990s, because it the intensity of perch fishery in all Estonian coastal sea has been high. It resulted in over-fishing and in sharp decreasing the abundance of local perch stocks in many areas.

Pike-perch ***Stizostedion lucioperca (L.)***
Pike-perch like the shallow waters relatively large bays with law transparency of water and high temperature already in May-June. Spawning begin usually when water temperature arise above + 12 – 13 ^{0}C. In Muuga Bay and surrounding sea areas there are not known pike-perch spawning grounds. Only the feeding specimens of pike-perch visited Muuga Bay.

Roach ***Rutilus rutilus (L.).***
The eutrophication of coastal sea and the decreasing abundances of some predatory species with law market interest resulted in increasing the roach stocks size also in the central part of the Gulf of Finland. The preferred spawning grounds of roach located in rivers and in almost freshwaters estuaries, including the Jägala river. Spawning is starting usually in end of April or in the beginning of May, when the temperature of water reached + 8 – 10 ^{0}C. When the level of water in rivers and in estuaries are law and it is difficult to go to the usual spawning grounds, the roach can use for spawning the small brackish water lagoons also, including those in Ihasalu Bay coastal sea. Recently, when the catches of pike-perch and pike have been law, the fishery for roach became more intensive and the first data of over-fishing were observed somewhere.

Pike ***Esox lucius L.***
Like the bodies of water with highly changing coastal line and closed or semi-closed from winds. In Muuga Bay pike was never been very abundant and nearest spawning grounds probably are located in Ihasalu Bay. In the last the pike is more abundant and from this area the pike can do feeding migrations to the Muuga Bay and also into the area of Aksi Island. Pike spawns early spring, often starting already during the time of very end of ice cover. Prefer for spawning the rivers and temporary lagoons (as the estuary of Jägala river), but also can use the shallow water coastal sea. Pike is very famous sport fishing object.

Vimba. ***Vimba vimba (L.)***
Spawning is taken place only in fresh water, mainly in rivers in May-July. Can do very long migrations up to river. The young vimba usually was living in rivers up to 2 years and then migrated to the sea for feeding. Feeding vimba can migrated everywhere in Muuga Bay and also in the area of Aksi Island.

Gibel Carp *Carassius auratud gibelio (Bloch).*
Gibel Carp is alien species which historically live in Far-East of Asia and was introduced in Estonian freshwaters lakes and pounds about 50 years ago. Due to rich food (algae and water plants) in Estonian lakes and usable for spawning areas where water temperature arise above 200 C for some weeks, as well the law abundance of predators, the Gibel Carp stocks have been increasing from year to year and recently they are occupied also almost all shallow water areas in Estonian coastal sea. This fish become an important object of artisanal fishery along the mainland coast.

Smelt *Osmerus eperlanus eperlanus L.*
Is not highly abundant within the area of the central Gulf of Finland, Spawning grounds are located in Pirita river and may be in Jägala river also. As whitefish, smelt needs the olygotrophic type of water (with high oxygen concentration) in spawning grounds area. Smelt is spring-spawning and the main time of spawning is April.

Eel. *Anguilla anguilla L.*
European eel is not high abundant, but commercially very important species everywhere in Estonian coastal sea. The spawning of eel take place in Sargasso Sea and in the Baltic ell is feeding during 10 – 15 years. Fished mainly by small fykes.

Cyclostomata: river lamprey *Lampetra fluviatilis L.*
Spawns in Jägala river. The spawning is taken place in September – February in the lower reaches of the river. The larvae lived in river during 3-4 first years and then migrated into the sea. After 1-2 years they come back to the river for spawning and died then. In Estonia the marinated and/or smoked lamprey is a very famous as dinner party and so this species has a high market value. In the other hand, river lamprey is included into the Annex II of EU Habitat Directives (see 3.2).

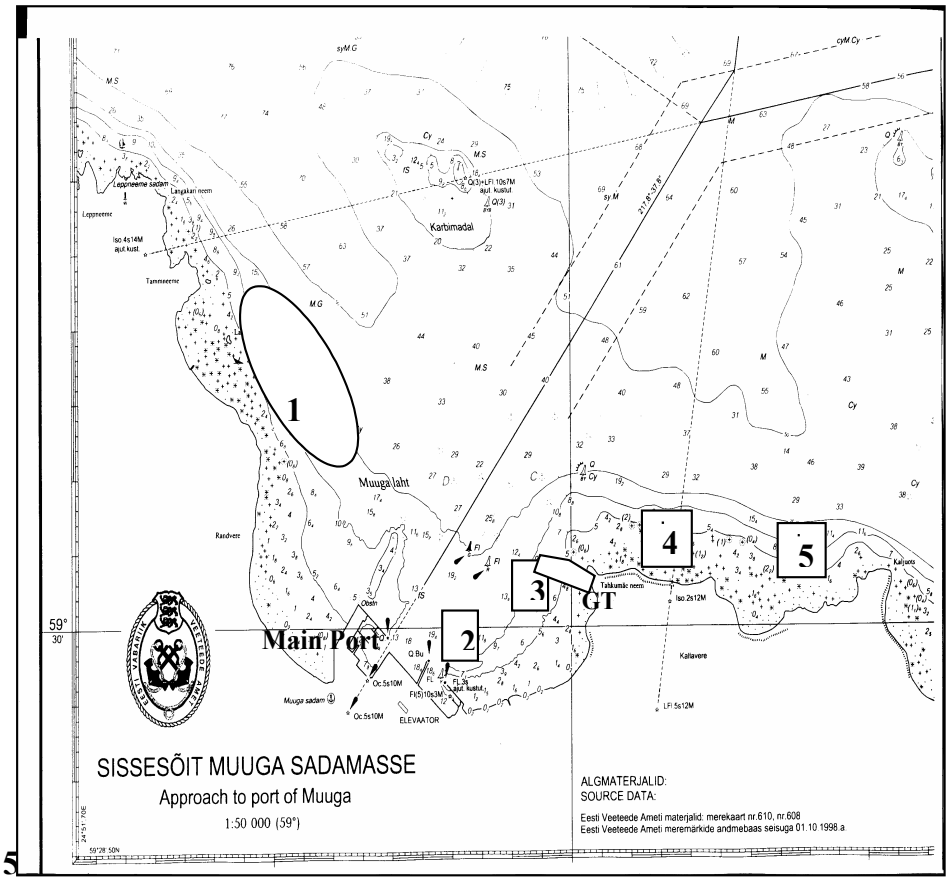
The results of monitoring of fish communities and fishery in Muuga Bay (on the basis of papers of Järvik et al. 2005 and 2006)

The main goal of this monitoring has been the assessment of the impact of Muuga Port on the fish communities (diversity, age and size composition, distribution pattern) and fishery (catch composition, fishing efficiency) in Muuga Bay during the period of active development of the Muuga Port within a certain area in 1994 - 2002. The dynamics of fish stocks by themselves is not the objective of the present survey, and therefore, has not been discussed here, because it is impossible to determine the local stock areas of freshwater species as the distribution areas of the stocks of marine and migratory species are considerably bigger than Muuga Bay.

Muuga Bay ecosystem has been suffering from severe anthropogenic pressure by inflow of the wastewater of the Maardu Chemical Factory during 1950-1980s. Since the closure of the factory in early 1990s no other significant pollution sources except for Muuga Port and its infrastructure are located in the Muuga Bay.

Fish monitoring up to 2003 was carried out in three sites in the Muuga Bay (Fig. 28). The analysis of the dynamics of fish catch statistics in Muuga, Ihasalu, and Tallinn bays were used to separate the impact of Muuga Port activities from the one exerted by natural and other sources on the fish communities. Tallinn Bay is under relatively high anthropogenic pressure, while the Ihasalu Bay is not.

Figure 28 Scheme of fish monitoring sites in Muuga Bay in 1994-2004: 1, 2 and 3 and new additional monitoring sites in 2003-2004: 4 and 5. GT – Coal Terminal



The effect of tanker ALAMBRA oil disaster on September, 16, 2000 on fish communities was specially monitored. The regular soak monitoring SE of Port was conducted shortly before this accident on September, 13-14 and after the accident an extra soak monitoring was carried out on September, 25-26.

On the basis of monthly catch report from professional and semi-professional fishermen the catch database was created for three national fishing rectangles: 130 (Ihasalu Bay), 134 (Muuga Bay), and 138 (Tallinn Bay). The annual catches and catch per unit of effort (CPUE) dynamics by species were estimated separately for each of those three rectangles and by gears used. Differences of CPUE values between bays were analyzed.

Annually observed number of species in both monitoring sites (NW and SE from Harbor) is given in Fig. 29 and the annual catch compositions in Fig. 30 and 31.

In 2003 the new phase of the enlargement of Port of Muuga was started. The new coal terminal was built in 2003-2004 situated in Tahkumäe Peninsula and the area to West from the new terminal up to existing berths of Muuga Port will be constructed fully during the 2005-2007. In this case the fish monitoring area was enlarged also (Fig. 28., sites 4 and 5). Furthermore, the monitoring of herring spawning grounds began in Muuga Bay, Ihasalu Bay and, as reference areas in Kaberneeme Bay and Kolga Bay.

Figure 30 Number of species in monitoring gill net catches in NW (Randvere) and SE (Tahkumäe) of Muuga Port

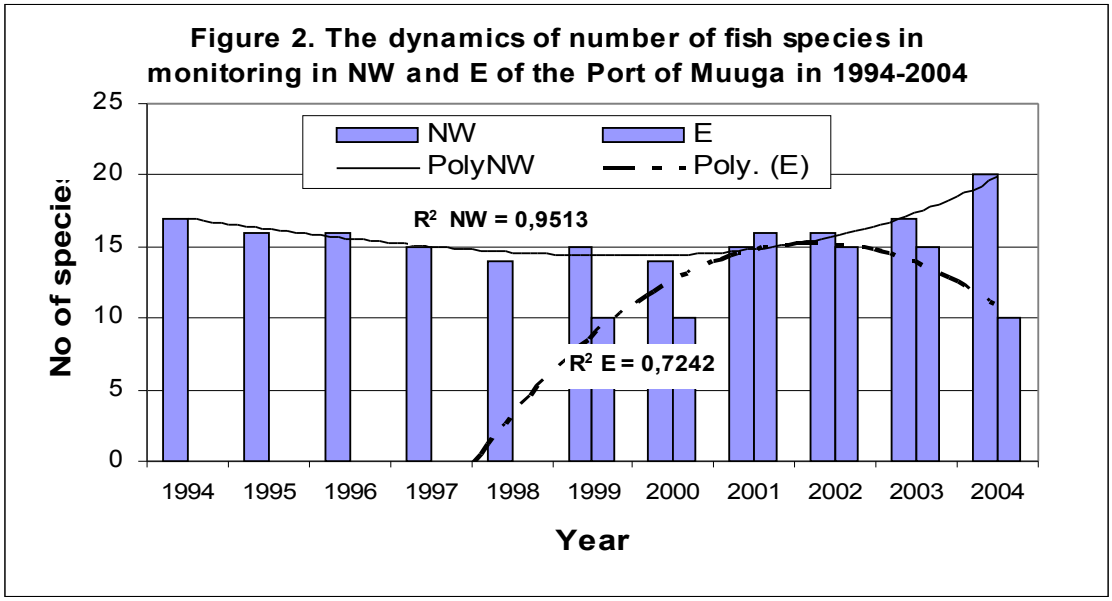


Figure 31 Catch composition of monitoring gill nets in NW (Randvere) in 1994-2004

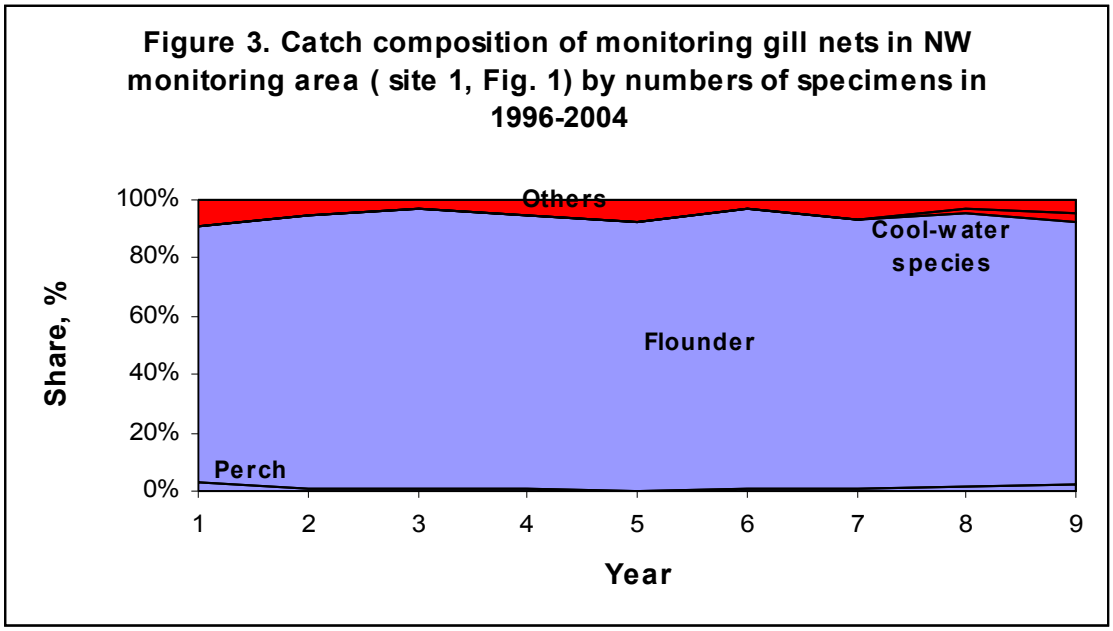
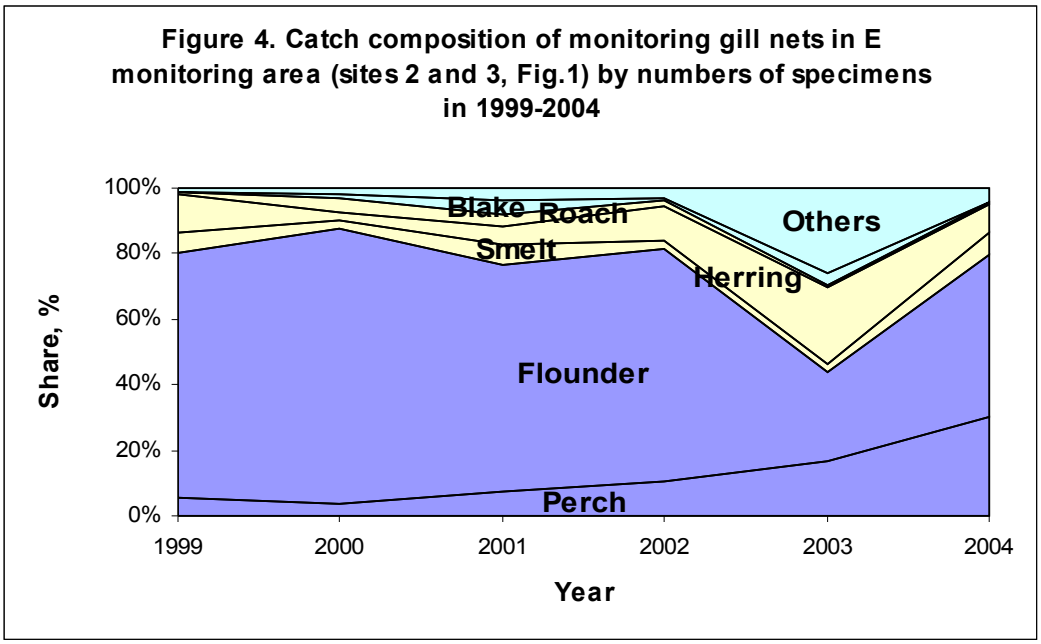


Figure 32 Catch composition of monitoring gill nets in SE (Tahkumäe) in 1999-2004



Changes in commercial fishery

The efficiency of fishing (CPUE) by both gill nets and traps in Tallinn, Muuga and Ihasalu bays are presented in Fig. 33 and 34 Similar to the monitoring gill nets in Muuga Bay, flounder was the predominant species in gill net catches in all the bays inspected. Herring and flounder were dominating in trap net fishery.

The annual catch of both gill and trap nets fluctuated widely in all the three bays studied, but no clear trends were revealed. Furthermore, the same conclusion can be drawn in case of efficiency of the commercial fishery (Fig. 33 and 34). The total CPUE as well as the CPUE by species also fluctuated without any clear trend.

Figure 33 **CPUE dynamics of commercial trap nets in Bay of Tallinn, Bay of Muuga, and Bay of Ihasalu in 1994-2002.**

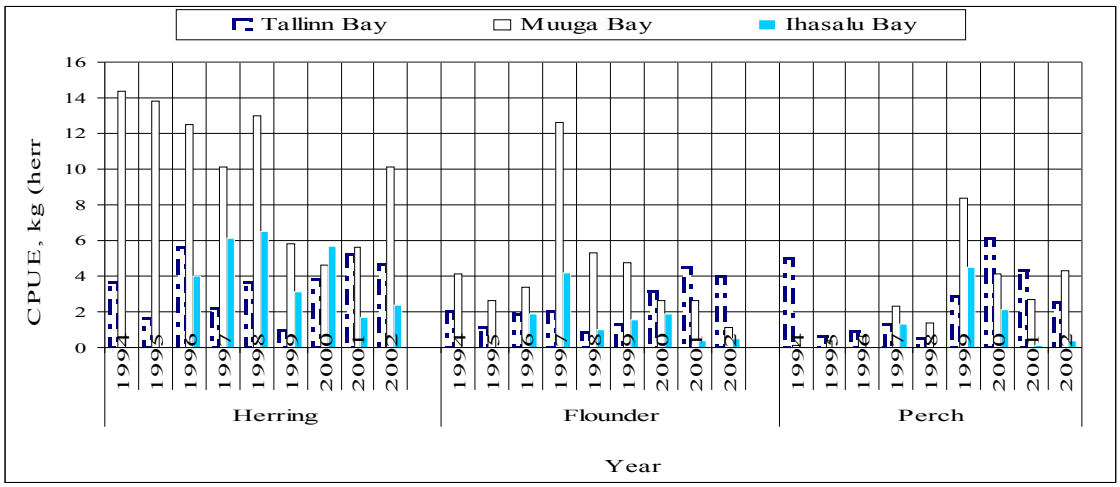
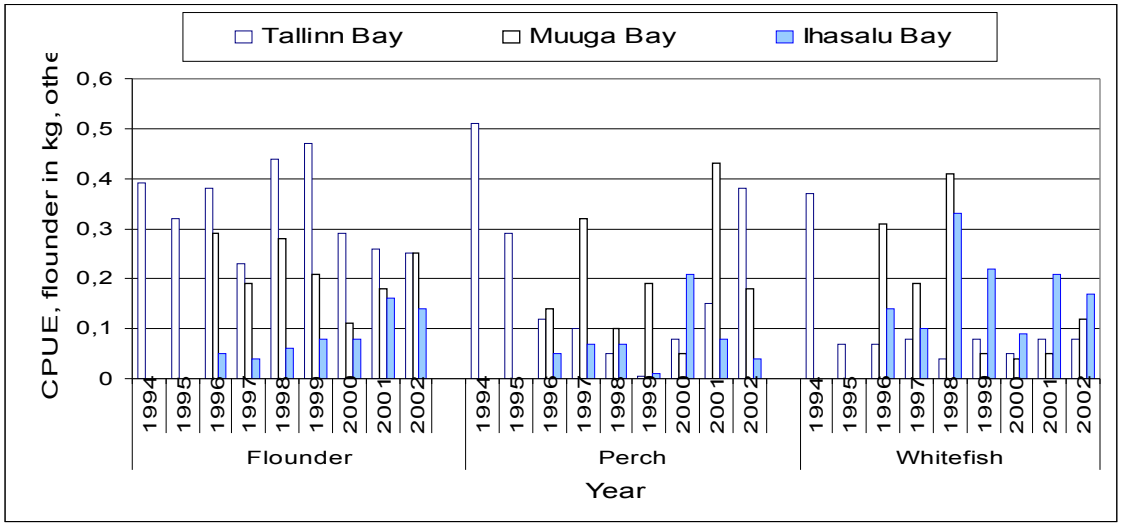


Figure 34 CPUE dynamics of commercial gill net fishery in the Bay of Tallinn, Bay of Muuga and Bay of Ihasalu in 1994-2002



Tabel 10-12 Catches in kg of professional fishermen by gill nets in Muuga Bay in 2002-2004 (Data for 2005 were not avaiable)

Table 10 Catches in kg of professional fishermen by gill nets in Muuga Bay in 2002

2002

Month	No of hauls	Flounder		Perch		Whitefish		Salmonids		Others		Total catches	
		Catch	cpue	Catch	cpue	Catch	cpue	Catch	cpue	Catch	cpue	Catch	cpue
Jan	48	-	-	-	-	14.0	0.29	9.0	0.19	-	-	23.0	0.48
Feb	-	-	-	-	-	-	-	-	-	-	-	-	-
March	158	7.0	0.04	-	-	29.5	0.19	9.7	0.06	20.0	0.13	66.2	0.42
Apr.	289	-	-	-	-	86.2	0,30	3.0	0,01	12.0	0,04	101.2	0,35
May	62	-	-	46.2	0,75	5.0	0,08	-	-	91.1	1.47	142.3	2.30
June	117	141.5	1.21	24.5	0,21	11.0	0,09	-	-	-	-	177.0	1,51
July	222	479,6	2.16	15.2	0,07	3.4	0,02	-	-	0.5	0	498.7	2.25
Aug	879	2924.1	3,33	101.0	0.11	118.1	0.13	10.8	0.01	57.0	0.06	3206.4	3,65
Sept	385	648.0	1,68	111.1	0,29	59.4	0,15	13.6	0,04	20.3	0,05	852.4	2,21

Table 11 Catches in kg of professional fishermen by gill nets in Muuga Bay in 2003

2003

Month	No of hauls	Flounder		Perch		Whitefish		Salmonids		Others		Total catches	
		Catch	cpue	Catch	cpue	Catch	cpue	Catch	cpue	Catch	cpue	Catch	cpue
Jan	28	-	-	-	-	-	-	12.0	0,43	1,9	0,068	13,9	0,496
Feb	-	-	-	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-	-	-	-
Apr.	39	2,7	0,069	5,3	0,14	36,4	0,93	43.1	1,12	1	0,026	88,5	2,27
May	86	12,3	0,14	83,2	0,97	8,2	0,085	2	0,023	13,4	0,16	119,1	1,38
June	121	136,5	1,13	46,1	0,38	3,5	0,029	-	-	11,4	0,093	208,1	1,72
July	199	396	1,98	53,5	0,27	1,6	0,008	2,5	0,013	1,4	0,006	455	2,29
Aug	891	2843,3	3,19	108	0,12	96,4	0,12	21,7	0,024	39,2	0,044	3108,6	3,49
Sept	393	622,6	1,58	122,5	0,31	48,9	0,12	30,1	0,077	12,5	0,032	836,6	2,13
Total	**1757**	**4013**	**2,28**	**418,6**	**0,24**	**195**	**0,11**	**56,3**	**0,03**	**80,8**	**0,05**	**4830**	**2,75**

Table 12 Catches in kg of professional fishermen by gill nets in Muuga Bay in 2004

2004

Month	No of hauls	Flounder		Perch		Whitefish		Salmonids		Others		Total catches	
		Catch	cpue	Catch	cpue	Catch	cpue	Catch	cpue	Catch	cpue	Catch	cpue
Jan	12	0,1	0,008	-	-			3,6	0,3	-	-	4,008	0,33
Feb	3	-	-	-	-	0,5	0,17	1	0,33	-	-	2	0,67
March	14	0,5	0,036	1,2	0,086	1,2	0,09		-	-	-	3,112	0.22
Apr.	22	1,2	0,055	1,9	0,086	33,4	1,52	6,4	0,29	-	-	44,851	2,04
May	79	8,4	0,11	83,5	1,06	3,8	0,048	12,2	0,15	8,3	0,11	117,68	1,49
June	154	104,9	0,68	44	0,29	4,4	0,029	-	-	10	0,065	164,36	1,06
July	223	412	1,85	67,1	0,3	-	-	-	-	-	-	481,25	2,16
Aug	912	3013,5	3,3	100,7	0,11	100,1	0,11	18,1	0,02	14,5	0,016	3250,5	3,56
Sept	367	927,4	2,53	139,5	0,38	46,7	0,13	41,2	0,11	21,4	0,058	1179,4	3,21
Total	**1786**	**4468**	**2,5**	**437,9**	**0,245**	**190,1**	**0,106**	**82,5**	**0,046**	**54,2**	**0,03**	**5235,6**	**2,93**

Conclusion

Despite the increasing trend in the share of cyprinids (eutrophication indicators) like roach (*Rutilus rutilus*) and bleak (*Alburnus alburnus*) observed in the vicinity of the Muuga Port

area, no direct and clearly defined impacts of Port of Muuga on composition of fish communities were revealed up to 2002. However, after the starting of the new Coal Terminal in 2003 the biodiversity of fish communities in Southern Muuga Bay was decreased, especially in the areas close to the Port (sites 2 and 3, Fig. 28).

The performance thus marine species as lumpsucker, (*Cyclopterus lumpus* L.), four-horn sculpin (*Triglopsis quadricornis quadricornis* L.), bull-rout (*Myoxocephalus scorpius scorpius* L.) and sea scorpion (*Taurulus bubalis Euphrasen*), known as cool-water species, in monitoring catches in NW area, allow to conclude, that the water quality in the Northern part of Bay of Muuga became better and the after-effects of Muuga Chemical Factory being shutoff at the beginning of 1990s, would disappeared as well, as that the overall negative impacts of Port of Muuga on the environment condition in northern Muuga Bay have been probably not high.

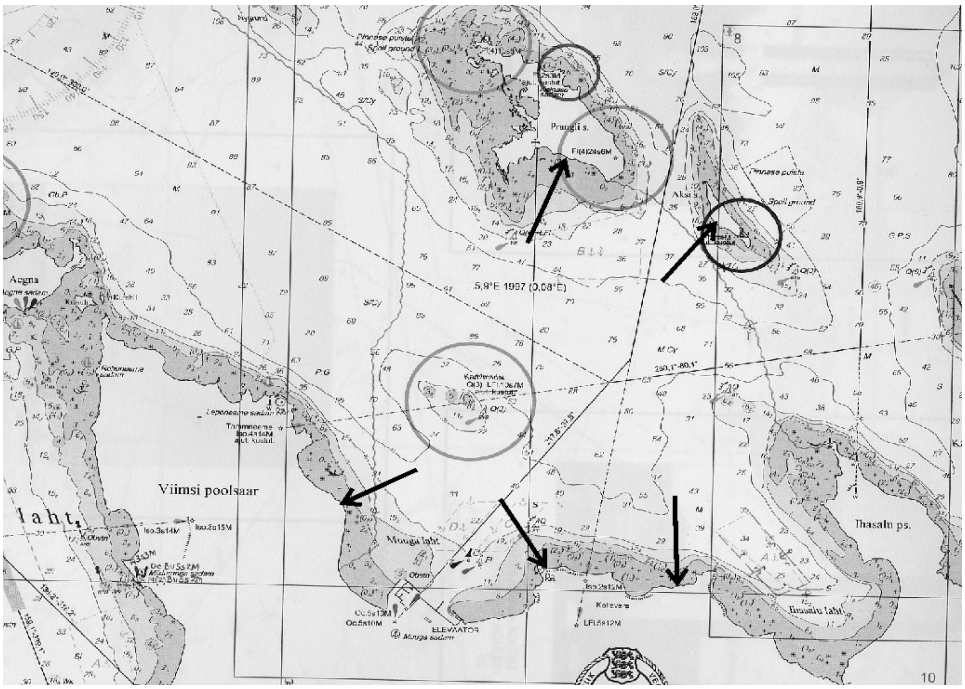
The commercial catches in Muuga Bay were fluctuated widely in 1994 – 2003, but no clear differences with comparative catches in neighbouring bays were revealed, which could be explained by activity of the Muuga Port.

The annual catches in Muuga Bay of flounder and several others species have been decreased since the mid of 1990s, but the annual catches of perch have been increased.
The reproduction conditions for some fish species, especially for herring, using the bottom algae as spawning substrate, have been seriously damaged in the area of East from the Port since the Coal Terminal building began in 2003.

3.6.2 BENTHIC COMMUNITIES

1996. Besides, bottom vegetation was monitored at one transect in Ihasalu Bay in the coastal waters of Aksi and Prangli islands. The studies on these transects were started in connection with the construction of coal terminal in the area of Muuga Port.

Figure 35. Schematic location of the transects used for bottom vegetation monitoring in Muuga and Ihasalu bays in 2005



The results of the monitoring carried out in 2005

The assessment was based on the species composition, distribution boundaries and coverage of the bottom vegetation.

Muuga 1 (E)

Like in previous years, sandy bottoms and single bigger stones occurred in shallower areas. From 3 meters downwards there is a clay plate on the sea floor. The share of stones was ca 40% at the depth of 2—6 meters. At the depth of 4—6 meters, sand occurred in a small amount.

A total of seven algal species were recorded in transect under the consideration. Ephemeral filamentous algae prevailed. The stones in shallow water were 100% covered with the green algae *Enteromorpha* sp. and *Cladophora glomerata.* In 2005, the brown alga *Pilayella littoralis* was relatively abundant in the area. A general standpoint is that this brown algae needs a hard substrate to attach to, but in the transect it grew attached mainly on clay and, to a lesser extent, on stones. During the last three years, the share of the brown alga *Sphacelaria arctica* has constantly increased in the area. The red algae were represented by *Ceramium tenuicorne* and *Polysiphonia fucoides* (Figs. 36-38).

Compared to last years, the number of species on transect has increased. The new species are mainly opportunistic annual algae. Surprising is the relatively great coverage of the brown alga *Pilayella litoralis*, which usually refers to serious environmental disturbances. In earlier years, the total coverage of algae was high only in the lower parts of transect. With the exposure of clay bottom in the deeper part, the transparency of water decreased abruptly, which resulted in the reduction of the total coverage by algae. In all likelihood, in the course of the construction of coal terminal the character of the substrate was essentially changed and

the reduced distribution of clay bottoms and increased water transparency are responsible for the massive occurrence of the communities of filamentous algae on transect.

Transect 2 (Muuga W)

From the water line down to the depth of 2—3 m the bottom sediments were prevailed by stones. At a depth of 3—5 m the stones covered almost 50% of the sea floor, the remaining part was covered by coarse sand. At a depth of 5—6 m the stones covered still ca 30% of the sea bottom, but deeper, there was only sand. Compared to the previous year, the differences in the sea bottom are small and mainly due to the spatial variation of marine sediments.

Eight different species of algae were recorded on transect. Of those, six were ephemeral filamentous algae; the perennial species were represented by *Zannichellia palustris* and the brown alga bladder wrack *Fucus vesiculosus. Cladophora glomerata* dominated in shallow water, at the depth of 1 m the red algae *C. tenuicorne* and the brown alga *P. littoralis* were added. The bladder wrack *F. vesiculosus* occurred at a depth 1—3 m accounting for only 10% of the total coverage as a maximum.

Compared to earlier years, the total coverage of bottom vegetation is somewhat smaller, particularly at greater depths (from 3 m downwards). At a depth of 3—6 m, 50% of sea bottom was covered by loose algae, mostly filamentous brown algae. If in 2004, a belt of bladder wrach was described at a depth of 2—3 m, then this year it did not occur. The species abundance has been stable during the course of recent years; however, it is considerably less than at the end of the 1990s (Figs. 39 - 41).

Compared to the previous year, the coverage of the bladder wrack has reduced and also the depth distribution of the plants has changed. Besides, ephemeral filamentous algae (*C. glomerata, C. tenuicorne, P. littoralis*) thrived in the area and loose algae were wide-spread.

Transect 3 (Ihasalu Bay)

The transect is characterized by stony bottoms in the depth interval 0—0.5 m and clay bottoms covered with erratic boulders at the depth of 1—10 m. Sand and gravel occur in small amounts at the depth of 3—6 m.

The green alga *C. glomerata* was the dominant down to the depth of 2 m. To a less extent, there occurred Enteromorpha sp. At the depth of 3—4 m the dominants were the red alga *C. tenuicorne* and the brown alga *P. littoralis.* Like in Muuga E transect, *P. littoralis* grew also attached to clay. At the depth of 4 m, the above-mentioned species were supplemented by the green alga *Cladophora rupestris* and the red alga *Polysiphonia fucoides.* Deeper, the brown alga *Sphacelaria arctica* and in a small amount also *Furcellaria lumbricalis* occurred.

Of a total of 8 species registered in transect 7, were ephemeral filamentous algae and only one perennial species (Furcellaria). Compared to earlier years the abundance of perennial species has reduced even more in the area. If in 2004, bladder wrack was growing in the area, then this year it was not found there any more. The coverage of *C. glomerata* has increased again reaching the values recorded in 2003 (Figs. 42—44). In comparison with the year 2004, the state of the area has deteriorated – the abundance of *C. glomerata* has increased and the bladder wrack *F. vesiculosus* has disappeared.

Transect 4 (coastal sea of Aksi Island)

Aksi transect is characterized by sandy bottoms. In shallower sea areas (0—4 m) coarse sand bottoms prevail, while deeper only fine sand bottoms occur.

In spite of the absence of hard bottoms, the species abundance in transect is relatively high. If in 2004 six species were recorded, then in 2005 the number of species was 7. Like last year, attached vegetation was found only in the depth interval 1—5 meters, where the sea grass *Zostera marina* dominated throughout the whole transect. This species prefers uneutrophied oxygen-rich water and is regarded as an indicator of pure water. In a polluted area the species perishes. The coverage of *Z. marina* was greatest at the depth of 3—4 m. The species occurred in patches, up to 5 m in diameter and the coverage of plants within it was up to 60%. At the depth of 2—4 m, alongside *Z. marina* the higher plant *P. pectinatus* and the red alga *F. lumbricalis* were recorded. Within the sea grass field unattached algae occurred in small amounts. The latter were dominated by the brown alga *P. littoralis* (Figs. 45—47).

Throughout transect, perennial plants dominated, most abundant was the sea grass. Since the sea grass is acknowledged as an indicator of pure water, then the quality of water in transect is good. The presence of algal mat in the sea grass community is indicative of some disturbance of the environment.

Figure 36 The dynamics of phytobenthos species variability on Muuga Bay transect 1 in 2005

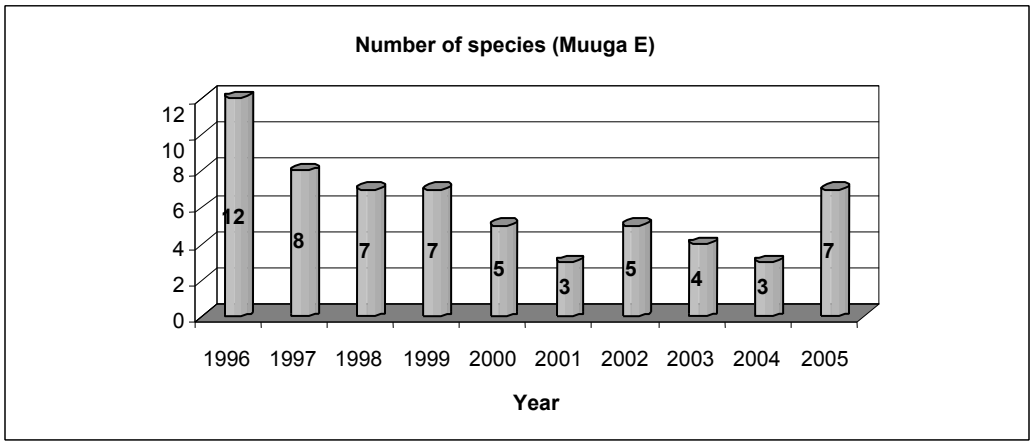


Figure 37 Depth distribution of the species of phytobenthos on Muuga transect 1 in 2005

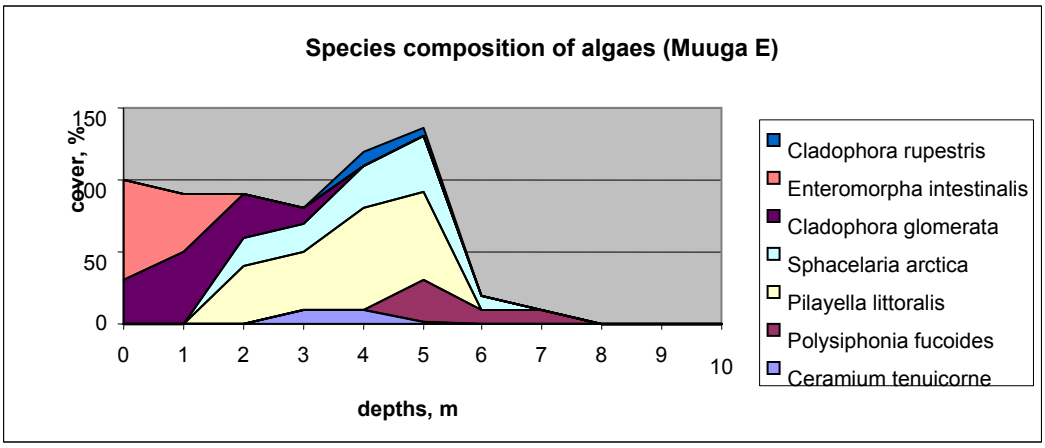


Figure 38 **The dynamics of the general coverage of phytobenthos on Muuga transect 1 in 2000—2005**

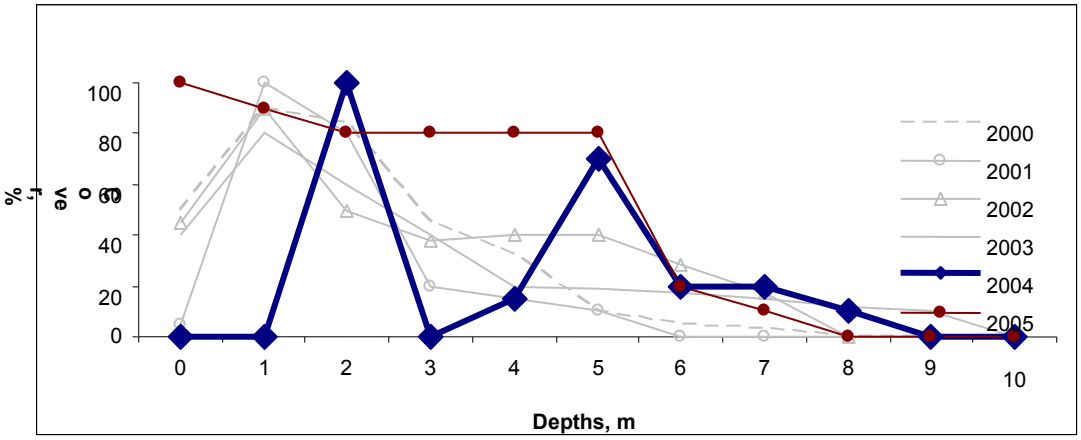


Figure 39 **The dynamics of phytobenthos species variability on Muuga Bay transect 2 in 2005**

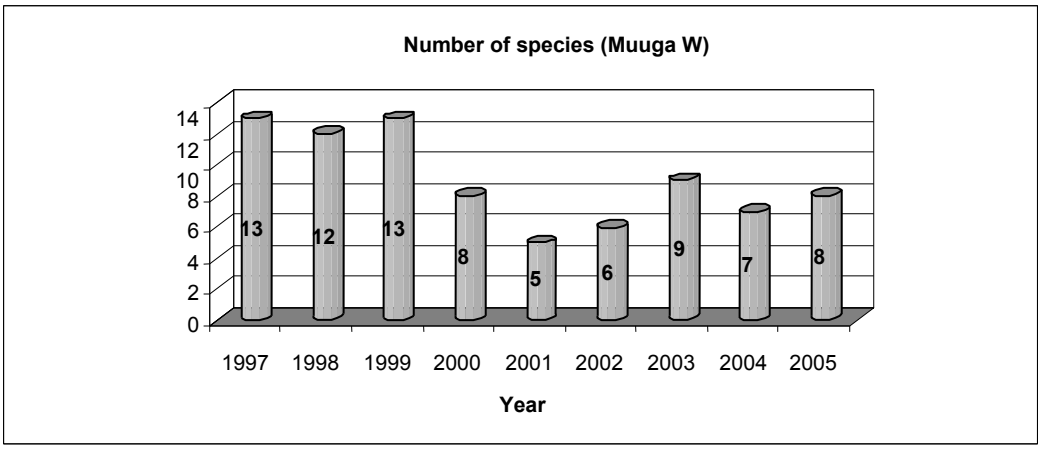


Figure 40 **Depth distribution of the species of phytobenthos on Muuga transect 2 in 2005**

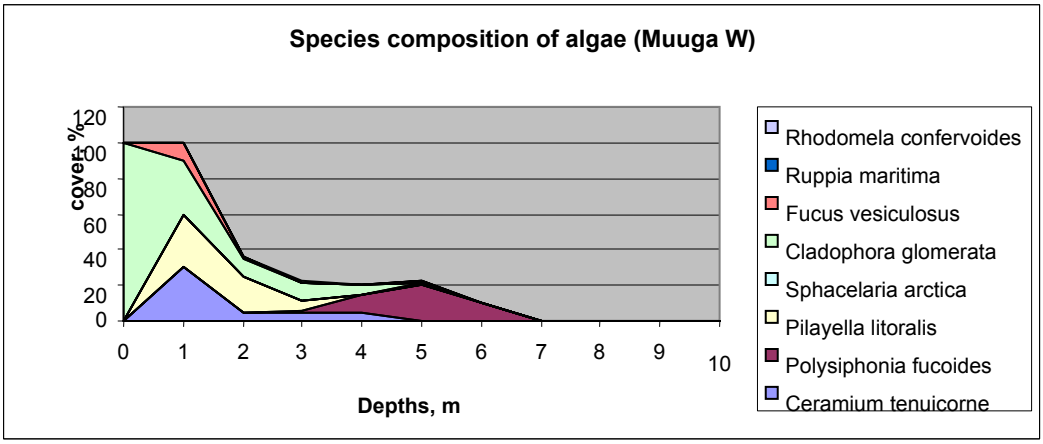


Figure 41 **The dynamics of the general coverage of phytobenthos on Muuga transect 2 in 2000—2005**

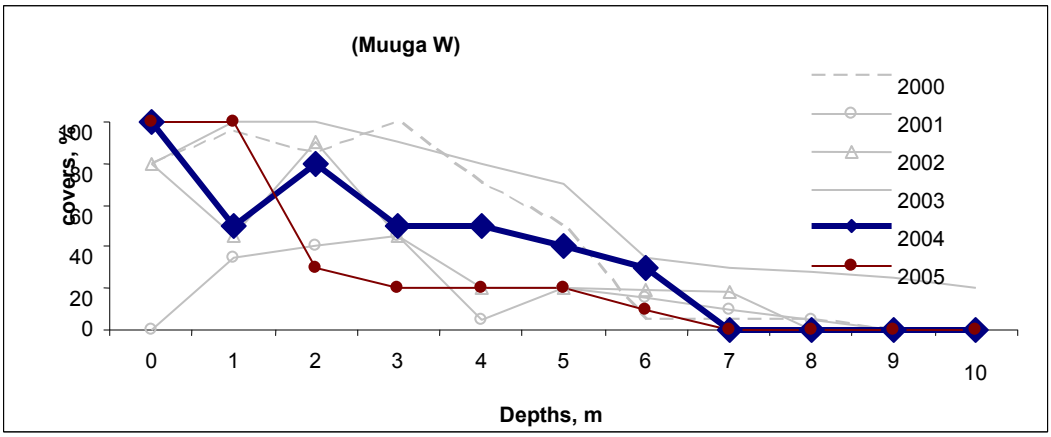


Figure 42 The dynamics of phytobenthos species variability on Ihasalu Bay transect in 2005

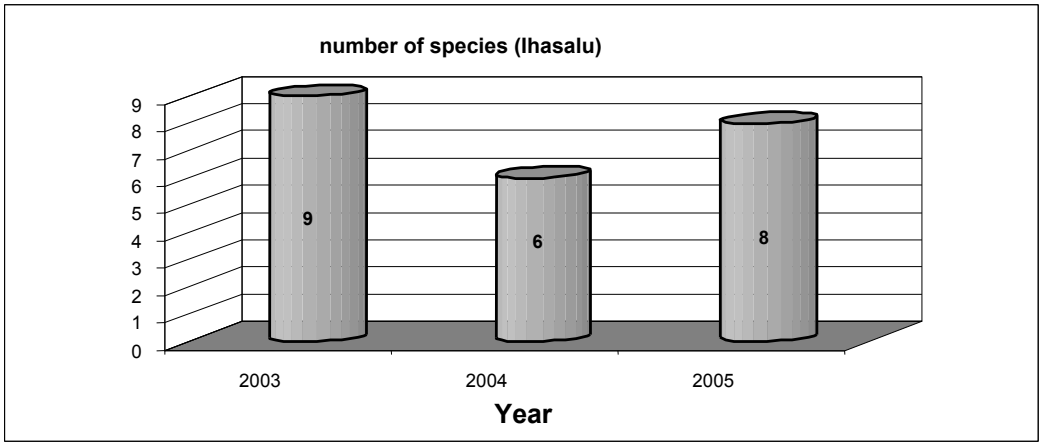


Figure 43 Depth distribution of the species of phytobenthos on Ihasaly Bay transect in 2005

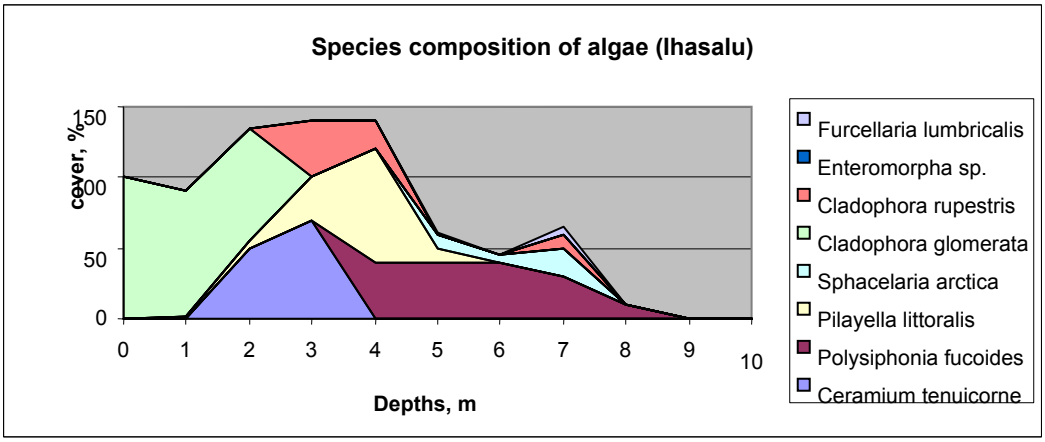


Figure 44 The dynamics of the general coverage of phytobenthos on Ihasalu Bay transect in 2003—2005

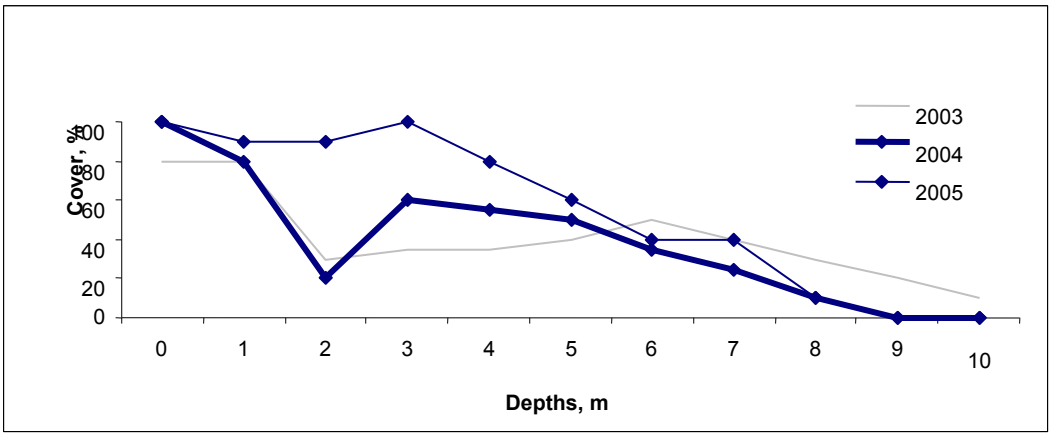


Figure 45 The dynamics of phytobenthos species variability on Aksi transect in 2005

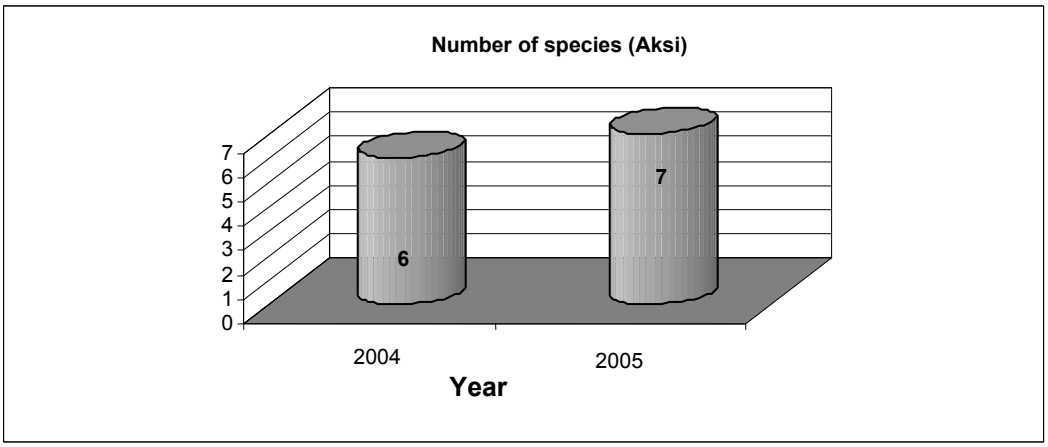


Figure 46. Depth distribution of the species of phytobenthos on Aksi transect in 2005.

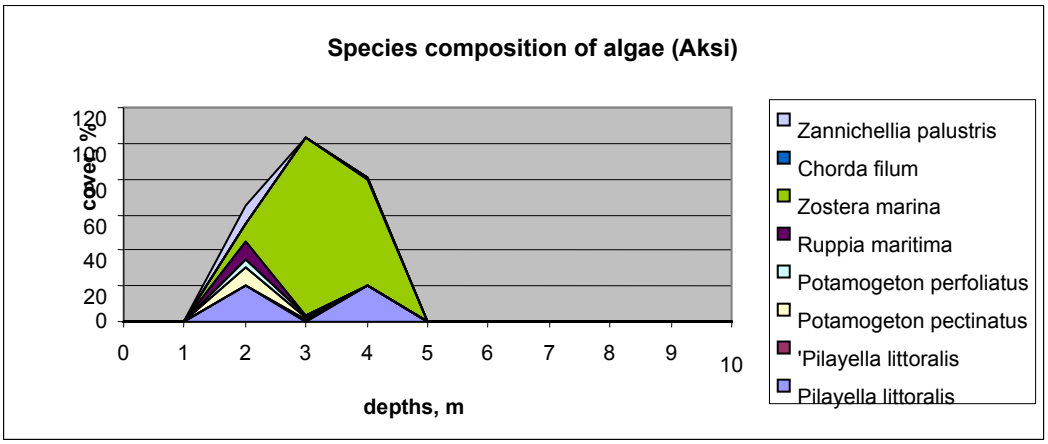
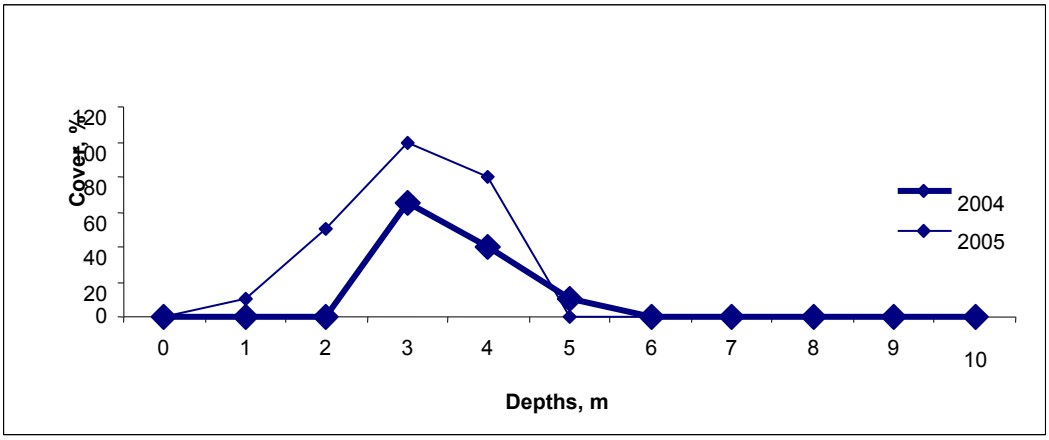


Figure 47. The dynamics of the general coverage of phytobenthos on Aksi transect in 2004-2005



Conclusions

1. Compared to the year 2004, in 2005 the species variability of bottom vegetation in Muuga and Ihasalu bays has increased or remained the same. At the same time, the species variability of bottom vegetation on transects is substantially less than that recorded at the end of the 1990s. On Muuga 1, Muuga 2 and Ihasalu Bay transects the abundance of ephemeral filamentous algae has essentially increased. In all likelihood, during the construction of the coal terminal the character of the substrate was remarkably altered. The reduced distribution of clay bottoms and increases water transparency accounts for massive occurrence of the communities of filamentous algae on transect.
2. The studies of year 2005 did not reveal the presence of bladder wrack on the transect in the western part of Muuga Bay, which was recorded there in 2004. On Ihasalu transect, the total coverage by bladder wrack and its depth distribution had reduced. The disappearance of the bladder wrack was probably caused by an extremely heavy storm in January 2005.
3. The bottom vegetation in the coastal sea of Aksi and Prangli islands was continuously dominated by sea grass. Although loose algae occurred in the coastal waters of the islands, it may be stated that human activities have exerted very little influence on these areas

MACROZOOBENTHIC COMMUNITIES

The condition of the macrozoobenthos communities inside the basin of the Port of Muuga is influenced by the extent and duration of the dredging activities in the area. Thus, the zoobenthos was not found during the time of dredging alongside the container quay in 2004. This was mainly due to the new sediment layer with thickness of about 20 cm in the named part of the Port. In next spring some amphipods such as *Corophium volutator* were already found. Already in summer 2005 the community of zoobenthos showed some signs of recovery. The colonies of the cirriped *Balanus improvisus* were attached to the quays and also the bivalve *Macoma balthica* colonized the upper layers of sediment. In October 2005 the communities of zoobenthos within the dredged area was almost fully recovered and did not differed from those in the adjacent parts of the Port basin. In autumn 2005 the maximum abundance of zoobenthos was estimated at 2961 specimens per m^2 and biomass at 134.6 g/m^2, respectively.

Beside hydrotechnical activities, the benthic communities are influenced by turbulent fluxes due to the working screws of vessels maneuvering inside the Port. The intensive movements of water make the bottom sediments very unstable. The finer particles of the sediments are lifted up and are suspended in the water column. Consequently, the concentration of organic matter increases in the water close to the sea bottom. It should be noted that inside the Port basin the accumulation processes are predominant and part of the sediments, suspended adjacent to the Port can be transported into the Port basin and be deposited there. Thus, the concentration of nutrients increases in the basin sediment.

The availability of relatively good but not regular dietary conditions is also expressed in zoobenthos communities inside the Port. In the grain basin and Marina in 2005 Oligochaeta,

Hediste diversicolor; *Balanus improvisus*, *Corophium volutator*; *Hydrobia ulvae*, *Macoma balthica*, *Mytilus edulis*, *Cerastoderma glaucum*, *Mya arenaria* were found. More rarely some *Chironomidae* larvae were found. The biodiversity of zoobenthos was much higher in the Port basins as compared to areas adjacent to the existing breakwaters. However, the abundance and biomass of zoobenthos were very variable within the Port basin being estimated at 250-3000 specimens per m^2 and biomass at 2-160 g/m^2, respectively.

Within the area adjacent to the Port basin the number of zoobenthic species is usually low. *Hediste diversicolor*, *Oligochaeta*, *Hydrobia ulvae*, *H. ventrosa* and *Potamopyrgus antipodarum* as well *Macoma balthica* and *Corophium volutator* are typical inhabitants of the area. In general small scale dredging activities in this area do not have clear impacts on zoobenthos except for the decreasing abundance of nectobenthic *Corophium volutator*.

As compared to 2003 the abundance and biomass of zoobenthos in areas adjacent to Muuga Port area (nearby quays) were substantially higher in 2004. Abundances increased from 400-825 to 3619-5076 specimens per m^2 and biomasses from 44-50 to 350-360 g/m^2, respectively. Further out to Muuga Bay the biomass of zoobenthos was only estimated at 10-100 g/m^2. This can be regarded as the artifact of dredging inside the Port basin causing the mass development of *Macoma balthica.* In 2005 the effect of the dredging almost disappeared and the abundance and biomass of zoobenthos in the area decreased down to 658-397 specimens per m^2 and biomass down to 53.3-153 g/m^2, respectively.

At the some distance from the quays with depths less than 20 m the wind induced currents are very active. As a consequence the bottom sediments of the area are lacking fine particles and are sorted. In the eastern part of Muuga Bay the bottom deposits are mainly rocky and clayier.

Due to the resuspension of the clayey particles the water transparency is poor. On the contrary, the Western Muuga Bay is mainly rocky but without resuspended sediments. Thus, the transparency of water is much better there.

In shallow-waters the dominant species of zoobenthos were *Hydrobia ventrosa, Hydrobia ulvae, Theodoxus fluviatilis, Potamopyrgus antipodarum, Balanus improvisus* and *Mytilus edulis*. In places with high deposition of partly decomposed organic matter also *Oligochaeta, Hediste diversicolor, Nematoda, Prostoma obscurum, Corophium volutator, Mya arenaria* and *Macoma balthica* were found with high abundances. In places with rich macro vegetation the following zoobenthic species prevailed *Gammarus salinus*, *Gammarus oceanicus*, *Idotea balthica*, *Jaera albifrons*, the larvae of *Diptera* and *Chironomidae* as well as *Cerastoderma glaucum*.

In the open part of Muuga Bay with depths more than 20 m the silted clay-sandy sediments dominated. The biodiversity of zoobenthos is lower than in more shallow sea. The typical species are *Macoma balthica, Halicryptus spinulosus*, *Monoporeia affinis* and Saduria entomon. Seldom *Hydrobia ulvae, Mytilus edulis, Oligochaeta and Potamopyrgus antipodarum* were found. The dominant species in deeper water are *Macoma balthica*.

Traditionally the impacts of the Port of Muuga on the local marine ecosystem have been assessed comparing the ecosystem of Muuga Bay to that of the neighboring Ihasalu Bay.

Conclusions of monitoring data

It can be conclude that up to the autumn 2005 the zoobenthic communities in Muuga Bay and surrounding shallow-water areas in Ihasalu Bay were not restored from the changes caused by the construction of the Coal Terminal. In the Eastern part of Muuga Bay the species composition was irreversibly changed. Instead of herbivores (that usually inhabits rocky and gravel bottoms) the nectobenthic deposit feeding species (inhabit sand bottom) are found there. Besides, the biodiversity has significantly reduced.

In the deeper sea below 30 m depths the biodiversity of zoobenthos is decreasing, and the share of opportunistic species *Macoma balthica* and *Mytilus edulis* biomass become higher (Figures 48 and 49).

Figure 48 The dynamics of total biomass (g dry weight/m^2) of zoobenthos by depths in Muuga Bay during 2003-2005

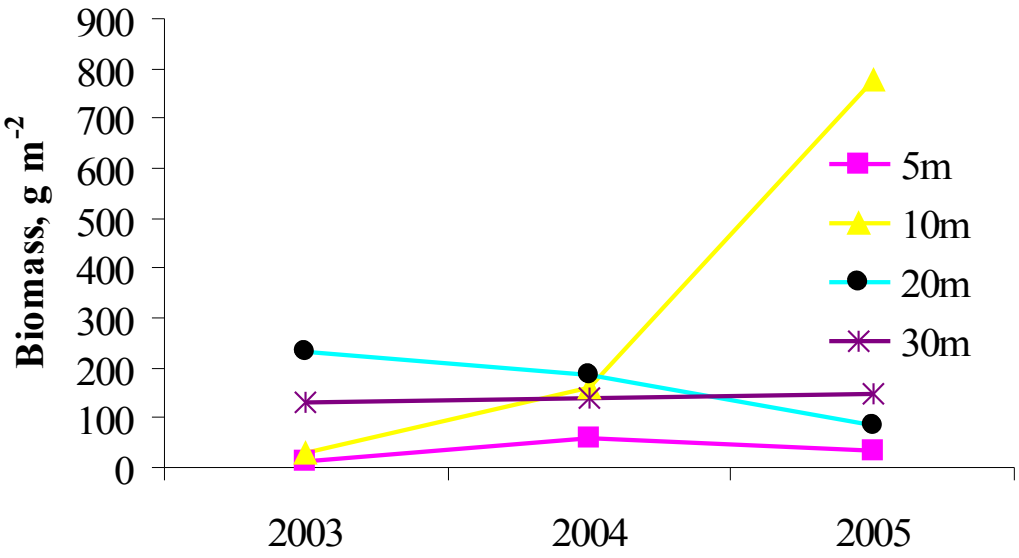
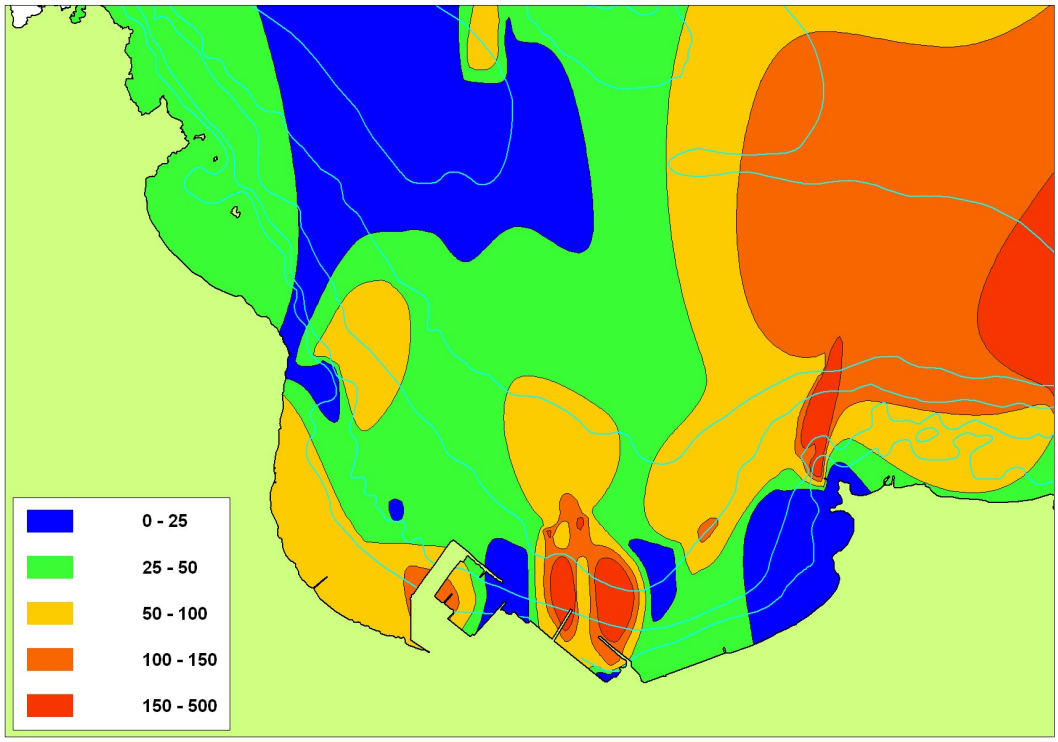


Figure 49 The distribution of total biomass (g dry weight/m^2) of zoobenthos in Muuga Bay in 2005



3.7. NOISE

3.7.1 BACKGROUND NOISE

The noise monitoring should be done during all the duration of the breakwaters construction due regard the cumulative effects of others Port activities included the Eastern Port extension works. When the equivalent level of cumulative noise will exceed the stated by the regulation no 42 of the Minister of Social Affairs of Estonia of 4 March 2002 noise norms: 60 dB(A) in the daytime and 55 dB(A) at night inside the dwelling land, the special measures should be taken and the relevant authorities must be informed. Those measures may include: the temporary layoff of works concurred with high level of noise (plugging, movement of heavy cars etc.) the coordination of breakwaters construction with others Port (construction) activities for regulation the cumulative noise level, the regulation of construction works (i.e. dredging and plugging) due regard the wind direction etc. Also, the building of special noise-barriers inside the dwelling areas may be needed.

3.7.2 NOISE STANDARDS

Estonian Ambient Air Protection Act (RT I 2004, 43, 298) establishes the requirement of noise map and action plan for reducing ambient noise levels.

<u>Normative values and noise limits for residential areas</u>

The normative values are specified in Act no. 42 of the Ministry of Social Affairs. The Act defines three types of levels:

- **Target level** is a sound level which generally does not cause annoyance and represents good acoustical conditions.
- **Limit value** is a sound level the exceeding of which may cause annoyance and which generally represents sufficient (acceptable) acoustical conditions.
- **Critical level** is a sound level which causes strong annoyance and represents unsatisfactory noise situation.

The noise level descriptor to be compared to all normative levels is the (rating) equivalent sound level L_{Req} during a specified reference time interval T. The rating means that the measured or calculated equivalent levels L_{Aeq} are adjusted, if applicable, based on the annoying quality of noise. Adjustments of +5 dB are specified for noises which are tonal or impulsive in character. Only one adjustment should be applied at a time.

Critical levels have been set for traffic and industrial noise.

The normative values are compared with rating levels during day and night periods and rating levels should not exceed normative values. The reference time intervals are:

- daytime 07–23 (including evening 19–23)
- night-time 23–07

Based on the classification in general planning, the area to be assessed belongs to category II: residential area. In this case the situation is an existing one, and the noise levels should be assessed considering the normative values for existing areas. The different normative values for environmental noise are given in table 13.

Table 13. Normative levels for environmental noise. The noise descriptor is the (rating) equivalent sound level L_{Req} *(dB)*.

	Daytime	night-time
Target levels		
Industrial noise	55	40
Traffic noise	60	50
Limit values		
Industrial noise	60	45
Traffic noise	60	55
—"— noisy facade[1]	65	60
Critical levels		
Industrial noise	65	55
Traffic noise	70	65

[1] allowed on the noisy side of a noise-sensitive building (facing road or railway)

The normative value requirements for industrial noise are stricter than the requirements for traffic noise.

The maximum noise levels L_{Amax} are assessed in relation to single noise events of traffic. The maximum noise levels should not exceed 85 dB during daytime and 75 dB during night-time. This requirement has been followed in this report.

3.8. AIR QUALITY

Construction activities of breakwaters in Muuga Port involuntarily do not caused any outside air contamination problems on the Port's territory or in its vicinities. However, during the process of building the breakwaters, some dust is emitted when building materials are loaded, stored and used on the construction sites. Exhaust gases of motor transport present another source of contamination.

It is not yet clear how the building materials will be transported. When land transport will be used, then dust will be emitted during several phases: putting the material into heaps, in days with strong wind and when removing the material from the heaps. Moving of loading equipment and trucks also causes dust emission. When marine transport will be used and materials will not be stored in land, then dust will emitted during loading the materials into the breakwaters frame and it may be substantial impact on local habitants and Port workers only with strong marine winds.

At loading the dry bulk building materials (as sand fill etc.), dust will emit into the atmosphere due to mechanical impact factors. In such cases the dust is classified as unorganized emission, because at the emission of dust the airflow's volume rate is not stable. The amount of dust emitted at loading of dry bulk materials depends on the material turnover, time of keeping it in the heaps, material's moisture content, and the share of fine particles in the material.

The distance of spreading of dust particles depends on the height at which they were emitted and particles' dimensions. Results of investigations indicate that at wind speed 16 km/h the particles over 100 µm in diameter deposit at a distance of 6–9 m, and those 30–100 µm in diameter 60–90 m away from the place of emission. According to published materials, at loading of sand the intensity of dust emission is 0.5 g/s and of gravel – 2.7 g/s. The measurements made during loading of dry bulk cargo in Estonian harbours, mining in quarries and storing show that actual emissions are always smaller than those presented above. (ILAG-HPC-ESP-TALLMAC. 2006).

The cumulative impacts on air quality of others Muuga Port activities should be taken account.

3.8.1. AIR QUALITY STANDARDS

The limit values of air pollutants are presented in Table 14 (according to the Regulation No 115 of the Minister of the Environment of 07.09.2004)

Table 14 The limit values in ambient air

Name	Code (Chemical Abstract Service Number)	The limit value of pollutant	
		One hour average SPV_1	24 hour average SPV_{24}
Solid particles,	-	500 µg/m^3	150 µg/m^3
Total	-	-	-
Inside Residential			

areas			
Solid particles: total	-	-	10 mg/m^{3*}
inhale dust	-	-	5 mg/m^{3*}
In Chemical factors (incl. fertilizer terminal)			

'* - during working day

3.8.2. AIR QUALITY MONITORING

It should be taken account, that in the eastern part of Muuga Port, both the coal terminal and the planned fertilizer terminal are the sources of cumulative dust emissions during the breakwaters construction. In order to operatively measure the ambient air pollution level (especially for dust concentration), it is necessary to establish a permanent, real-time monitoring station by the coal terminal. If the dust concentration target levels (Table 16) are exceeded, the operator must have an action plan to reduce the level of pollution.
In the Western Port there will be almost not any potential sources of dust emission and due regard that the dust emission from breakwaters building should be not marketable, the special air monitoring will not be needed.

3.9. NAVIGATION

The safety of navigation and operation of vessels within the Port aquatory is regulated by Port Rules. These include:

- All persons operating on the territory of the harbours of Port of Tallinn shall fulfill the International Convention for the Safety of Life at Sea (SOLAS convention), incl. International Ship and Port Facility Security Code (ISPS code) and Regulation (EC) No 725/2004 of the European Parliament and of the Council of 31 March 2004 on enhancing ship and port facility security and the requirements of port facility plans prepared based on the latter coordinated by the Maritime Board.
- Entering and leaving of vessels in the Port: when entering or leaving the port, pilotage is compulsory for all vessels with the exception of vessels sailing under the Estonian flag (GT of 300 and less), technical ships and dredging vessels of the port.
- Vessels traffic in the Port aquatory: in the port aquatory the vessel shall move at minimum speed at which it can maintain maneuverability with the steer. The operating regime of the vessel's propellers shall be such that it does not endanger the vessels lying at the quay.
- The loading and discharging of oil and oil products established in annex 1 to MARPOL (Marine Pollution) 73/78 to tankers shall take place at a berth built or modified for that purpose in accordance with requirements. If the loaded or discharged cargo, depending on its characteristics, remains floating (does not dissolve or evaporate completely), the person in charge of loading operations shall ensure quick deployment of suitable booms for the localization of pollution.
- Since 2001 the Muuga Port started to introduce a quality and environmental management system, which based on the international and standards contributing greatly to the

trustworthiness and transparency of the port Lloyd's Register Quality Assurance declared the Management System of Port of Muuga (as part of such system of Port of Tallinn) to be in compliance with the requirements of the international quality management standard ISO 9001:200 and the environmental management standard ISO 14001.

Problems needs to solved by construction of Breakwaters

Downtime

Vessels berthed at present at Berths 4, 7, 8, 11, 12 and 33 experienced downtime during rough weather conditions. The port rules regulated the following (wind) conditions for vessels vacating these berths:

3.3.2 In Muuga Harbour the moorage of vessels at berths no.7, 8, 9 and 10 is allowed in cases wind speed does not exceed 12 m/ s, at berths no.7 and 8 only in case of favorable weather forecast for the next 24 hours.

4.2 Special terms

4.2.1 Upon receiving a storm warning (wind speed of 25 m/s and over) the captain of the vessel or chief officer will arrive at the vessel. In such a case vessels will be plugged off the electricity system on shore. The warning is forwarded by the Harbour Master's office, which will set the order of vessels leaving the port.

4.2.3. The aquatory of Muuga Harbour and inner roads are not protected from northwest, north and northeast winds. If the speed of such winds exceeds 17 m/s, the standing of vessels, especially at berths no. 4, 7, 8 and 11 will due to high sea become dangerous for the vessel. If the height of waves exceeds 1.5 m, the use of tugboats will be restricted. Then the captain of the vessel together with the Harbour Master's office will decide the leaving of the vessel.

- Up to 12 m/s – All small vessels with a length below 100m;
- Up to 17 m/s – All ballasted vessels;
- Up to 25 m/s – All vessels even with cargo.

The main disturbance occurs due to winds from NW to NE. The number of days that vessels had to wait at anchorage locations, due to bad weather was (Royal Haskoning 2006a)

- 2002 – 125 days;
- 2003 – 77 days;
- 2004 – 45 days;
- 2005 – 28 days.

The new port development at the eastern side of Muuga Port has a number of port basins with vessels berthed in a NW – SE direction as well as with a number of NE – SW berths (Fig. 1.3). In particular the latter berths will be susceptible to considerable downtime due to incoming waves.

In the Preliminary Project Report of Royal Haskoning (9 June 2006) the reduction of downtime as a result of the construction of break water is calculated. It is concluded that the breakwaters will considerably increase the number of operational days.

The problems with using the tugs

The limiting significant wave height for effective tug operation is 1.5m. The implementation of breakwaters would allow extending the operational window for tug fastening inside the then protected Harbour area.

A limited number of instances lines between the tug boat and vessel ruptured due to excessive ship motions of the smaller vessels caused by high waves.

Maneuvering s inside Harbour Area

As stated above, in particular the smaller vessels experience difficulties while manoeuvring inside the harbour area during the more rough weather conditions. Therefore, the construction of the new breakwater should aim at reducing such wave impacts whilst manoeuvring in the port.

Icing of Quays

The existing NW – SE oriented berths (and to a lesser extend the berths inside the Western Basin) experience ice impacts in the winter time with northerly winds as the ice is then moved onto these berths. The new breakwaters should be aligned such that this ice impact is reduced.

Icing of Vessels

Due to over topping of icy waters on to the deck of vessels while manoeuvring in the harbour basin, vessels as well as tug boats may ice up, which may results in dangerous situations for the crew.

3.10. TRAFFIC

The percentage of motor transport in the goods turnover of the Muuga Port is relatively small (5-10 %; mainly container cargo transport) and it is not expected considerable increase of the percentage upon developing the eastern part of the harbour. Motor transport as a noise source is considerable mainly on the territory of the harbour and its connecting roads. There is a speed limit for trucks in the area of the terminals and on the connecting roads of the eastern part of the Port, which is why the noise caused by air resistance is not considerable. Additional speed limits shall be established, if necessary. The increase of noise in case of heavy-duty vehicles is noticeable at the speed over 60 km/h.

Traffic data of Muuga railway station was (ILAG-HPC-ESP-TALLMAC. 2006).

- The average number of trains composed is 16 per day (117 trains per week, 507 per month and 6092 per year). No data is available of the distribution of composing the trains over different weekdays. The composing of trains takes nominally place in the day and night during four time intervals: 09-12, 16-19, 21-24, and 04-07.
- The average speed of locomotives and trains in Muuga railway station is 15 – 25 km/h.
- The locomotives drive from the depot to the station and back an average of 60 times per day.
- Currently 3 trains arrive at and 3 trains depart from the coal terminal daily.
- The arrival of trains takes mainly place on the four tracks closest to the depot (tracks no. 1-4) and the departures take place from tracks 11-17.
- There are altogether 20 tracks in Muuga railway station; the nearest track is 70 m away from closest residential house.

It should be concluded that the traffic in Muuga Harbour is already intensive and altogether 28 new tracks are planned next to the existing tracks of the rail yard. The main purpose of the new tracks is the transport of goods to and from operator warehouses and ships. The traffic is estimated to increase up to 100% in the future after the entire infrastructure whole Muuga Port has been developed.

The construction of breakwaters will not be occurring with large amount of land traffic, because mainly the sea transport planned to use.

3.11. CULTURAL HERITAGE

Muuga Port breakwaters construction and the further exploitation are not expected to have a negative impact on the cultural heritage of the area. The valuable landscape nearest to the Muuga Port to East includes Kallavere traditional landscape, which is traditional village landscape next to the panel houses of the residential area of Maardu town. To the South and West the summer-houses (now partly used around the year) of Muuga and Muuga-Aedlinn are located at the marketable distances, also (Fig. 4 and 5). Breakwaters construction activity remains sufficiently far from the aforementioned area and will not influence this.

3.12. RECREATION

There are some small beaches to both, East and West direction from the Muuga Port (Fig. 4 and 5). But these are at safety far distance for ruining the sand with suspended during the breakwaters construction silty sediments.
The region of Port of Muuga is not the area of pleasure craft sailing.

3.13. EMPLOYMENT

During the construction works of Muuga Port Breakwaters up to 60 local people can have an additional source of employment for three years. It may have a significant support for example the habitants of Maardu city, where not all people have a job today.

3.14. LOCAL COMMUNITY

The Muuga Port located at the territory of three municipalities: Eastern Part – Jõelähtme rural municipality, Central part – Muuga city and Western part – Viimsi rural municipality.

According to the comprehensive plans of both, Viimsi and Jõelähtme rural municipalities, it is not recommended to reconstruct garden houses and summer-houses into residential buildings in the areas adjacent to the harbour and the railway. It is also not recommended to construct new residential buildings in the harbour area due to potential air pollution and high noise level.

Jõelähtme rural municipalities comprehensive plan take into consideration the locality of Muuga railway station, the railway and road of the harbour, which is accompanied by industrial and transport noise, noise from technological equipment; pollution of ambient air by fertilizers and coal dust and gaseous pollutants and potential pollution by oil products. The comprehensive plan requires the establishment, ensuring, planting with vegetation of a sanitary protection zone. So far an estimated sanitary protection zone of 100 m has been left for the Port. Background noise level shall be checked and noise and dust barriers shall be constructed.
The any increase in the noise level will not be considerable, as the main noise sources for the residential areas remain the same.

Viimsi rural municipality sees Muuga port and its industrial development as the weak point of its perspectives for development (comprehensive plan of Viimsi rural municipality), which means that the intensive development of the Port, including the transit transport has a certain negative impact on the environment and the health of the inhabitants.
City of Maardu development plan supporting of Port development and in relation to this development of transit and construction of the transit corridor connecting Muuga Port and Tallinn-Narva Road are considered important, plans also foresee the construction of a multi-layer traffic knot of Peterburi Road and Muuga Port.

3.15. SUMMER HOUSING

The location of nearest summer houses is given in Fig. 4 and 5. As it is written above the all municipalities are not planning the enlargement of the areas of summer-houses as well, as residential houses.
In EIA of Eastern Port extension there are recommended some specific mitigation measures for decreasing the negative impacts on the welfare of people lived in local summer-houses. The necessity of regular and comprehensive air pollution and noise level monitoring was pinpointed as of urgent necessary measure (ILAG-HPC-ESP-TALLMAC. 2006). The special air protection management plan was recommended to implemented in Port of Muuga. The several measures of preventation of air pollution and heavy noise within the summer-houses areas were also presented, including the construction of noise barriers when needed.
The construction of breakwaters itself will not be generated a marketable additional air pollution as well, as noise. As the most potential negative impact the noise occurs with stamping of piles should be pinpointed.
500 m is distance to nearest house. Legislation (65db during daytime; 60 db during night time). Main source is port and railway.
Dust and smell – smell is a high problem – from the oil terminals – dust from the coal terminal
What is the cumulative impact? Used very dusty coal which is transported by rail – technology and permissions to reduce dust from coal – coal from the Ukraine – operators of the coal terminal are unknown.
Very low cumulative impact. Temporary loading of dredged waste to land may cause problems / cumulative but this is not planned.

3.16. HYDRODYNAMICS AND SEDIMENTATION PROCESSES

3.16.1 CLIMATE

SEA LEVEL

The sea level in the Bay of Muuga is influenced by the sea level in the whole Baltic Sea. During storm surges, the local sea level can deviate significantly from the mean sea level in the Baltic.

The Baltic is a typical semi-enclosed sea that is connected to the ocean by narrow and shallow Danish Straits. Restricted water exchange through the straits significantly influences the hydrographic state and water mass dynamics of the Baltic. Sea level oscillations in the ocean are mainly caused by tides. In the Baltic the tidal component is small, ca 5-10 cm. Baltic sea level variability is caused mainly by local factors. Among them, the most important are wind speed, direction and duration, air pressure changes, river discharge and water exchange through the Danish Straits. All these factors have strong seasonal component. Therefore the sea level behavior is also cyclic, with higher sea level in September-October and December, and lower sea level in March-May and November. However, this seasonal cycle is well evident only in monthly mean sea levels whereas the amplitude of monthly mean sea level amounts to 20...40 cm. Instantaneous sea levels may be significantly different due to the variable local forcing factors. In the Muuga Bay, as in the major part of the Estonian coast (excluding small nearly closed bays and river mouths) the amplitude of instantaneous sea levels amounts to ca 2.5 m as determined by the difference between the highest and lowest values (in the Muuga Bay +152 and –90 cm relative to the mean sea level).

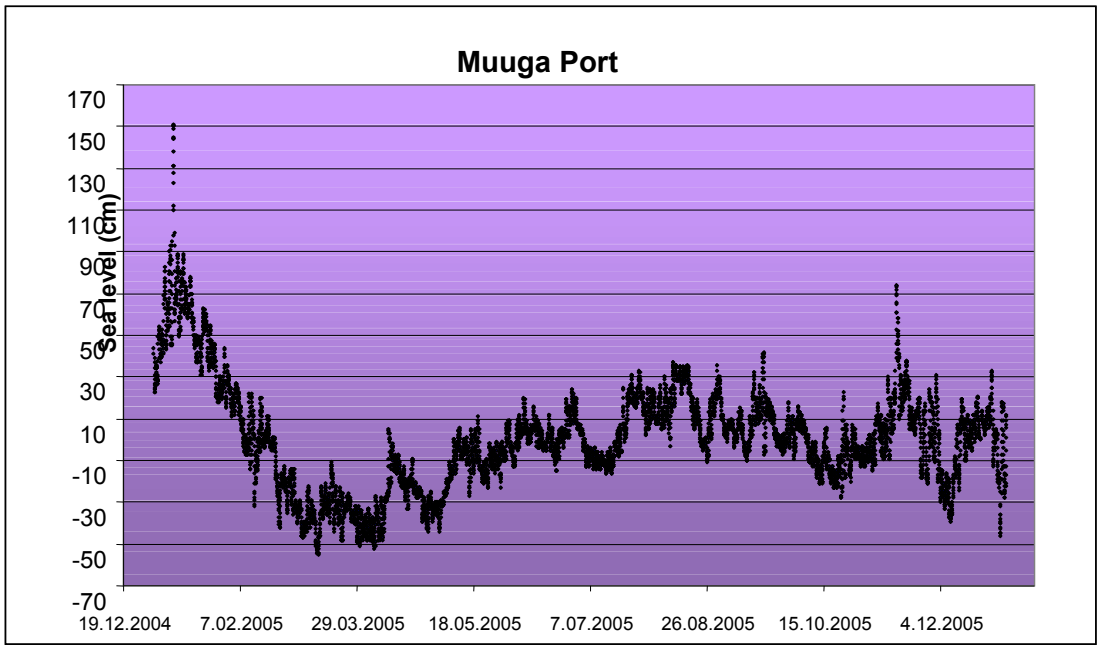
Wind forcing, as one of the most important for the sea level, is non-periodic (but cyclic, time scale 3…7 days) and related to the passage of atmospheric cyclones/anticyclones over the Baltic Sea area. This activity is also related to the air pressure difference over the sea area. Long waves forced by the moving weather patterns are generally of the amplitude 0.5...1.5 m. Long waves may interact with sloping bottom and coastline configuration, resulting in anomalously high and low water levels. Muuga Bay is wide open to the Gulf of Finland and significant local sea level effects do not occur.

Amplitudes of daily sea level oscillations (it is also interfered by the about 27 hour seiche period) are higher in the autumn and spring and lower during the summer. In winter the sea level oscillations are damped by the ice cover, isolating the water column from direct wind forcing.

Regarding the shipping, significant sea level effect belongs to the storm surges occurring on top of the seasonal course. In the northern Estonian coast the seasonal cycle is a bit shifted compared to the overall Baltic description given above. There are two sea level maximal (August-September and December) and two minimal (March-April and October). The fastest sea level changes take place in autumn and winter, while during the spring and summer the sea level changes are less intensive.

Figure 50 depicts the yearly sea level course in the Muuga harbor during 2005. It includes also the highest (since 1805) sea level observed in the morning of 9 January +152 cm.

Figure 50 Sea level variability in the Muuga harbor during 2005



N.B. On the 9th of January 2005, long-term maximal sea level +152 cm was observed.

SEA WATER TEMPERATURE

Yearly mean water temperature of the Muuga Bay surface layers is 7.1…7.4°C, being influenced mainly by the changes of air temperature. In the shallow coastal sea the actual water temperature is highly variable and depends besides the water depth also on the wind speed and direction. The highest monthly mean water temperatures (15,6...16,7°C) occur in July and August. During the calm and sunny weather, a thin surface layer may be heated up to 25°C. If this layer mixes up with the colder layers below, the surface temperature may easily drop by 5…10°C without the weather conditions significantly changed. Figure 50 depicts the yearly surface temperature variability measured at 2-m depth of the quay 10A. In July-August the maximal water temperature was above 20ºC, but can also rapidly drop down to 2ºC. These temperature drops are caused by the upwelling events (see the satellite maps of the Gulf of Finland, Figure 51), when seaward drifted surface waters are replaced by the colder waters lying below the surface waters. Upwelling s have important effect for the nutrient dynamics and water quality, since the upwelled colder waters are rich in nutrients. During the winter the surface temperature is mainly below 4°C. The lowest monthly mean temperatures 0.1...-0.1°C occur in February-March. Just below the ice cover the water temperature may be -0.4…-0.6°C depending on the salinity. In general, the coastal sea water temperature is higher during the summer and lower during the winter, as compared to the open sea water temperature. In the deeper layers the water temperature decreases with depth and the minimum value, below 3°C is observed around 60-m depth. Further below, the temperature slightly increases by depth (due to the lateral advection of more saline and warm waters). In the deep bottom layers the temperature is 4...5°C.

Figure 51 Water temperature variability in the Muuga harbor during 2005 registered at 2-m depth of the quay 10A.

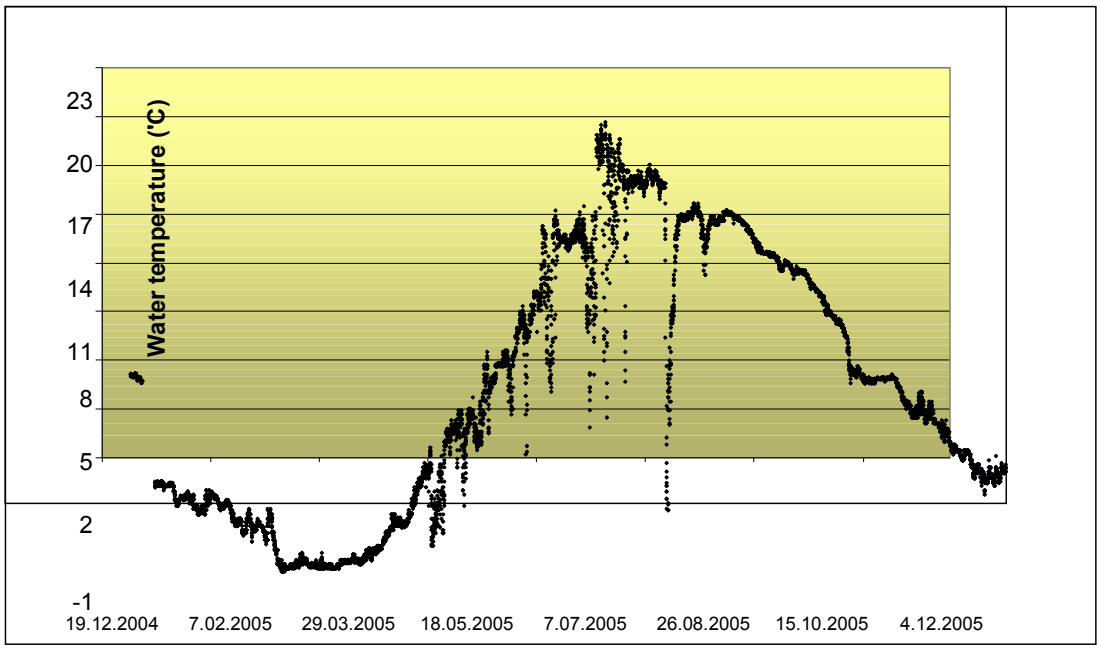
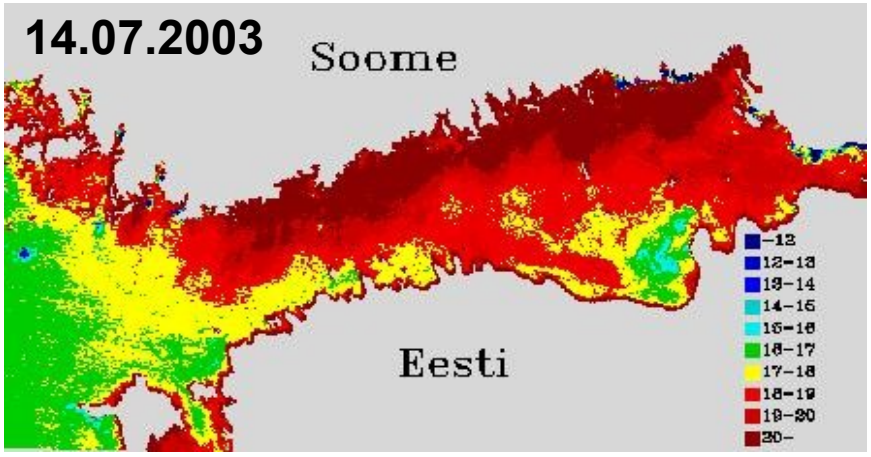
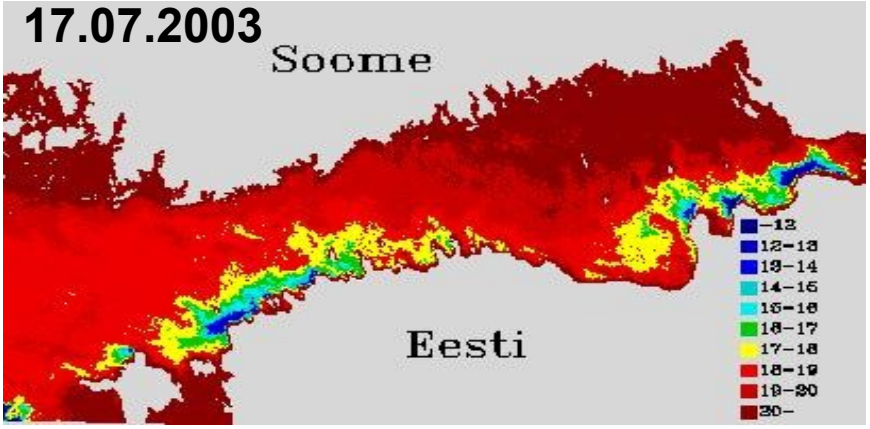
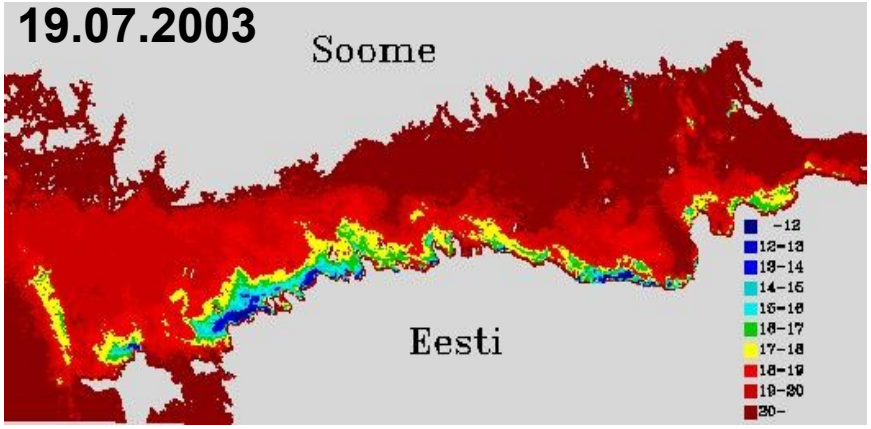


Figure 52 Sea surface temperature patterns in the Gulf of Finland observed by satellite







Low temperatures along the Estonian coast is resulting from the upwelling, taking place after easterly winds (Jaan Laanemets, personal communication).

SEA WATER SALINITY

Salinity is distributed in the Muuga Bay quite uniformly since the bay is wide open to the Gulf of Finland and the water exchange is intensive. Surface salinity is in a range 6...7 psu (‰) depending on the variable salinity conditions of the Gulf of Finland. In the yearly cycle, surface salinity is somewhat higher from November to January, due to the more intensive water exchange processes and reduced river discharge. Salinity increases by depth due to the inflow of more saline and dense waters from the Baltic Proper.

ICE CONDITIONS

Regular ice observations have been conducted on the Estonian coast more than 100 years. Including the log notes of the harbors, the time series are nearly 500 years long.

Based on the Baltic Sea salinity, the freezing point of sea water is about –0.4°C. In the open sea it is lower and near the coasts and river mouths somewhat higher. During the autumn cooling the ice is formed first in the coastal area and then it spreads further towards the open sea. In some cases the strongly cooled water masses sink to the bottom and form the bottom ice. The bottom ice binds sediments, transporting them together with moving ice. Although severe winters have become less frequent in recent decades, it is important to consider severe winters as well. In normal winters the ice condition along the Estonian coast is milder than along the Finnish coast or the eastern part of the Gulf of Finland. The reason for that is the general circulation scheme of the Gulf of Finland, transporting warmer and saltier open sea water masses along the Estonian coast.

By the long-term statistics the ice is formed in the Muuga Bay at the end of January (Table 14). Melting and ice run takes place on the average by the first half of April (Table 15). Average number of ice days (from the first appearance to the final melting) is 55-70 days (Jevrejeva et al., 2002). It is smaller in the open deeper part of the bay. Towards the east, the number of ice days gradually increases and in the Kunda Bay the number is already 100 days. The harbors to the west from the Muuga Bay, for example the Paldiski harbors are practically ice-free and icing takes place only in exceptional severe winters.

Table 14 Long-term mean temporal characteristics of formation of ice cover in the Muuga Bay

	Air temperature persistently below 0ºC	Water temperature persistently below 0ºC	First ice appearance	Formation of persistent ice cover	Formation of persistent fast ice	First full freezing
MEAN	26 Nov	-	7 Jan	18 Jan	26 Jan	6 Feb
MIN	29 Oct	7 Jan	12 Nov	31 Dec	18 Jan	1 Jan
MAX	15 Jan	15 Feb	21 Feb	11 Mar	24 Feb	20 Mar

Table 15 Long-term mean temporal characteristics of melting of ice cover in the Muuga Bay.

	Air temperature persistently above 0ºC	Formation of snow water on the ice	First decay of fast ice	Decay of fast ice	First ice run	Final ice run	Number of ice days
MEAN	24 Mar	13 Mar	2 Mar	28 Mar	19 Jan	10 Apr	69
MIN	12 Jan	27 Feb	3 Jan	31 Jan	7 Dec	1 Feb	0
MAX	18 Apr	21 Apr	24 Apr	24 Apr	30 Mar	6 May	128

In estimating the long-term ice cover changes in the Muuga Bay we have to consider that during the last 100-150 years the yearly mean air temperature in Estonia has increased by about 1°C (Balling et al., 1998; Jaagus, 1996). Within that, warming of the cold season is more pronounced. Therefore the long term ice regime characteristics are biased relative to the last 10-15 years with climate warming, since there has been exceptionally large number of mild winters: 1988/89, 1991/92, 1992/93, 1996/97, 1999/2000, 2001/02 (Table 16). Severity of the Baltic winters has been estimated by the maximum ice coverage during 1720-1992 (Seina and Palusuo, 1993): very mild (*VM*: Baltic ice coverage 52-81 thousand km²), mild (*M:* 81-139 thousand km²), moderate (*T*: 139-279 thousand km²), severe (*S*: 279-383 thousand km²) and very severe (*VS*: 383-420 thousand km²). At that the Baltic Sea area is 424 thousand km² and the mean ice coverage is 218 thousand km². By the ice statistics from 1720-1992, very mild and very severe winters both occupied 11%, mild and severe winters took both 22% and moderate winters occupied 33%. During the last 12 years (Table 16) the winters were only "very mild", "mild" and "moderate". The recent most severe winter 2002/2003 can be classified as moderate since the maximum Baltic ice coverage amounted in the beginning of March to 200 000 km^2. For the comparison, in severe winter the ice coverage exceeds 300 000 km^2 (even over 400 000 km^2) and in mild winter it remains below 100 000 km^2 (Figure 53).

Table 16 Baltic Sea ice coverage (thousand km²) during 1991-2003 and ice appearance in the Muuga Bay.

Winter	Max. ice area thousand. km²	Severity	Ice appearance in the Muuga Bay
2002/03	~200	moderate (T)	+
2001/02	102	mild (M)	-
2000/01	128	mild (M)	+
1999/00	95	mild (M)	-
1998/99	157	moderate (T)	+
1997/98	129	mild (M)	-
1996/97	128	mild (M)	+
1995/96	262	moderate (T)	+
1994/95	68	very mild (VM)	-
1993/94	206	moderate (T)	+
1992/93	70	very mild (VM)	-
1991/92	66	very mild (VM)	-

Source: Finnish Institute of Marine Research, DATE

Figure 53 Probability of fast ice in the Muuga Bay

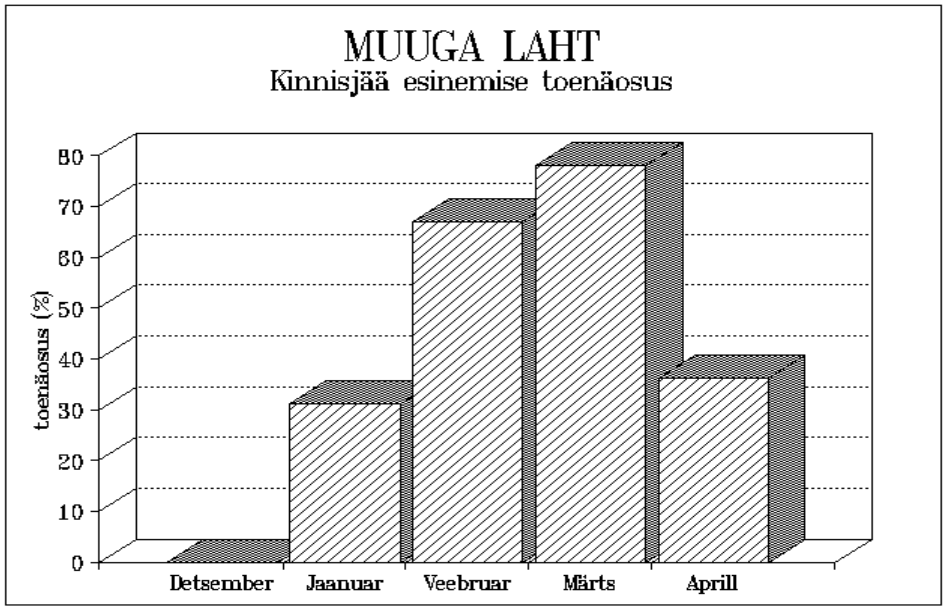
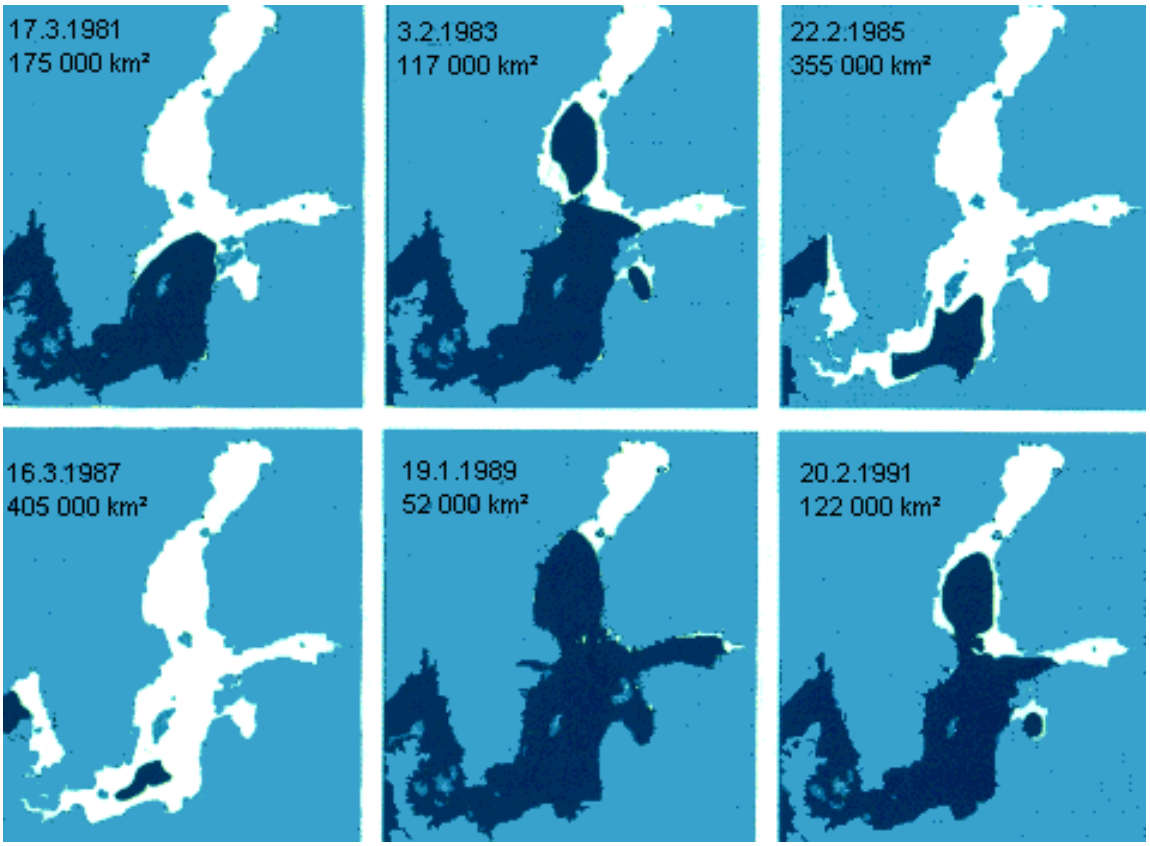


Figure 54. Extent and area of Baltic ice cover in recent winters of different severity



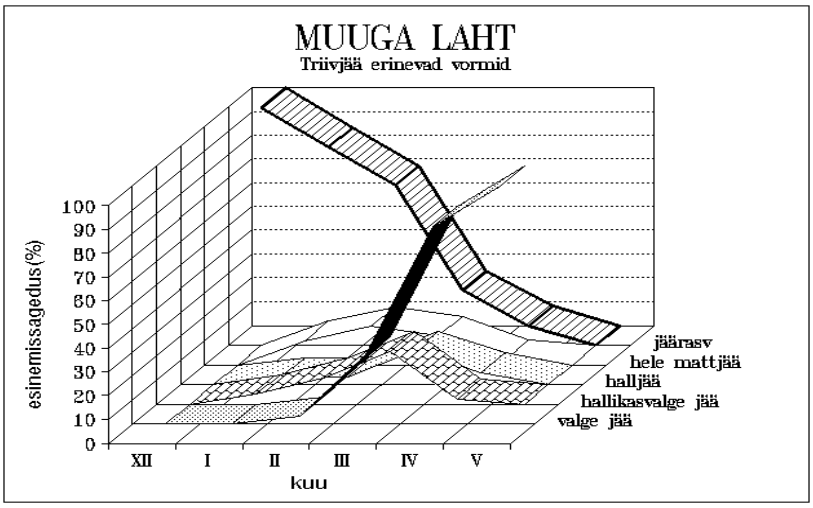
As can be observed in Figure xx, moderate (normal) winters occurred in 1980/81, 1982/83 and 1990/91; mild winter in 1988/89; and, severe winters in 1984/85 and 1986/87. The latter was the most severe winter during the 20th Century (Finnish Institute of Marine Research, DATE).

In the Muuga Bay the formation of ice cover starts normally at lowered air temperatures when in a few hundred meters wide coastal strip about 10 cm thick coastal ice is attached to the coastline. It also happens, that ice formed in the other regions of the Gulf of Finland drifts into the bay. In the latter case the bay may be filled by the drifting ice in a few hours. Permanent ice cover appears in the Muuga Bay when the ice edge of the Gulf of Finland approaches its entrance area with the Baltic Proper. Variability of ice conditions on the northern Estonian coast is significant, depending on the severity of winter. Probability of ice appearance in the Muuga Bay is 1 January 10%, 1 February 75%, 1 March 90%, 1 April 55% and 1 May 10% (Figure 43). Typical ice thickness in the Muuga Bay is 25-40 cm, in exceptional winters up to 50-60 cm. At that thinner ice is more dynamic, drifting easily from one sea area to another and forming ridges obstructing navigation.

Ice run starts in the Muuga Bay usually in the middle of April, when the open sea ice edge is destroyed by some stronger wind event. When ice has decayed in the open areas of the bay, then the whole bay is free of ice in about 10 days. At that some of the coastal ice drifts towards the open sea and melts there. Since during the winter S, W and especially SW winds dominate, the drifting ice is usually concentrated on the Finnish shore. By changing the wind direction, the Muuga Bay may be filled again by drifting ice in a few hours.

During mild and moderate winters the Muuga Bay is covered by different forms of drifting ice (Figure 55). At severe winters fast, immobile ice dominates. At certain wind scenarios ice ridging may take place just the vicinity of Muuga Harbor and its installations, including the planned location of breakwater (Photos 2-3). Ice cover in the Muuga Bay and nearby open sea area is often quite uniform (Figure 56), but polynyas are formed in the wake of Äksi island and Viimsi peninsula. These polynyas favor ice ridging at changing wind conditions. The wind scenarios favoring ice ridging in the port area are variable easterly and westerly winds, also NW and NE winds that carry drifting ice into the bay. Detailed ice loads on the harbor constructions (including the breakwaters) can be determined by means of physical and numerical modeling. The input information required is shape, orientation and design characteristics of the breakwater.

Figure 55 Probabilities of different forms of drifting ice in the Muuga Bay.



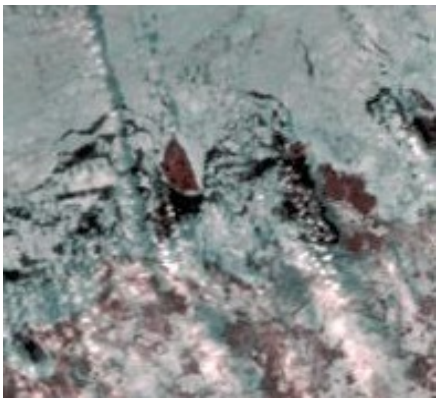
Definition: jäärasv – grease ice; hele mattjää – white mat ice; halljää – grey ice; hallikasvalge jää – grayish-white ice; and, valge jää – white ice.

Photo 1 **Dense drifting ice has covered the Muuga Port area, March 2004 (by T.Kõuts).**

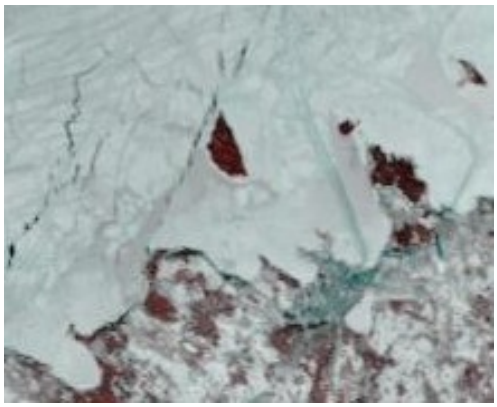
Photo 2 During moderate winter medium-size cargo ships need assistance by tug, March 2004 (by T.Kõuts).

Photo 3 **Ice affects significantly the harbor structures by stress forces appearing in the drifting ice, but also by icing the structures and the attached weight loads, March 2004 (by T.Kõuts).**

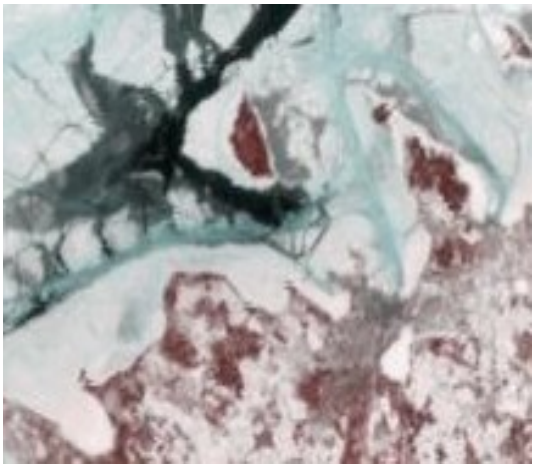
Figure 56. Satellite images of ice cover in Tallinn and Muuga Bays during the severest recent winter 2002/2003



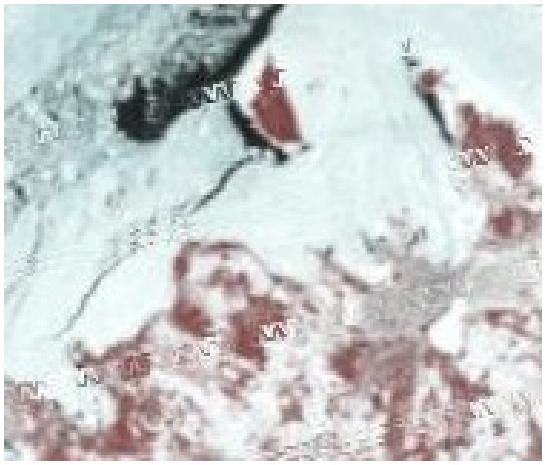
31. December 2002



6 January 2003



5 March 2003



7 April 2003

Table 18 Ice thickness in the Muuga Bay observed in 1964-80

	DECADE	MEAN	MAX	MIN
DECEMBER	I	-	10	9
	II	-	10	10
	III	-	4	1
JANUARY	I	-	9	6
	II	-	27	9
	III	-	45	1
FEBRUARY	I	-	61	3
	II	37	70	16
	III	36	71	10
MARCH	I	35	73	11
	II	35	52	3
	III	35	52	16
APRIL	I	-	50	12
	II	-	32	18
	III	-	-	-

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SECTION 4 METHODS OF MODELLING

4.1. IMPACTS ON THE NATURE OF THE LOCAL HYDRODYNAMICS

Introduction
Different hydrodynamics are compared, the product of a 100 year storm which struck the two areas bordering the Bay of Muuga.

Shoreline of the Muuga: A Recreational Area
This area is situated near the Port of Muuga Coal terminal at the Saviranna shoreline.

The MIKE 21 NSW was used to propagate the waves across the Muuga Bay. The aim of the modelling of the 100 year storm is to gain insight into the extreme conditions that will result

in extreme wave heights and closely related current and sediment transport loads along the coastline.

Another situation with wind speed 15 m/s was calculated to reflect the limiting wind speed for construction works during dredging and reclamation. Two different wind directions were investigated which are most important for the Port of Muuga, namely winds blowing at 300 degrees and 3300 degrees. The results are presented in the Figures provided in this document. The isocline's shown on the graphs depict a significant wave height and vectors wave directions around Prangli and Aksi Islands, in the Bay of Muuga and near the Ihasalu Peninsula.

The offshore wind and wave data was taken from British Met Office (BMO). The data was compared with the data obtained from the "Lenmornii" project. It was found that there is a good correlation between the two sets of data. The offshore wind and wave data for the scenario of a storm once every 100 years is summarized in the Table below.

Table Data for Scenario of a Storm in the Bay of Muuga once every 100 years

No	Wind direction	Wind velocity [m/s]	Significant wave height [m]	Wave period [s]
1	300	21,0	4,0	7,2
2	3300	24,0	4,8	7,9

Various modules of MIKE 21 were used for numerical analyses of waves, currents and suspended sediment during the construction phases of the project.

4.1.1 NUMERICAL CALCULATION RESULTS

Storm once every 100 years

The graphical representation of the results obtained from the various numerical calculations of the two environmentally sensitive areas around Prangli and Aksi Islands, are illustrated in Figures 57 to 58. Three different points were determined in order to characterize the influence of the hydrodynamic conditions that can arise from the different breakwater layouts presented, and to compare these with the current situation at each part of the shoreline.

Tables 19 and 20 highlight the results obtained according to breakwater layout. Points RP1, Rp2, and RP3 are located close to the shoreline at Muuga recreational area, whereas points RP4, RP5 and RP6 are close to the shoreline near Saviranna.

The results obtained from the calculations made and which correspond to the various alternative breakwater layouts, are as follows:

- 0A representing the current situation without breakwaters; and,
- Breakwater Alternative1A, what is used as an example.

The results presented in Table 19 correspond to those of storms of *fewer than* 30 degrees which occur once every 100 years in the Bay of Muuga. Table 6 represents calculations results when storm act less than 330 degrees. The corresponding graphical representation of the calculations made, are illustrated in Figures 59 to 63.

Results

The numbers presented in Tables 19 and 20 show a significant wave height (H_{mo}) in meters at given points. The analysis of the wave modelling results highlights that the current situation of no breakwaters or the introduction of the proposed breakwater layouts, will not significantly alter the wave height H_{mo} at the given points for which the calculations have been done.

Conclusion

It is concluded that in light of the probability of a storm occurring once every 100 years acts in Bay of Muuga, the alternative breakwater lay-outs will not impact on the environmentally sensitive areas that the Port of Muuga. Hence, it can be concluded that the breakwaters will not alter the current environment around the Prangli and Aksi islands.

Table 19 Winds Blowing at 30 Degrees

Alternative	0- Alternative	I -Alternative	Layout 006-1B	Layout 007-2A	Layout 009-4A
RP1	0.489714	0.489729	0.489709	0.4897	0.489701
RP2	0.35665	0.356652	0.356644	0.356633	0.356634
RP3	0.362683	0.362658	0.362679	0.362671	0.362674
RP4	0.286383	0.284923	0.284803	0.284701	0.285084
RP5	0.297565	0.296321	0.296309	0.296156	0.296319
RP6	0.322423	0.321793	0.321781	0.321753	0.321794

Table 20 Winds Blowing at 330 Degrees

Alternative	0- Alternative	I -Alternative	Layout 006-1B	Layout 007-2A	Layout 009-4A
RP1	1.009492	1.009494	1.00952	1.009493	1.009497
RP2	0.981476	0.981477	0.981497	0.981478	0.981479
RP3	0.996797	0.9968	0.996822	0.9968	0.9968
RP4	0.883391	0.883486	0.883056	0.883456	0.883398
RP5	0.803543	0.803543	0.803543	0.803544	0.803543
RP6	0.488608	0.488606	0.48857	0.48857	0.488607

Figure 57 Alternative 0, 30 degrees of a Storm in the Bay of Muuga every 100 years

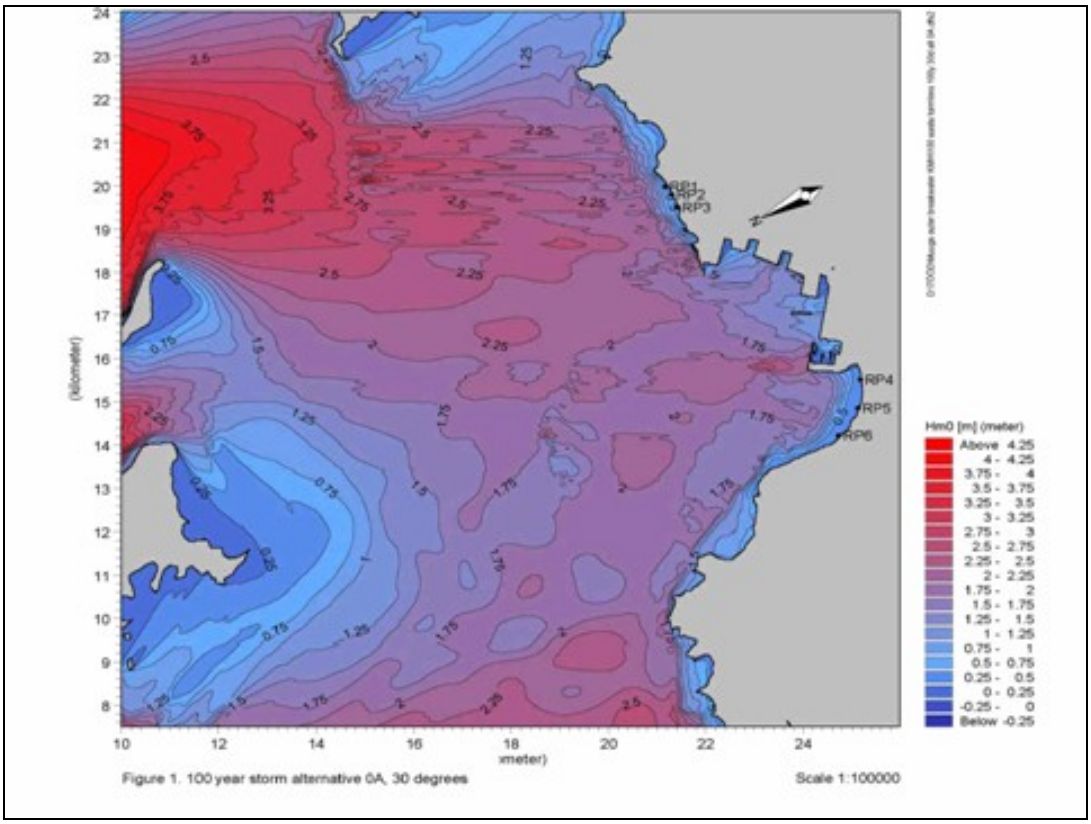


Figure 58 100 year storm alternative 1A, 30 degrees

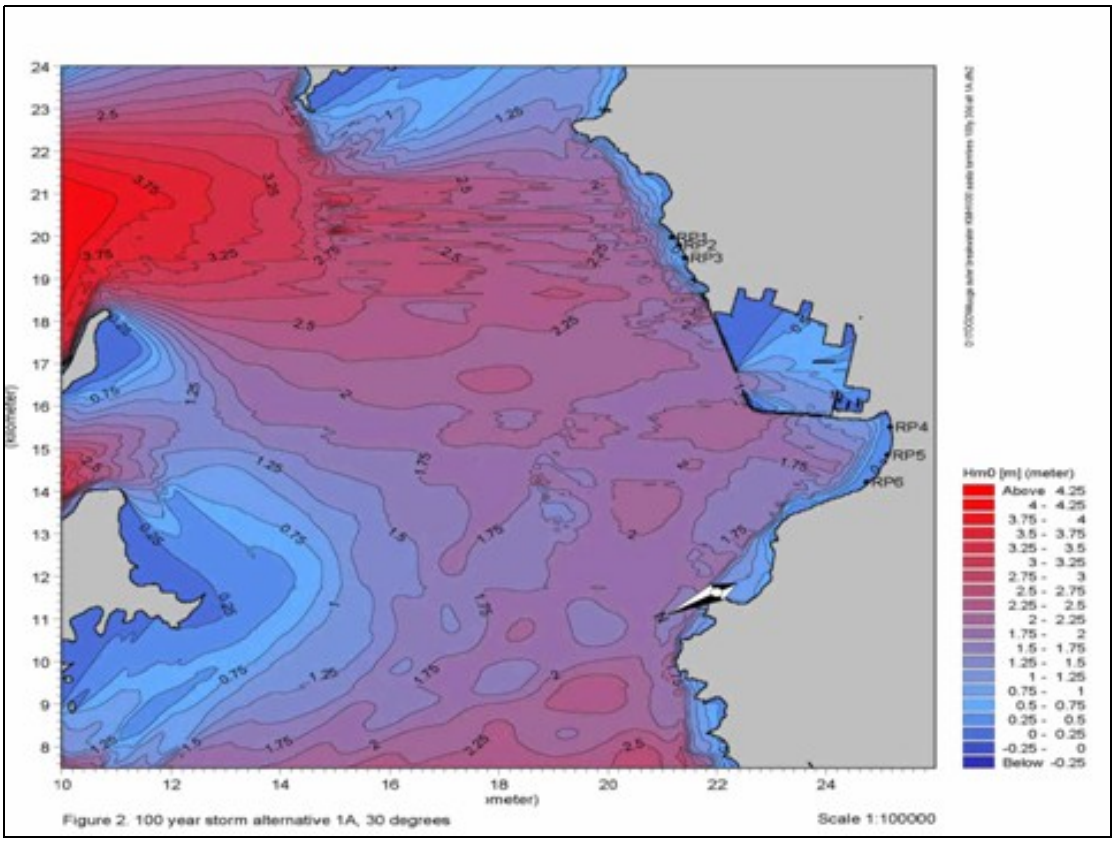


Figure 59 Alternative 0A, 330 degrees of a storm in Muuga Bay every 100 years

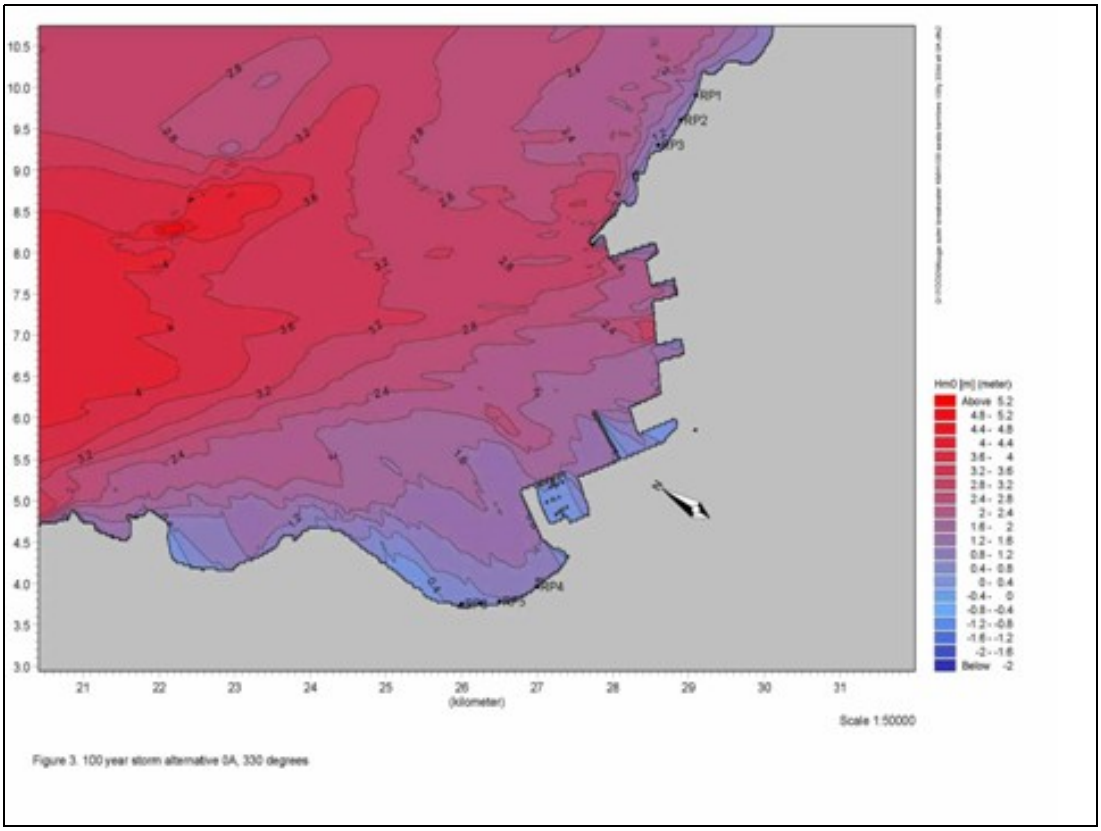
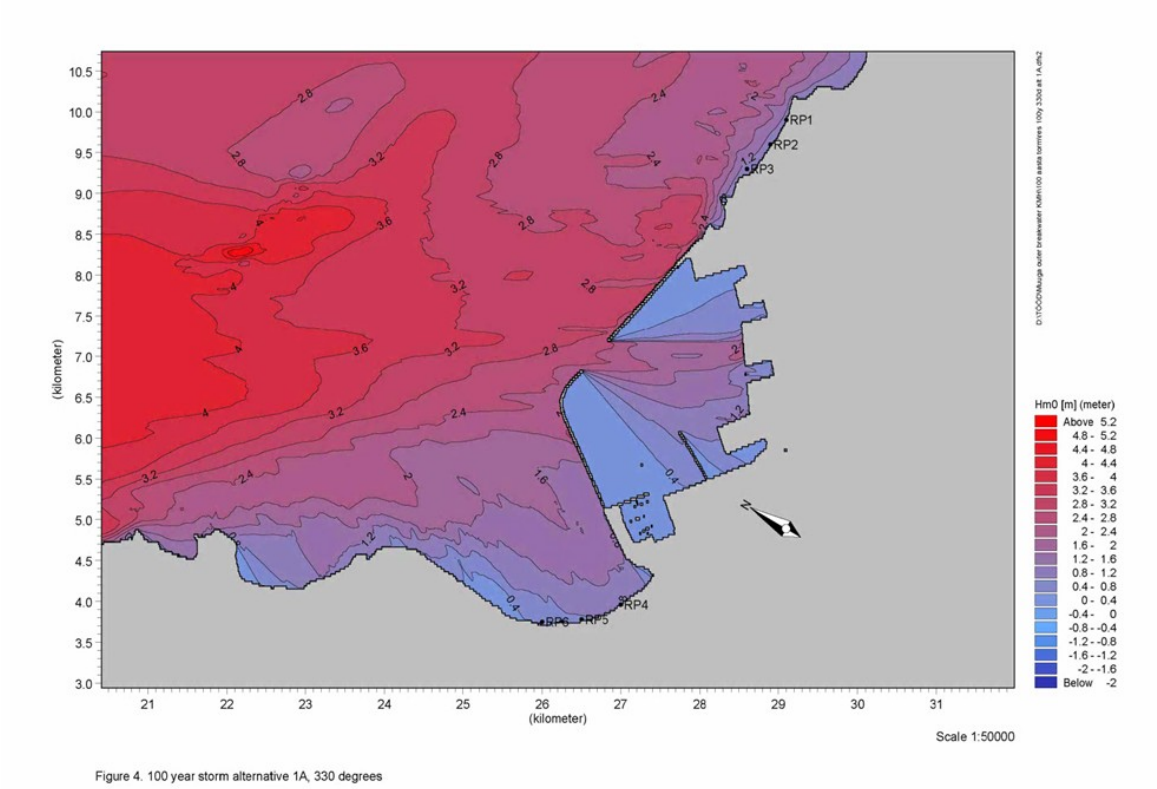


Figure 60 Alternative 1A, 330 degrees of a storm in Bay of Muuga every 100 years



Wind Speed at 15 m/s

Wave fields were calculated using MIKE 21 NSW. The MIKE 21 HD model was used for current field calculation near the two environmentally sensitive areas. These areas are:

- At the shoreline of the Muuga recreational area; and,
- Near the Port of Muuga Coal terminal at the Saviranna shoreline,

The flow of water around the breakwater alternatives and area of Port basin having different breakwater alternatives were calculated. The results obtained are illustrated in Figures 61 to 67. The vector field shows that the value of the current speed in meters per second (m/s) and that the direction of the current at a given point in the area. All figures are supplied with the scale of the calculated items.

Two lines are separated near the environmentally sensitive areas to compare the calculation results and determine the influence of alternative breakwaters.

Wind Speed at 30 degrees

Data is presented in Figure 61 which corresponds to the Alternative 0; notably, the existing situation. In this scenario, the wave trains run *under* 300 degrees along the Saviranna coastline and around the coal terminal, with a current that has a speed reaching up to 0.4 m/s and which turns into the Port basin. This current causes circulations in the whole area which under the project design will be surrounded with breakwaters.

The current fields are presented in Figures 62 to 66. These currents correspond to the breakwater layouts 1A, 1B, 2A and 4A, respectively. They indicate that the velocities are small, even following the introduction of breakwaters in the Port. The breakwater alternatives will not allow the wind speed to exceed 0.25 m/s.

Figures 67 and 68 illustrate the current speed along Lines 1 and 2. These Figures illustrate the situation of no breakwaters and the introduction of four alternative breakwater layouts. It can be observed that the introduction of the breakwaters will not change the speed of current currently present in the Bay of Muuga, without breakwaters. Hence, the introduction of breakwaters will not significantly change the current situation.

Figure 61 Alternative 0A - currents and flow directions at wind 30 degrees 15 m/s

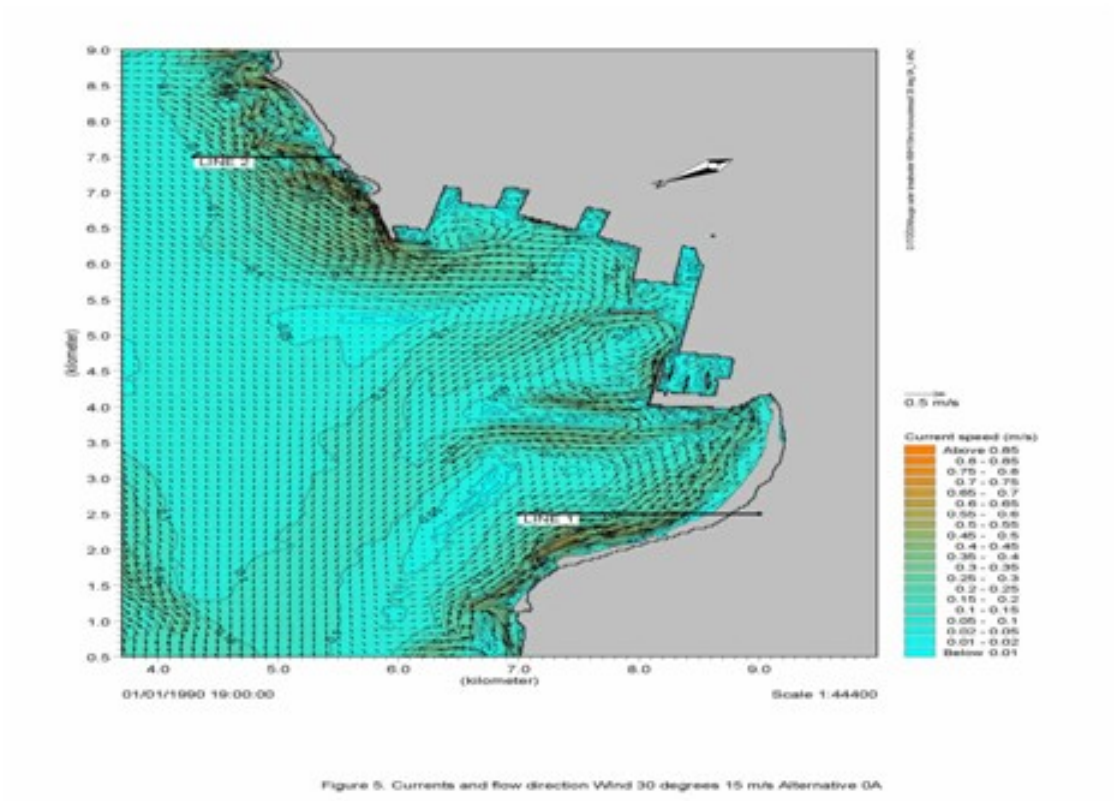


Figure 62 Alternative 1A - currents and flow directions at wind 30 degrees 15 m/s

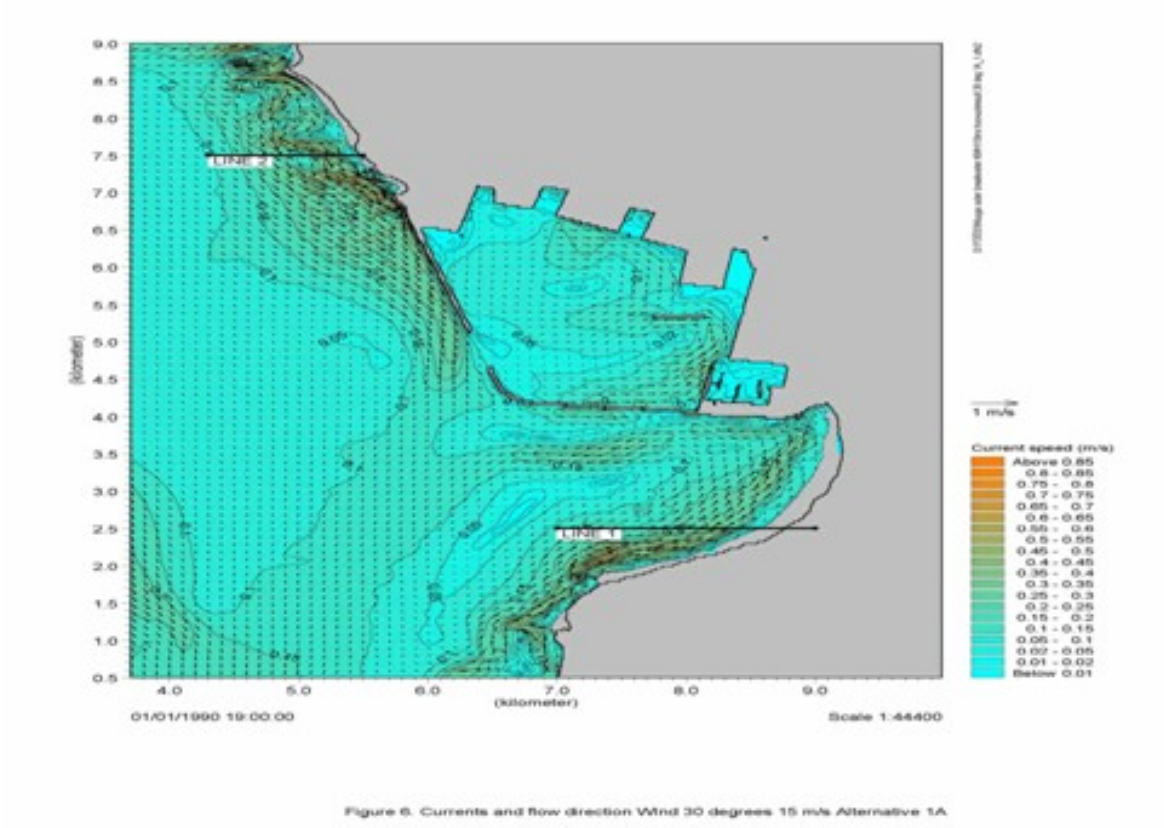


Figure 63 Alternative 1B - currents and flow directions at wind 30 degrees 15 m/s

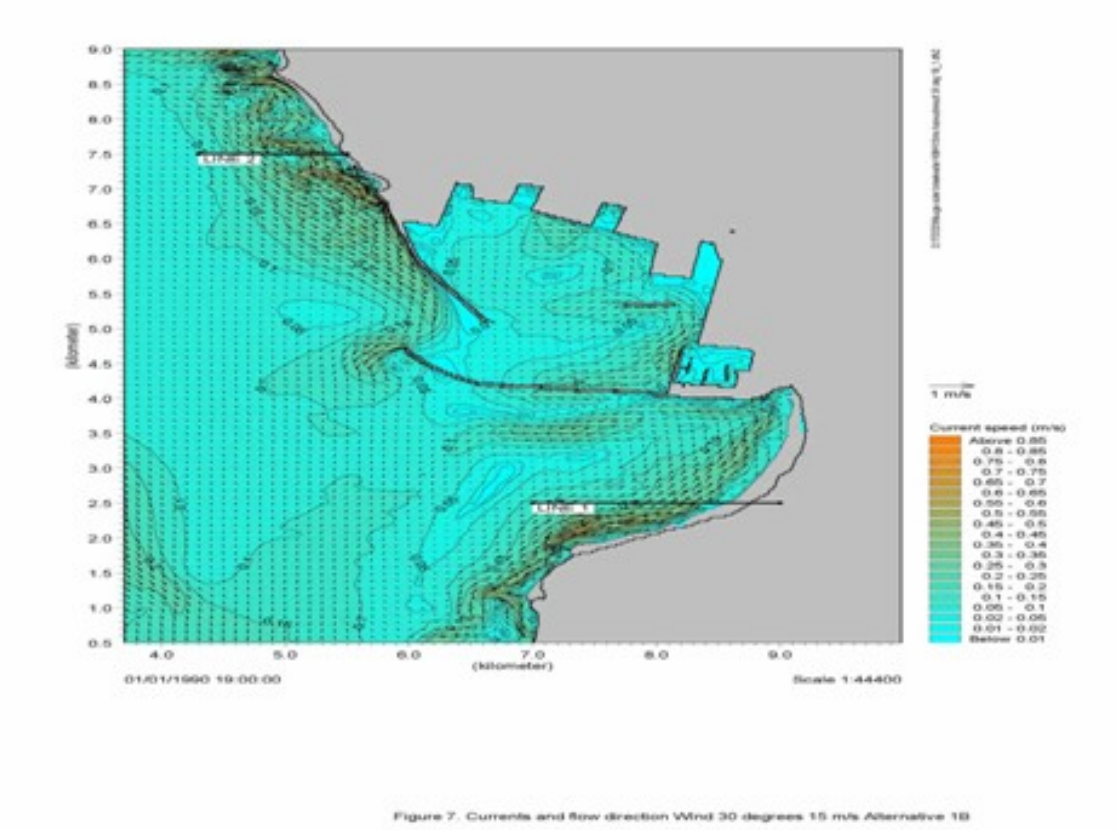


Figure 64 Alternative 2A - currents and flow directions at wind 30 degrees 15 m/s

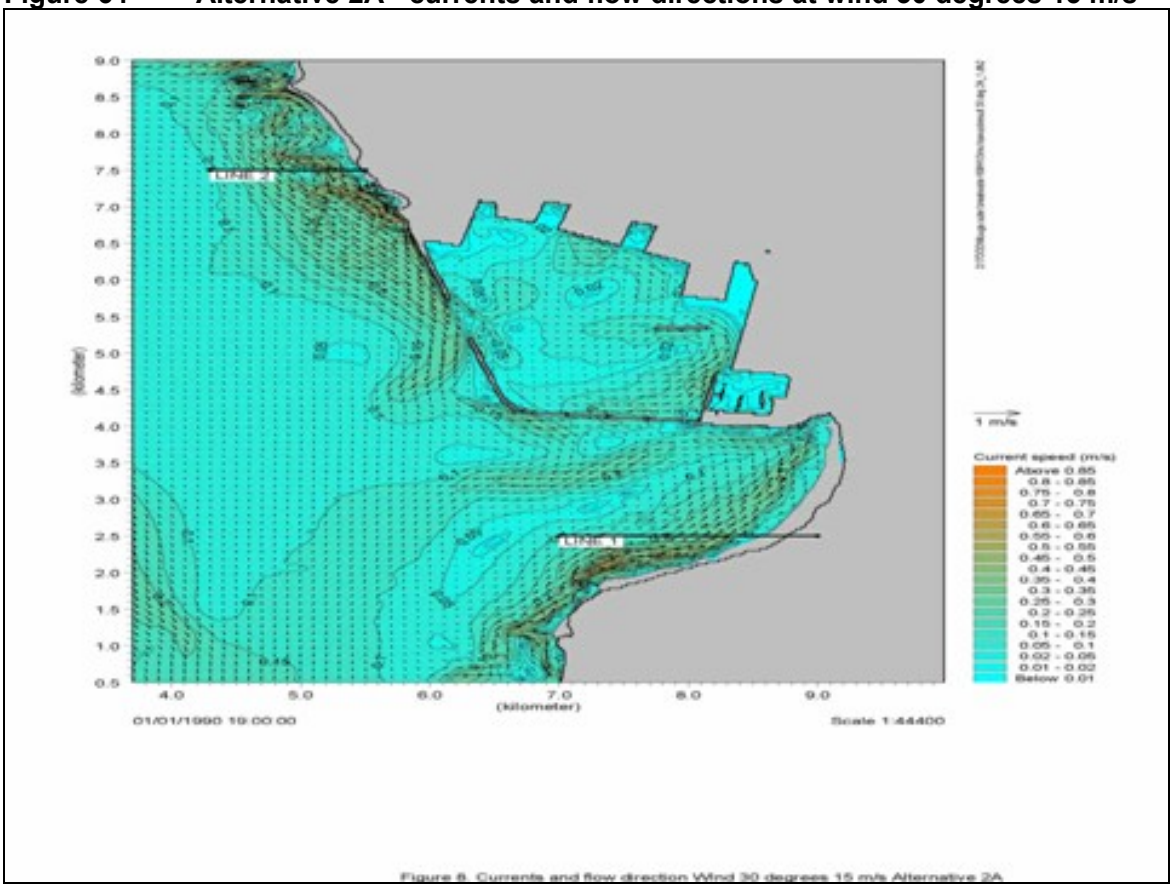


Figure 65 Alternative 4A - currents and flow directions at wind 30 degrees 15 m/s

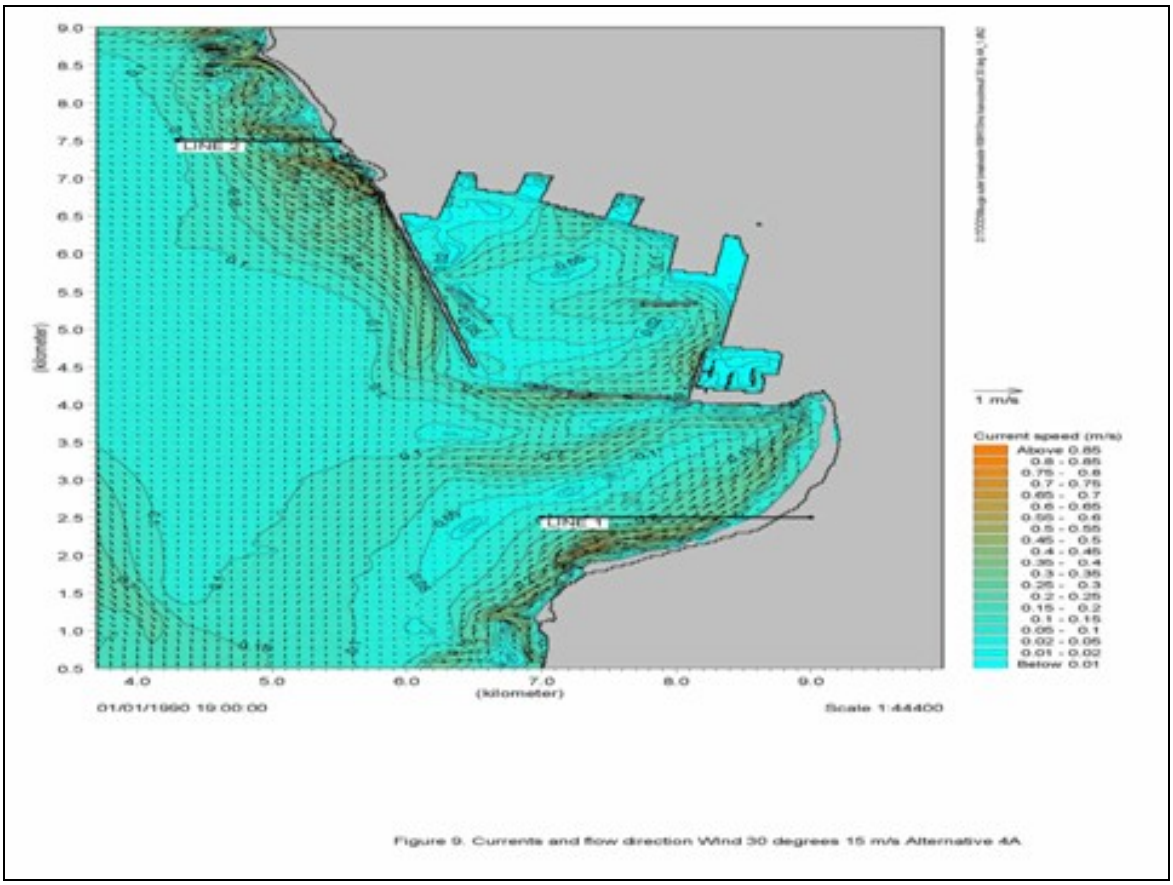


Figure 66 Current speed Line 1: Alternatives 0A, 1A, 1B and 4A

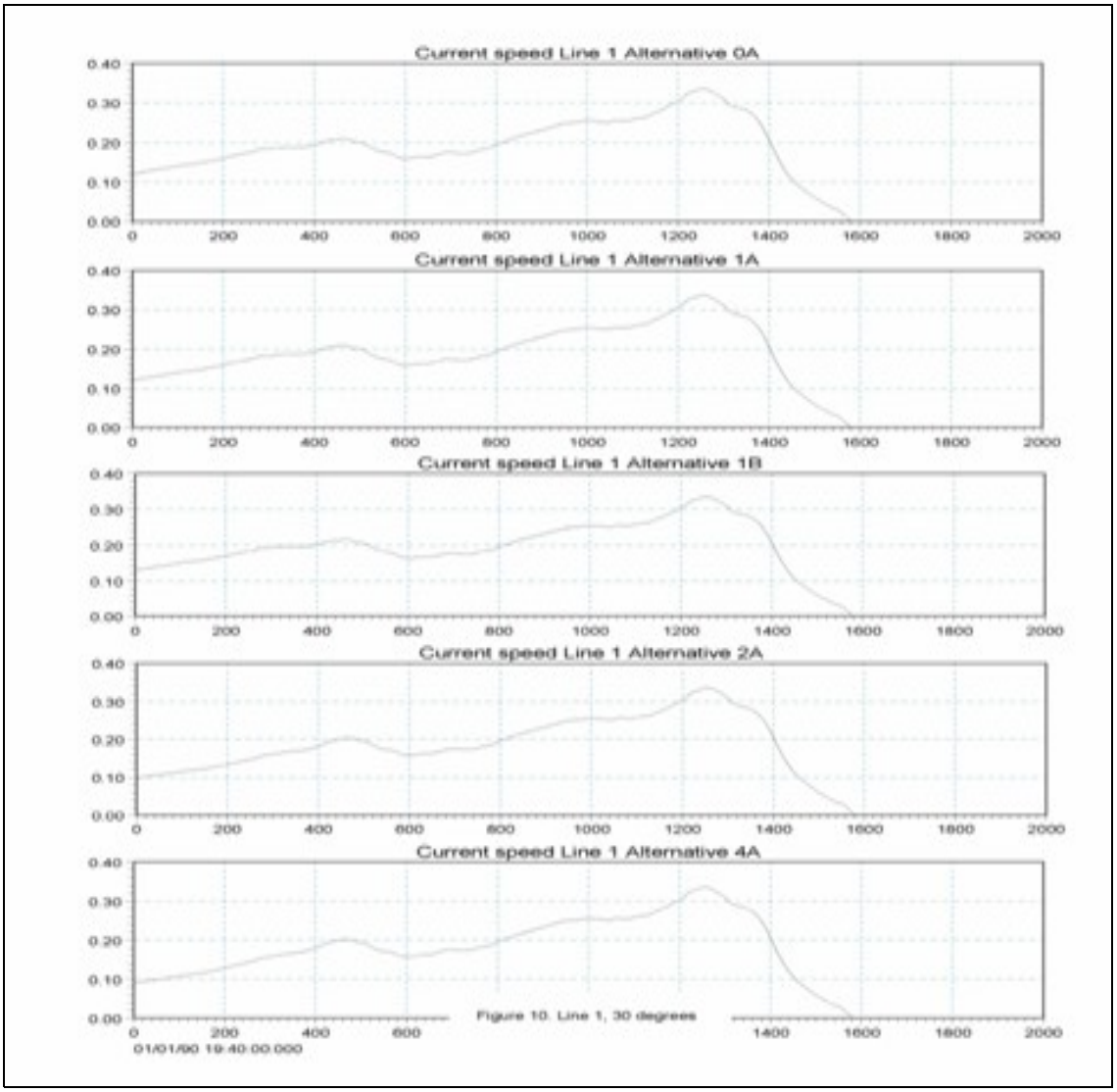
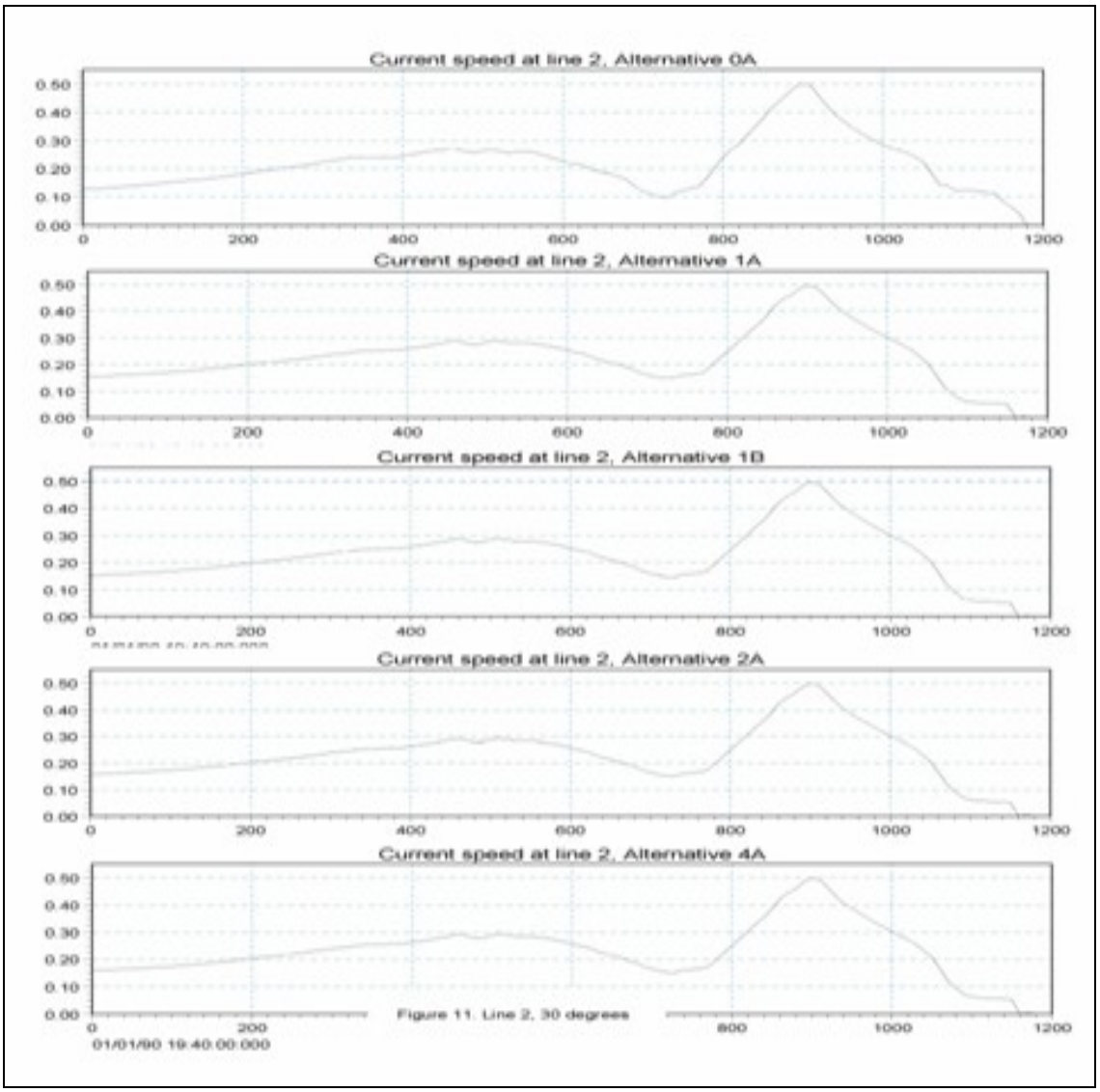


Figure 67 Current speed Line 2: Alternatives 0A, 1A, 1B and 4A



Wind from 330 degrees

When the wind in Gulf of Finland is blowing at 330 degrees, wave trains run between the area of Viimsi peninsula and Prangli Island to the Bay of Muuga. The shallow water areas around the Port of Muuga have a characteristic wave current speed ranging between 0.3 m/s and 0.7 m/s. This is shown in Figure 68. These areas are located in front of the Muuga recreational area; i.e. near the oil terminal and Krabimadal in the middle of the Muuga Bay, and near the coal terminal on the shoreline of Saviranna. The current speed near the grain terminals at the top of quays 9A and 10A is slightly less than 0.25 m/s.

The calculations show that the current speed in front of the Muuga recreational area does not depend on the breakwater alternative. This is illustrated in Figures 69 to 72. Inside this area, any of the proposed breakwater layouts will create wave current speed not greater than 0.05 m/s. Outside of the western to north western part of the breakwater, the current speed reaches 0.5 m/s.

The lines 1 and 2 in Figures 73 and 74 highlight the variation in the current wind speed along the Muuga shoreline.

Figure 68 Alternative 0A - currents and flow directions at wind 330 degrees 15 m/s

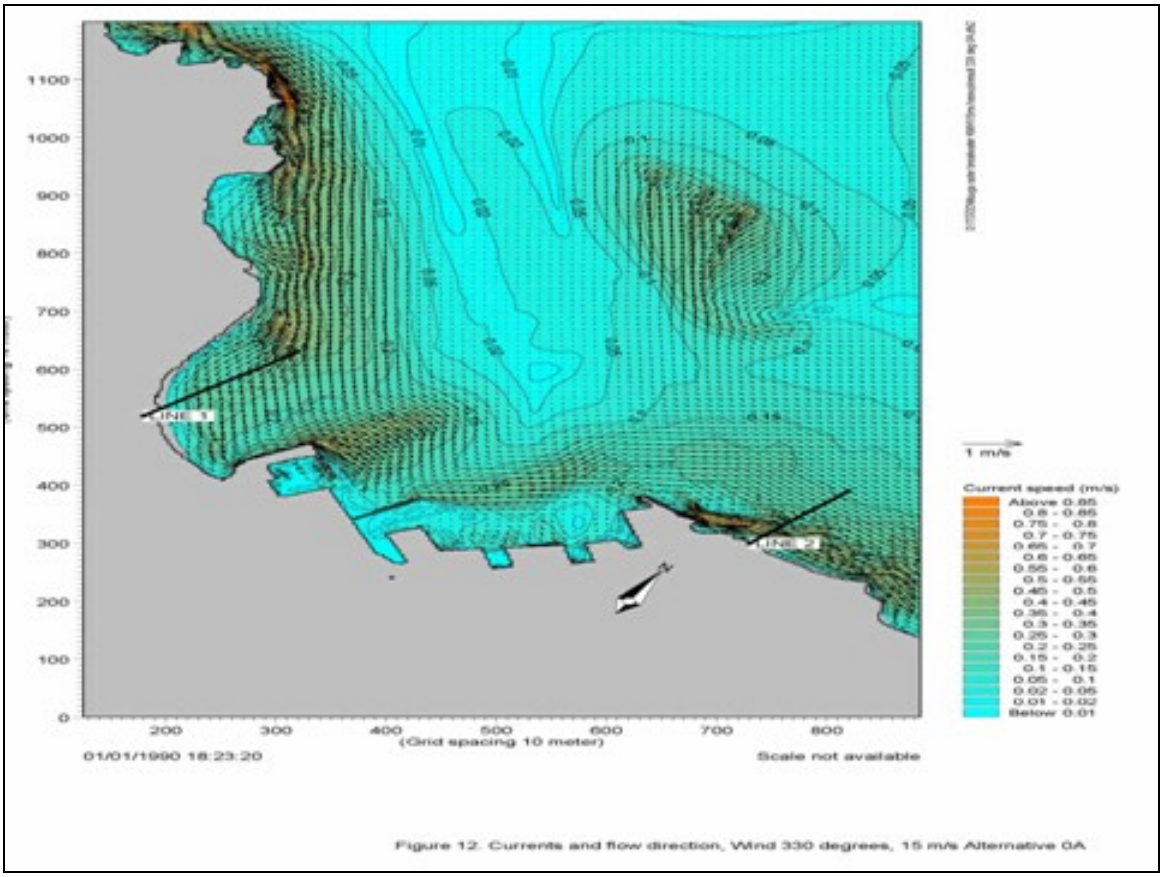


Figure 69 Alternative 1A - currents and flow directions at wind 330 degrees 15 m/s

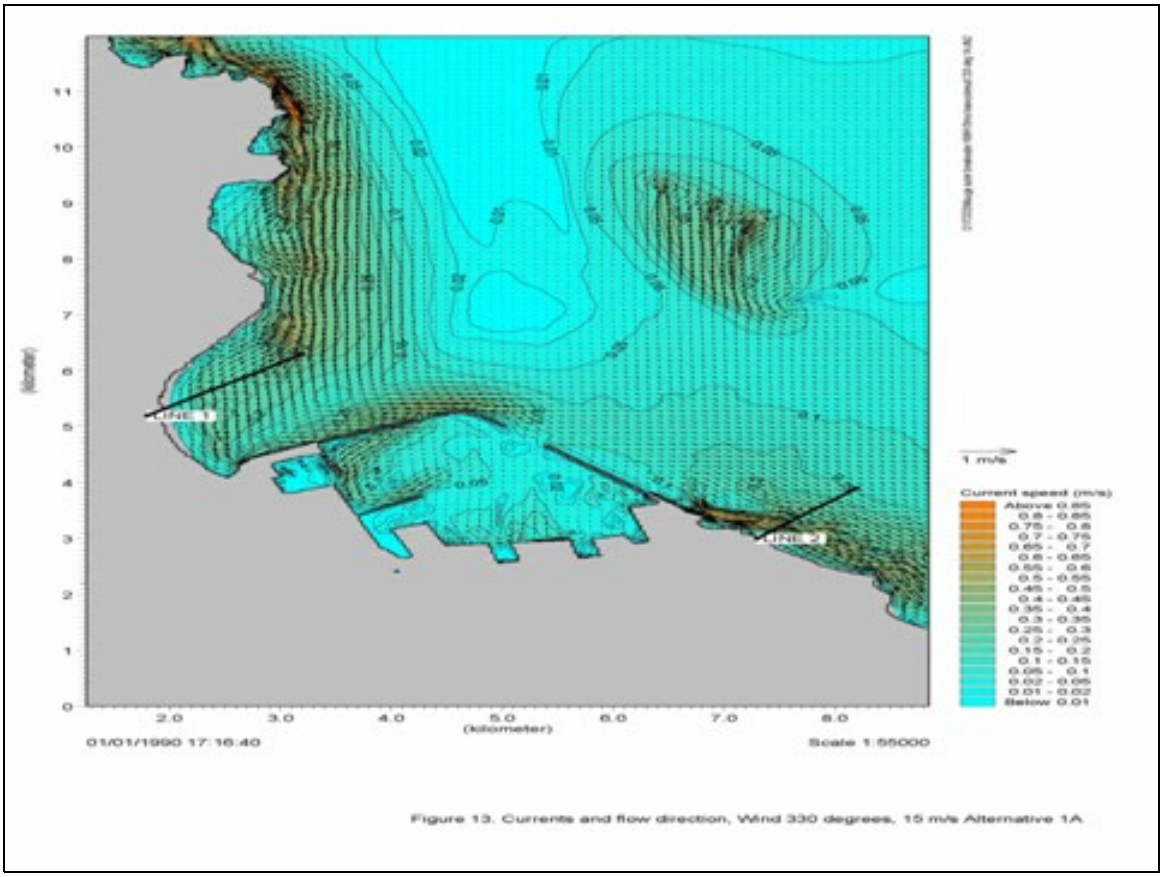


Figure 70. Currents and flow directions, Wind 330 degrees15 m/s, alternative 1B

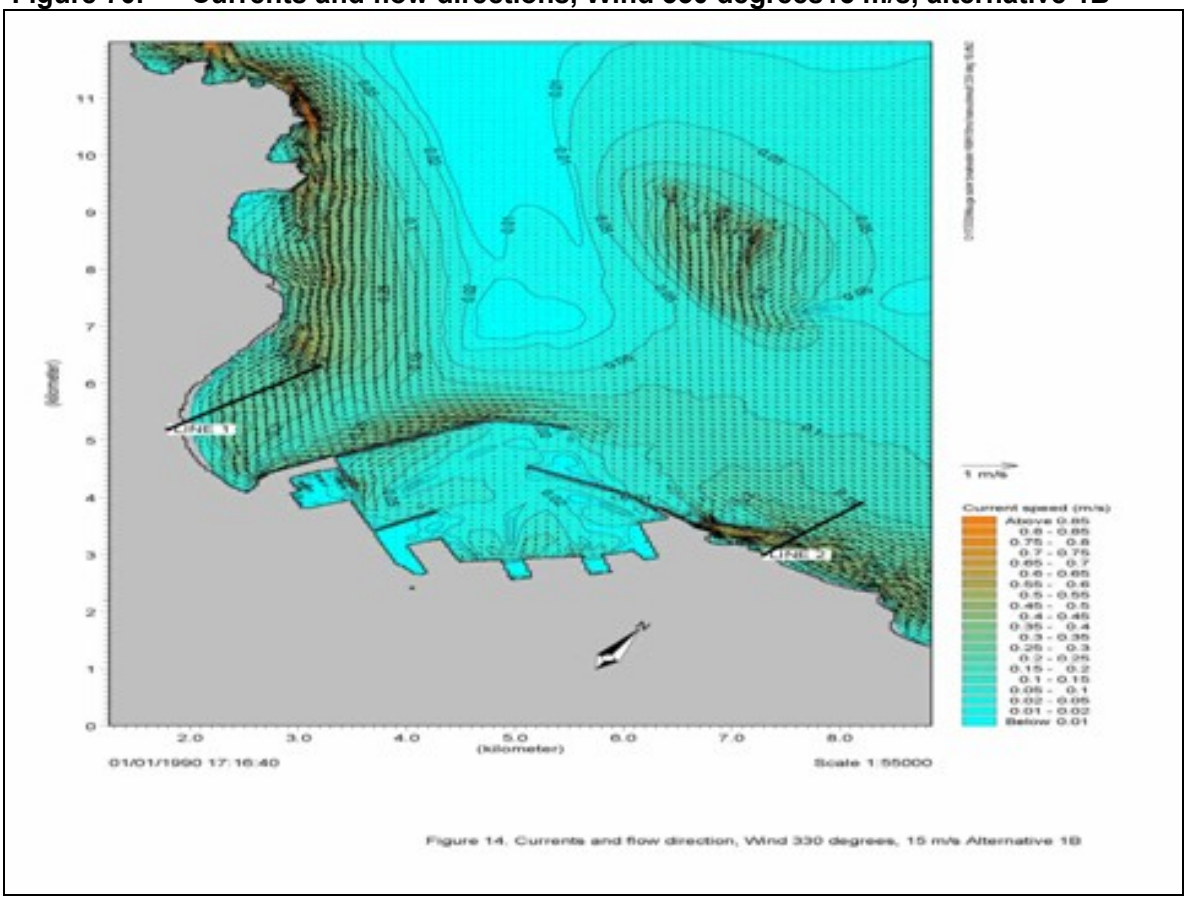


Figure 71 Alternative 2A - currents and flow directions Wind 330 degrees 15 m/s

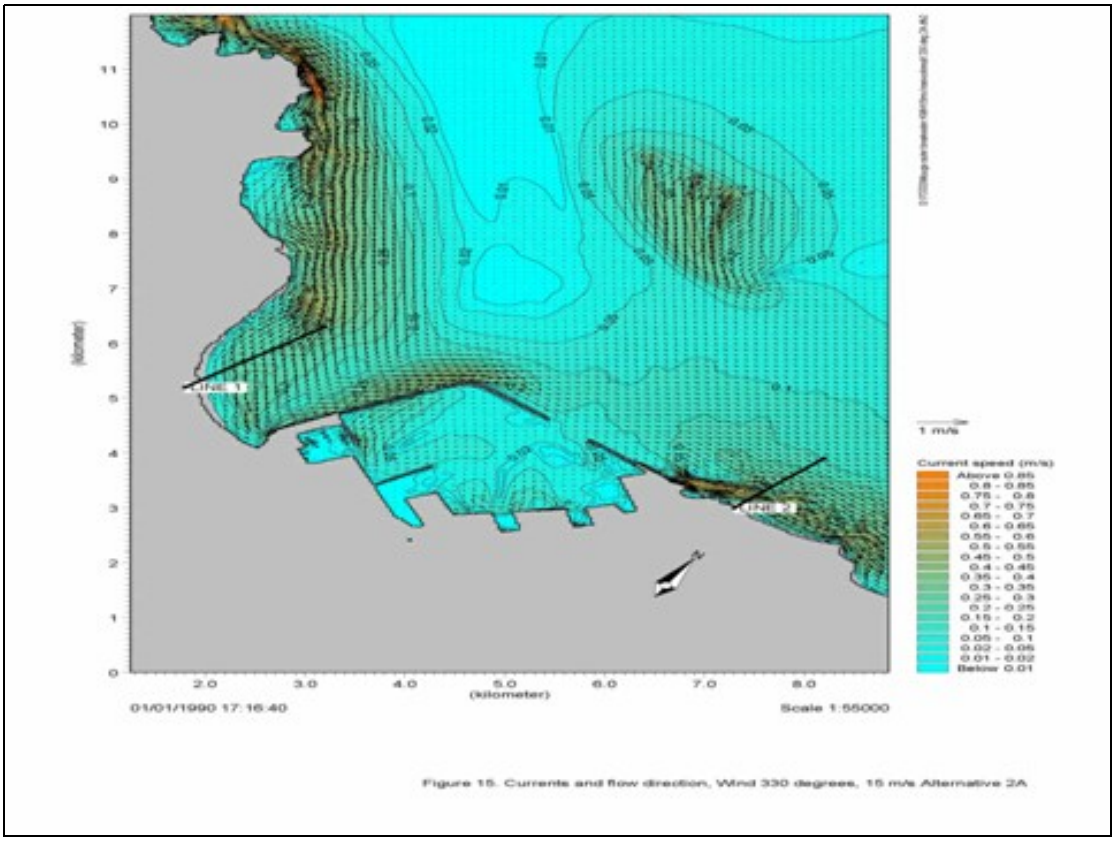


Figure 72 Alternative 4A - currents and flow directions at wind 330 degrees 15 m/s

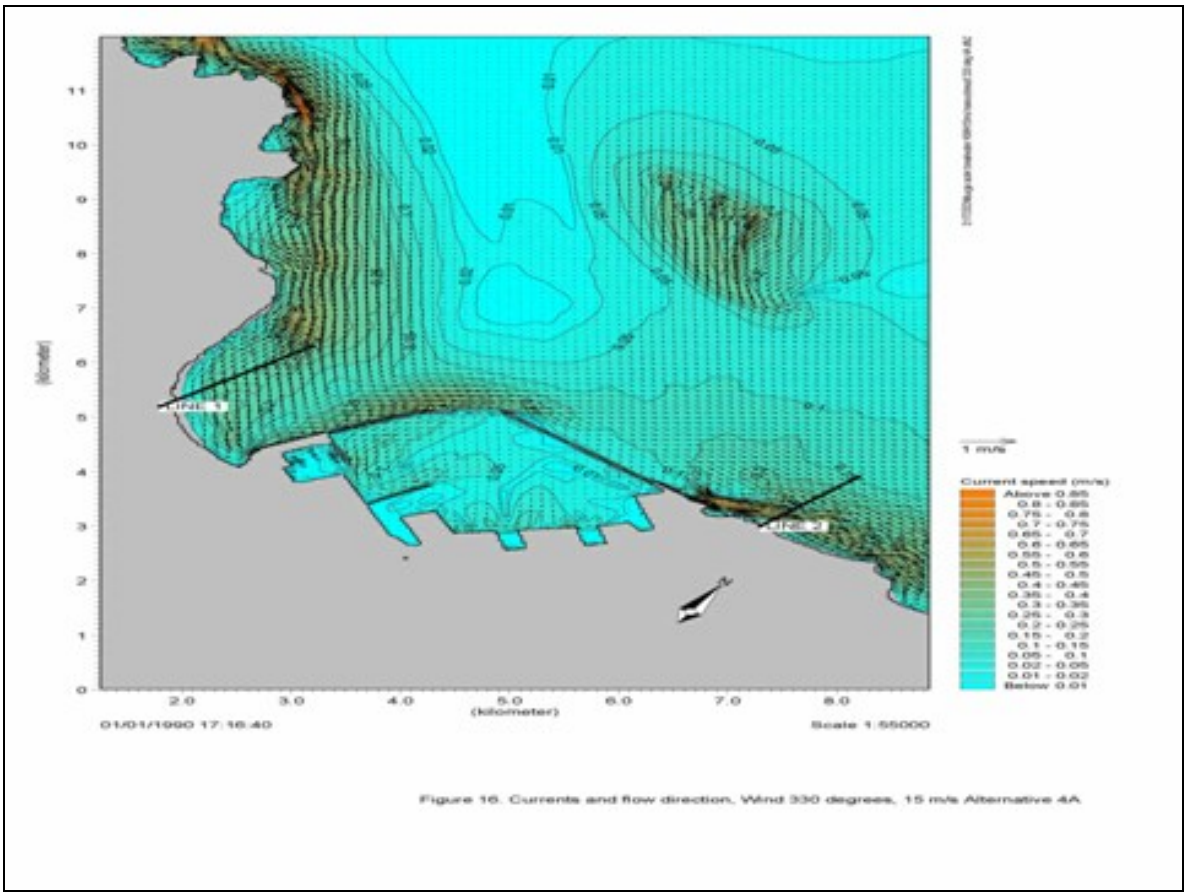


Figure 73 Current speed Line 1 - Alternatives 0A, 1A, 1B and 4A

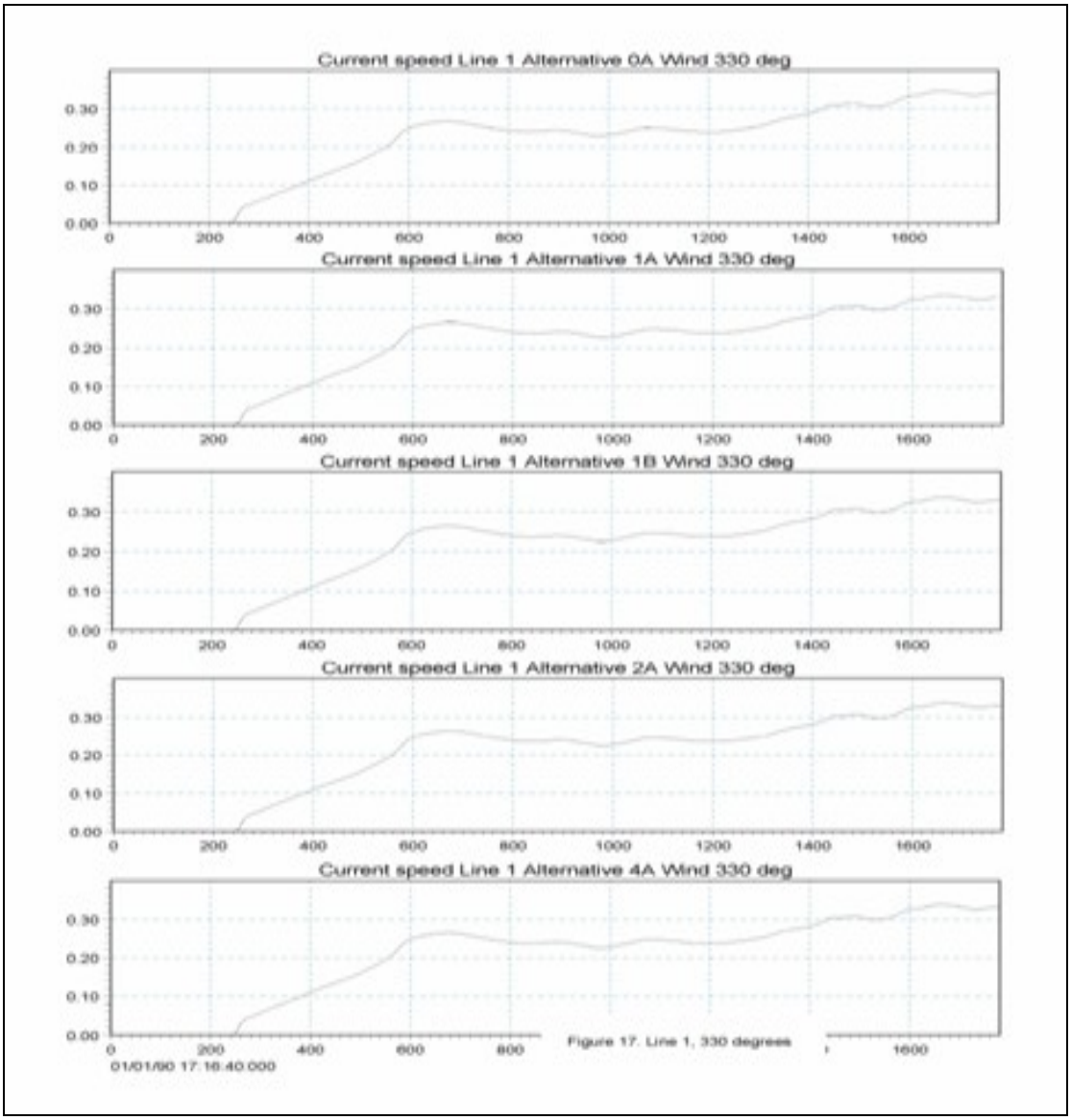
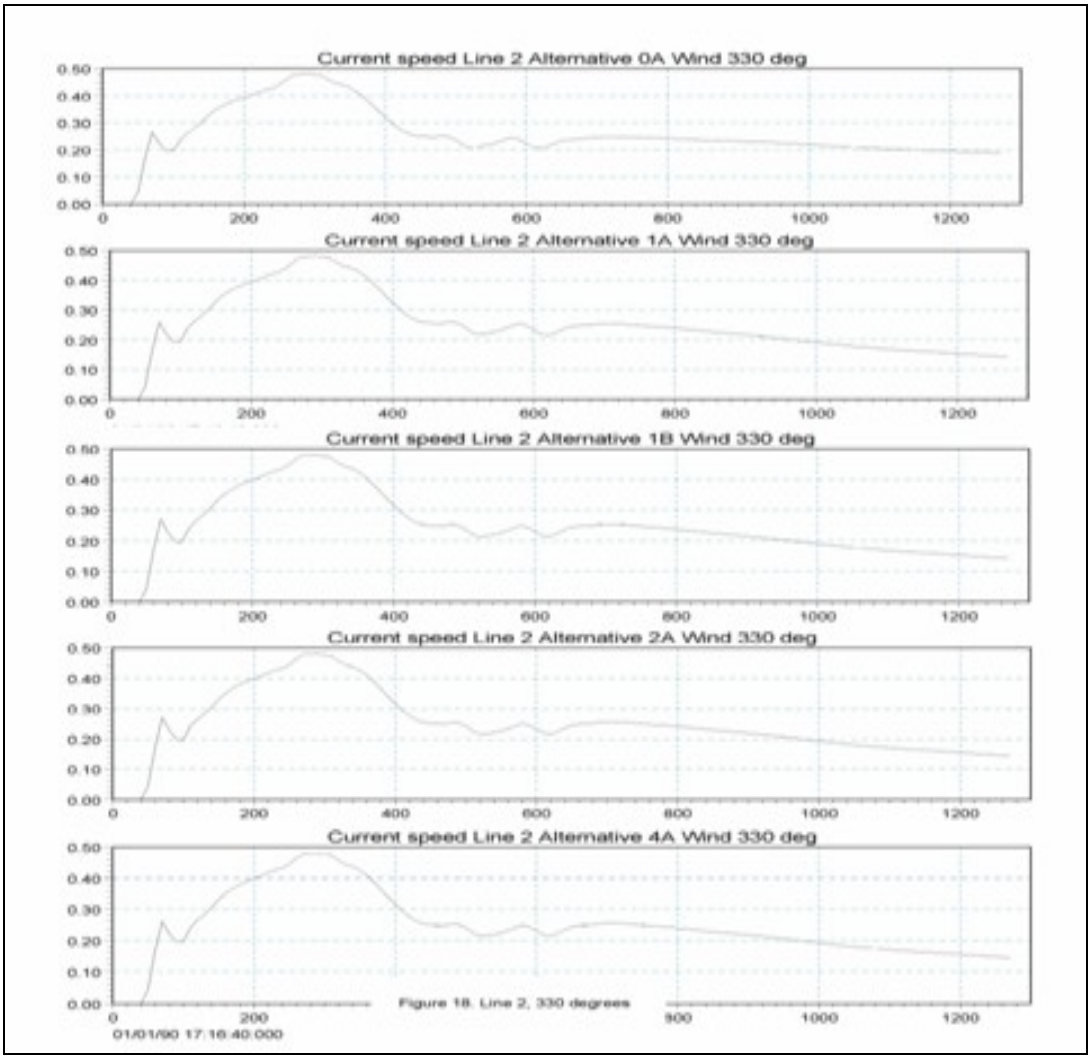


Figure 74 Current speed Line 2 - Alternatives 0A, 1A, 1B and 4A



Summary

The calculation data shows that in comparison with the present situation 0-Alternative, different layouts alternatives of the breakwater retain the same values of the current speed.

4.2 OIL SPILL RESPONSE

The spreading of an oil spill was simulated using a system of nested models that were validated with the current time series conducted in the Bay of Muuga in 1996 and 1997. Maps of different wind conditions obtained from a considerable number of episodic current measurements at various locations in the Bay of Muuga Bay, were also used. These measurements were taken during the time period ranging from 1975 until 1989 (Elken and Kõuts, 2001; Elken, 2003a; Elken et al., 2004).

Wind force data for the oil spill simulations were taken during the period ranging from the First of May to 30 September 1997, for which the model verification has been done (Elken, 2003a). For the given breakwater configurations including four different options and the situation where there is no breakwater, sequence of 3D current fields was calculated with a horizontal grid step of 120m, vertical grid step of 2m and time step of 5 minutes. The surface currents were saved at one-hour time intervals. For the calculation of 5 different options, about 180 hours of process time was needed in total. Earlier studies have shown that breakwaters do not significantly influence the currents in the open part of the Muuga Bay (Elken, 2003b).

Oil spill characteristics were calculated on the basis of pre-computed and saved current fields. Since the winds and surface currents vary considerably, the overall spill risk estimate was calculated as spreading probability during 24 hours from 3 different initial spill locations (Figures 75 - 77). The contour line 20% means in the figures, that after 24-h spreading the spill is by 20% probability located inside the contour. The same is with 40%, 60% and 80% contours. Time interval 24 hours was chosen by the consideration that after the oil spill it is the likely maximum time for mobilization of oil combating vessels and blocking the further spill spreading.

Within the simulation period, the oil spill moves outside the breakwater's area preferably to the east and to the west. After 24 hours, by 80% probability the oil spill has moved by 4-5 km to the east or by 3-4 km to the west. If the oil spill occurs near the harbour quays (as "Alambra" in September 2000) then oil drift to the breakwater's entrance area (spreading distance about 2.5 km) takes most probably more than 24 hours.

Conclusions from the conducted oil spill simulations are:

1) Breakwaters significantly prevent spreading of oil spill occurring in the harbour to the natural coastal areas of the Muuga Bay. With efficient oil spill surveillance system it is possible to block the spill spreading at the port's entrance between the breakwaters and this way to exclude spreading of oil spill outside the port area.

2) When oil spill happens outside the area confined by breakwaters, presence of breakwaters (including their different configurations) does not have significant influence on the spreading of oil spill.

Method of modelling

1) location of initial oil spill is chosen, where every hour a large number (presently 1600) of oil markers are inserted;
2) the lagrange markers simulating the oil spill are moving during 24 hours (drift by the currents and deviation/diffusion due to the turbulence);
3) in each 120x120 m model grid cell, the number of markers reaching the cell after 24 hours is counted;
4) the steps 1-3 are repeated for each next hour until the end of the modelling period of currents (in the given case 5 months, from 1 May to 30 September 1997);
5) total number of markers reaching during the whole simulation period into the 120x120 m grid cells is smoothed, using the number of markers in the neighbouring grid cells (in the given case by 5x5 matrix filter, therefore in Figures 4.10.1-4.10.3 the markers may be artificially found also on top of breakwaters);
6) mean numbers of markers $M_{i,j}$ at grid cells with indexes i, j are sorted into cumulative frequency tables, by that the level values $\widetilde{M}_k$ of marker numbers are found, exceeding of what takes place with a given frequency/probability $P\{M_{i,j} > M_k\} = P_k$ (in the given case P_k is 20%, 40%, 60 % and 80%).

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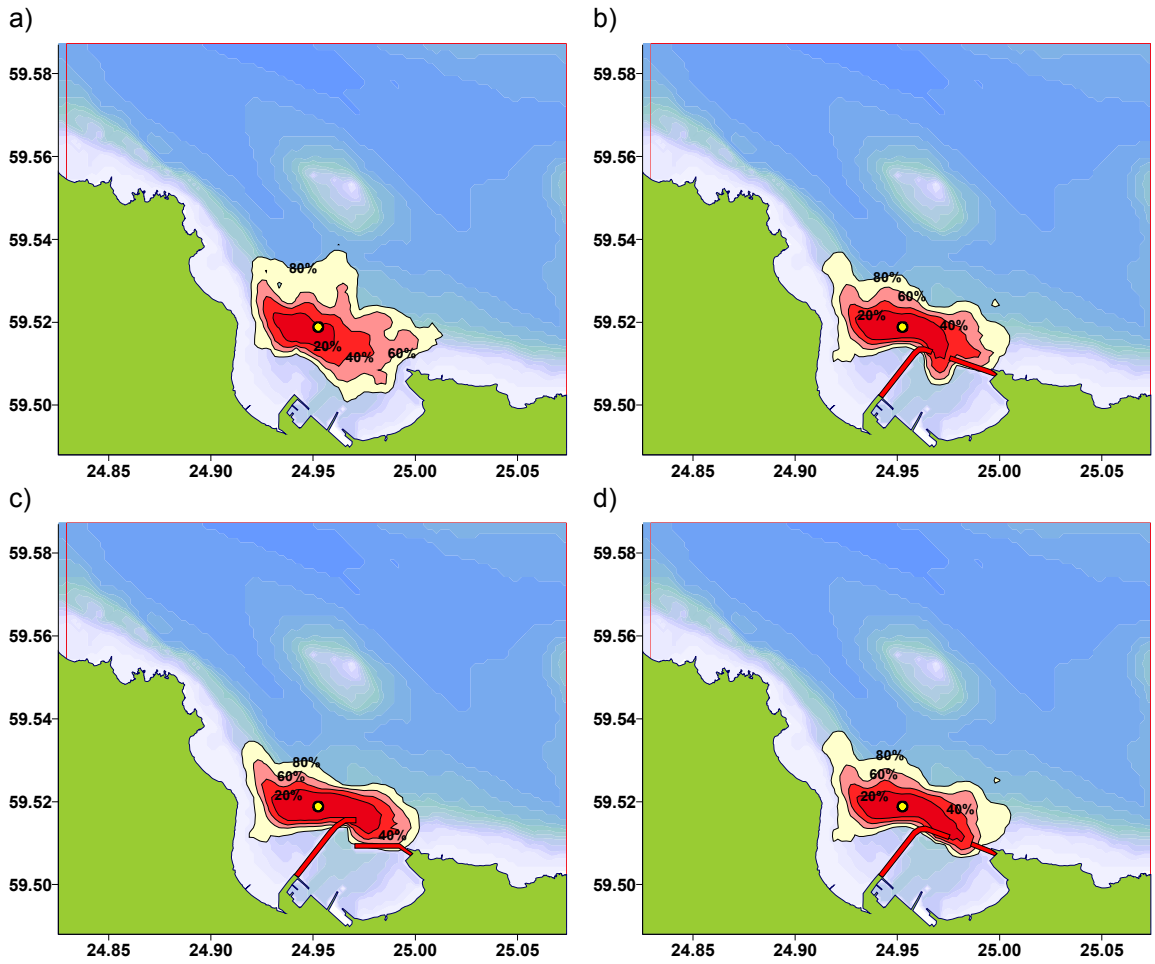
Environmental Impact Assessment of the Breakwater for the Port of Muuga in Tallinn

Figure 75 **Oil spill spreading probability during 24 hours from the initial spill location at coordinates 24 57' 07.5"E, 59 31' 07.5"N (circle in the figure): a) situation without breakwaters; b) reference layout; c) modified reference layout; d) breakwaters with eastern entrance, e) breakwaters with western entrance.**



e)

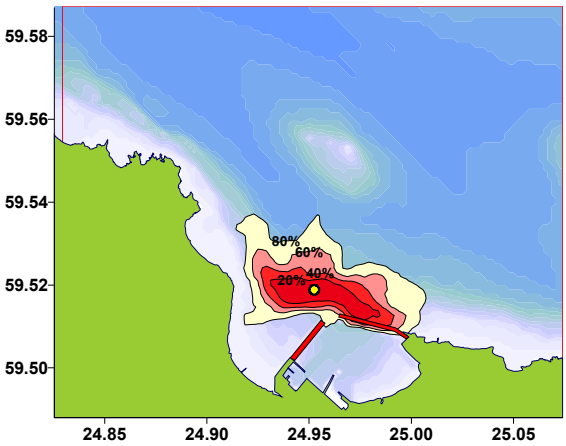
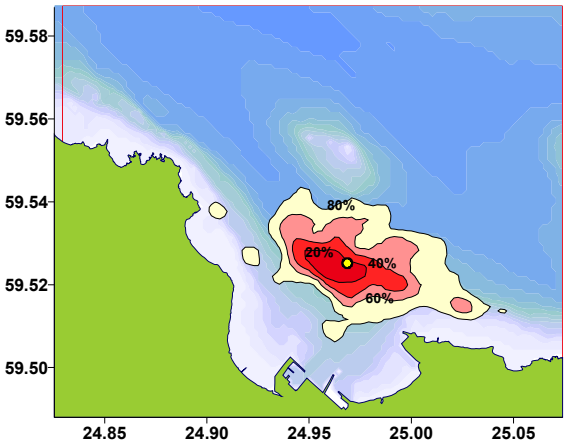
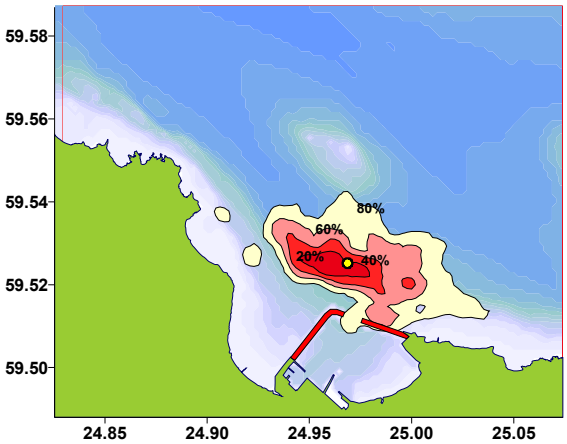


Figure 76 Oil spill spreading probability during 24 hours from the initial spill location at coordinates 24 58' 07.5''E, 59 31' 30.0''N (circle in the figure): a) situation without breakwaters, b) reference layout, c) modified reference layout, d) breakwaters with eastern entrance, e) breakwaters with western entrance.

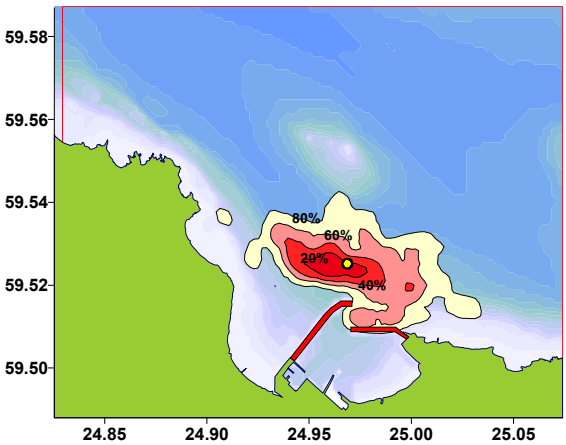
a)



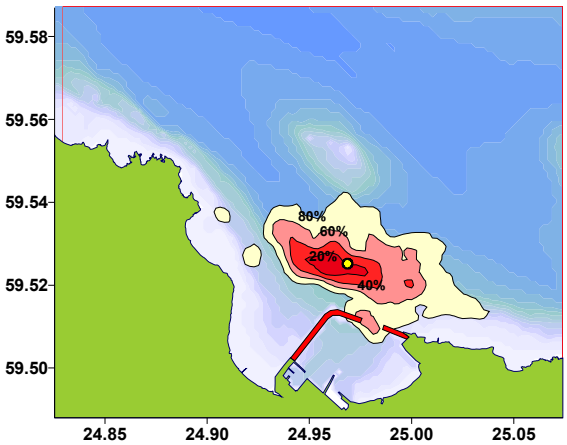
b)



c)



d)



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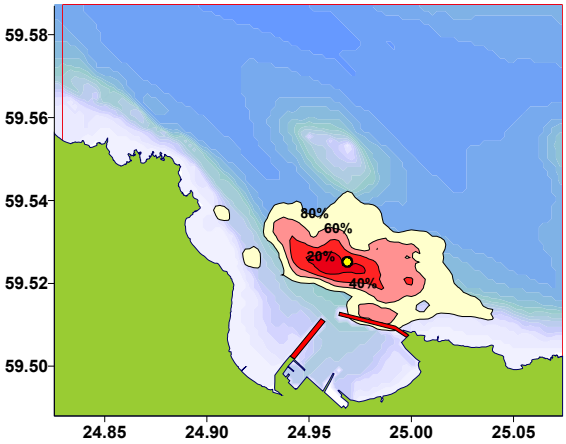
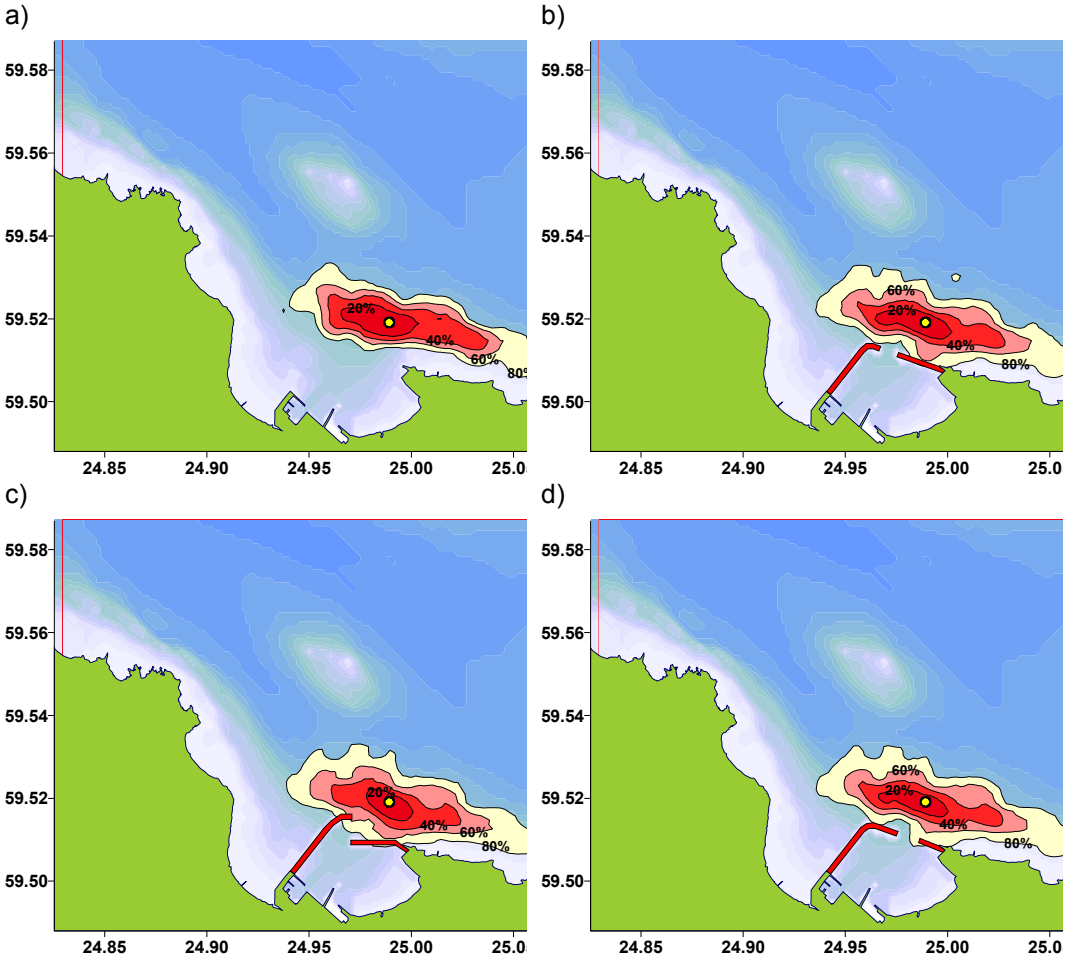
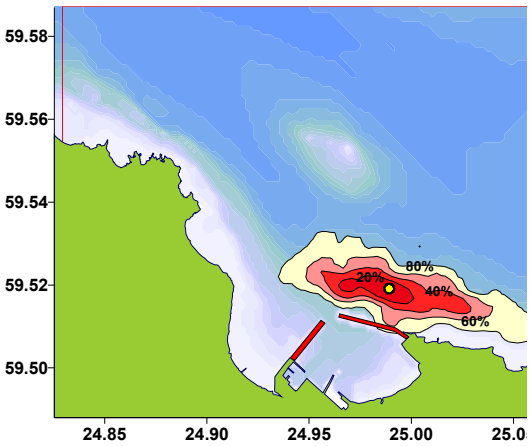


Figure 77. Oil spill spreading probability during 24 hours from the initial spill location at coordinates 24 59' 22.5''E, 59 31' 07.5''N (circle in the figure): a) situation without breakwaters, b) reference layout, c) modified reference layout, d) breakwaters with eastern entrance, e) breakwaters with western entrance.



e)



5 SECTION V ENVIRONMENTAL IMPACT ASSESSMENT

5.1 IMPACTS ON SEDIMENTS AND SHORE PROCESSES

The construction of the breakwaters will not cause significant changes in the dynamics of the waves and currents in the areas of shallow water typifying the Bay of Muuga. This is illustrated in Figures 61 - 68.

The only possible exception is the Randvere coastal sea area which is located close to the Muuga Port from west. However, it is difficult to foresee what the actual impact could be because the local shore and coastal shallow waters have not been monitored since the construction of the Port of Muuga in the 1980s. A preliminary observation was completed in the 1980s. Since then, some changes may occur because the beach area has shrunk in size as well as the muddy sea area situated close to the west of the Port of Muuga.

0-Alternative

In Section 2, it has been assumed that the large extension of the Eastern Port Basin was planned to be subject to a large amount of dredging. In light of this, the current sea sediments localized in the Bay of Muuga will be altered significantly (ILAG-HPC-ESP-TALLMAC 2005). Furthermore, the experiences of Muuga Port exploitation since 1980s without breakwaters, allow us to conclude that the periodical needs for remount dredging will most likely be on a yearly basis.

Alternatives I and II

As described in 3.5, the combined structural design of the planned breakwaters, (i) the rubble mound reef type breakwater will be considered for waters at depths of *less than* 12m, and (ii) the piled type of breakwaters will be selected for deeper waters.

The amount of dredging required for either of these two breakwater alternatives is more-or-less equal (see Section 6). It can be concluded that during the construction works, the impacts on sea bottom sediments caused by dredging will be similar. In light of the need to enlarge the eastern part of the Port, which is planned to be done in parallel to the construction of the breakwaters, the cumulative environmental impacts on sea bottom sediments and those impacts caused by the breakwaters built in the eastern part of the Bay of Muuga, will be minor. It is, however, difficult to forecast what the impacts will be on the shore processes in western part of the Bay of Muuga during the construction of western breakwater. In light of this uncertainty, we recommend implementing a programme to monitor the environmental impacts.

Alternative III

The planned activity does not include further dredging in the Port area. Some dredging near the building areas of the breakwaters (e.g. the foundation indents) is carried out at some distance from shoreline (i.e. more than 1 km to the west and about 0.5 km to the east), which will not affect the beaches in the surrounding areas.

No substantial changes are expected to be caused to the direction and speed of the waves and currents in the shallow waters areas in the Bay of Muuga following the construction of the breakwaters and during their operation (see Sections 4.1.1 and 4.1.2). In light of this, the total amount of required dredging will be less than that for Alternatives I and II. Hence, the impact to the shorelines in Saviranna and Randvere is negligible.

The need for remount dredging inside the Port basin enclosed by breakwaters will not be considerable although it is impossible to state such a forecast the amount of dredging at such an early date. It is possible, however, to anticipate a need for remount dredging during further the operation of the breakwaters in the Port of Muuga as a result of a decrease in the quantity of suspended sediments.

References

ILAG-HPC-ESP-TALLMAC: Technical Assistance for Extension of Muuga Port on the Trans-European Network, Eastern Extension of Muuga Harbour, Environmental Impact Assessment, October 2005

5.2 DISPERSION RATE OF SEDIMENTS DURING CONSTRUCTION, DREDGING AND DUMPING

Initial conditions

The current breakwater project the layout for the Port of Muuga; notably, the construction and operational details of the breakwater, have not been conclusively determined. It is however clear that the construction of the breakwater will demand the dredging of a large quantity of sand and other materials, which will consequently be dumped close to the breakwater location. In order to determine the granulometric sediment grading of the material dump and the possible impact of a sediment spill on the marine area, the diameter of the dumped material (i.e. d = 0.02mm) is used. The relative densities of the quartz sand (ρs) and water (ρw) in the calculations, is equal to ρs/ρw = 2.62.

The graphs presented below show that intensity of the impact of the dumped material on the environment, is of the order of 450 kg/s at 11-hour periods at the two chosen locations. Although the type of breakwater for the location has not yet been identified, the modeling is based on the initial points of dumping which are the midpoints of the eastern and western breakwaters. These points are concluded to be the points where there is a maximum dispersion of sediments.
The basis of the following suspended sediment impact area calculations are the wind generated wave-current fields described in Section 4.1.

Wind from 300 degrees

The Figures give a report of the value of the suspended sediment impact area after 5,5 and 11 hours after the start of dumping. Two different cases are studied:
- initial period of the dumping,
- Final phase of the dumping when almost all of the breakwater system is completed.

Initial period

Figure 78 shows that 5.5 hours following the dumping of suspended sediment in the middle of the eastern breakwater, the concentration of the suspended sediment is about 1.2 kg/m^3. The area impacted has a sediment concentration of 0.6 kg/m^3. Following dumping, this sediment spreads to north of the dumping area.
From the middle of the western breakwater, the area is impacted with a sediment concentration of 1.8 kg/m3. This sediment concentration subsequently spreads to the oil terminal and then on to oil terminal entrance. Secondary currents then carry this sediment along the outside of the oil terminal breakwater to north. At this point, the sediment concentration has reached a value of 8 to 9 kg/m3.
Figure 79 illustrates that after 11 hours following the dumping of the sediment, the impacted area has a low concentration starting from the eastern breakwater midpoint, and spreads into a north-south direction towards the middle of the Bay of Muuga throughout an area which is two kilometers in length. Starting from western breakwater midpoint, the impact area after 11 hours decreases first until 1.2 kg/m3. The currents carrying low concentrations of suspended sediments reach the oil terminal quays, where the concentration of the suspended sediment is greater than 10.8 kg/m3.

Figure 78 Sediment spill during final stages of dumping. Wind 30 degrees 15 m/s. Dumping time 5.5 hours.

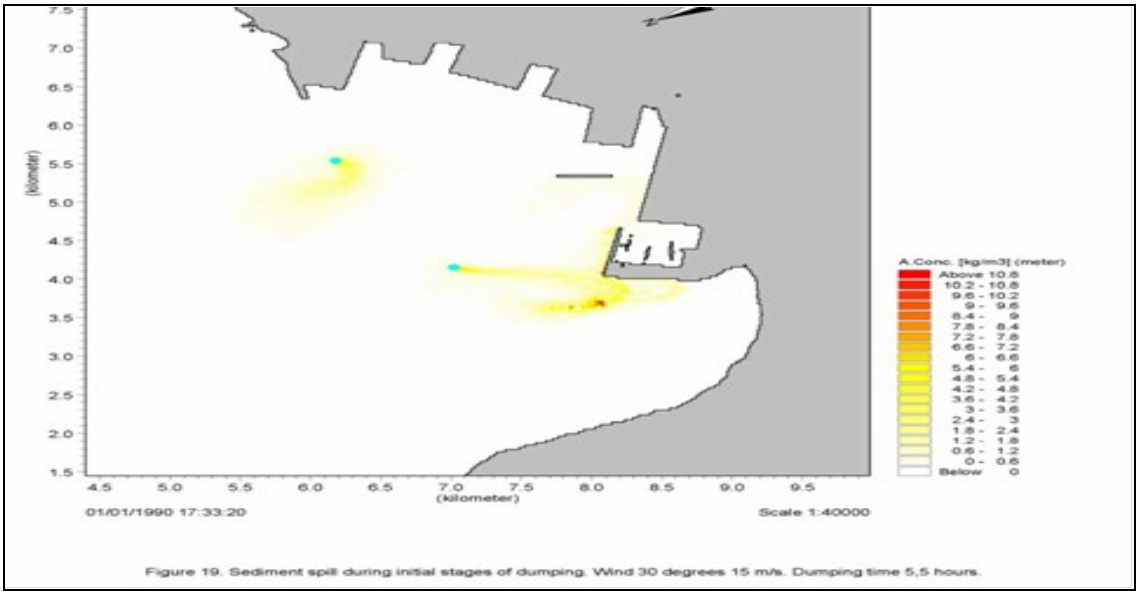
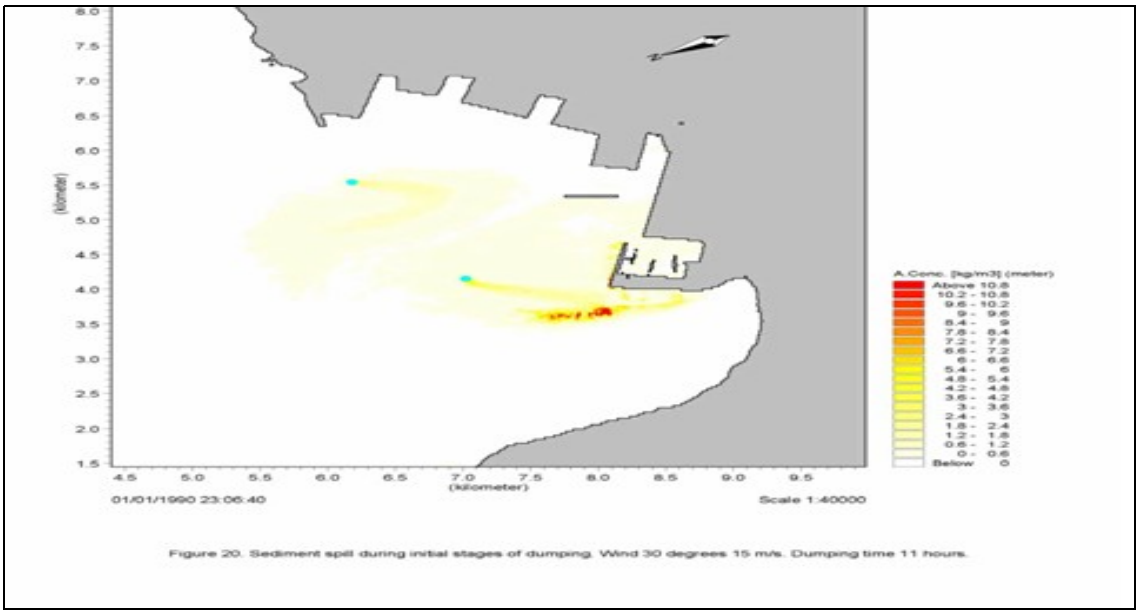


Figure 79 Sediment spill during initial stages of dumping. Wind 30 degrees 15 m/s. Dumping time 11 hours



Final phase of the dumping

After 5.5 hours, the impact area starting from the midpoint of the eastern breakwater when moving along the eastern breakwater turns to the Port basin, as shown in Figure 80. Starting from the midpoint of the western breakwater impact area accumulates at the outside of the northwestern oil terminal breakwater.

Figure 81 shows the situation after 11 hours following dumping. It can be observed that the impact area with low concentration spreads to the middle of the Muuga Bay, passing along the western breakwater and then spreads through the entrance into the Port basin. The impact area starting from the midpoint of the western breakwater accumulates in an area outside of the northwestern oil terminal breakwater, carrying with it suspended sediment of a concentration of 3 to 4 kg/m^3.

Figure 80 Sediment spill during final stages of dumping. Wind 30 degrees 15 m/s. Dumping time 5.5 hours.

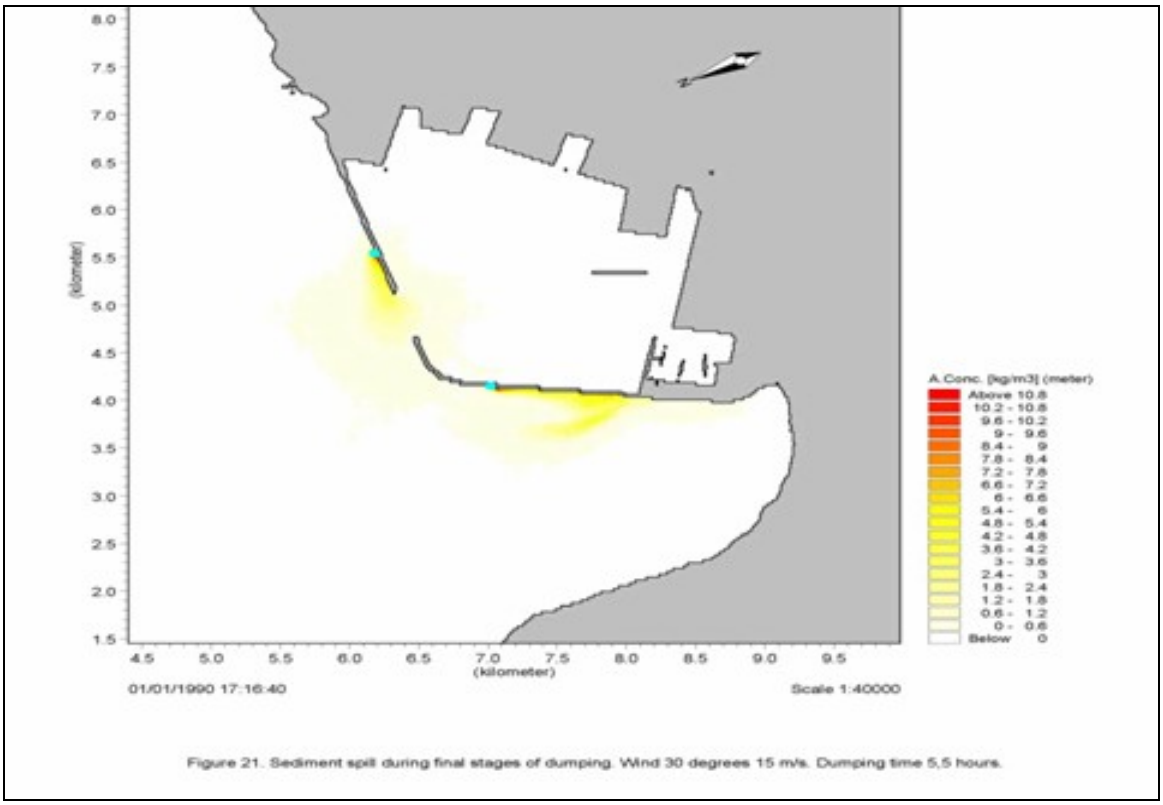
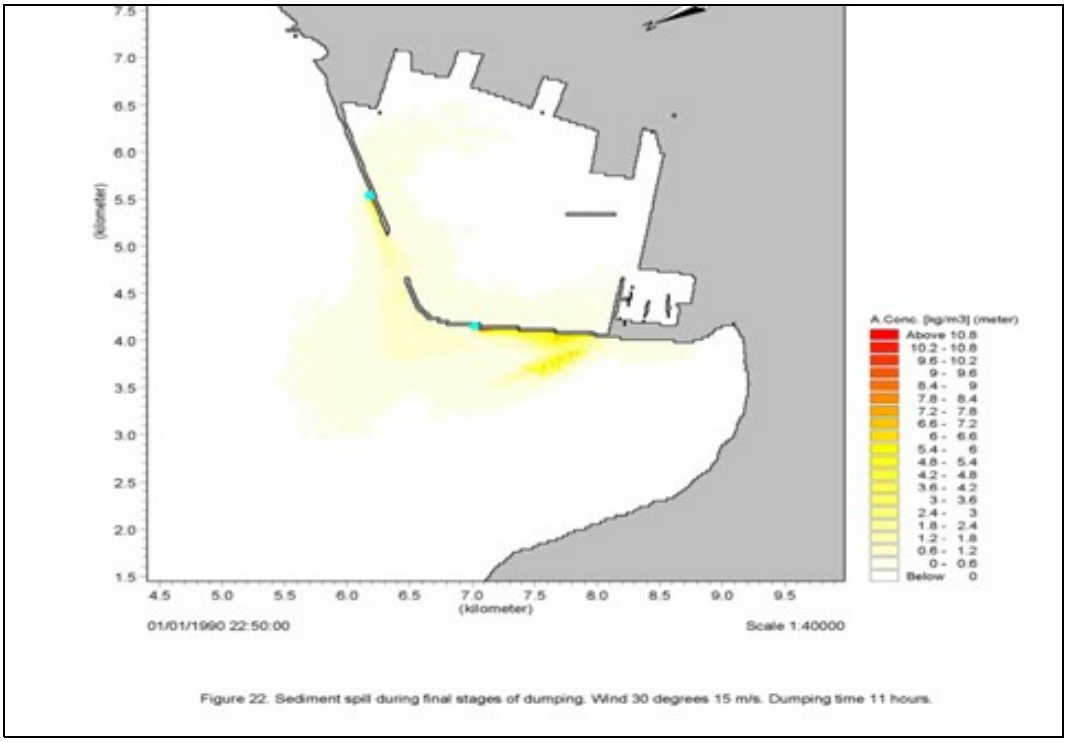


Figure 81 Sediment spill during final stages of dumping. Wind 30 degrees 15 m/s. Dumping time 11 hours.



Wind from 330^0 degrees

Initial period

As illustrated in Figure 81, the sediment spreads from the midpoint of the eastern breakwater to the coal terminal, from where it moves into an eastern direction. At the shoreline near Saviranna, the suspended sediment concentration reaches 10 kg/m^3. Frp, here, some active zones are identified which could have a high range of sedimentation. The suspended sediment particles which are dumped at the midpoint of the western breakwater, spread with low concentrations until the quays of the proposed eastern development area.

After 11 hours of having been dumped, the impacted area on into an eastern direction. The maximum values of the suspended sediment concentrations of 10.8 kg/m^3, are found in the Saviranna area as illustrated in Figure 82. The impact area with a concentration less than 0.6 kg/m^3, starts from the western breakwater midpoint and reaches Saviranna area.

Figure 81 Sediment spill during initial stages of dumping. Wind 330 degrees 15 m/s. Dumping time 5.5 hours.

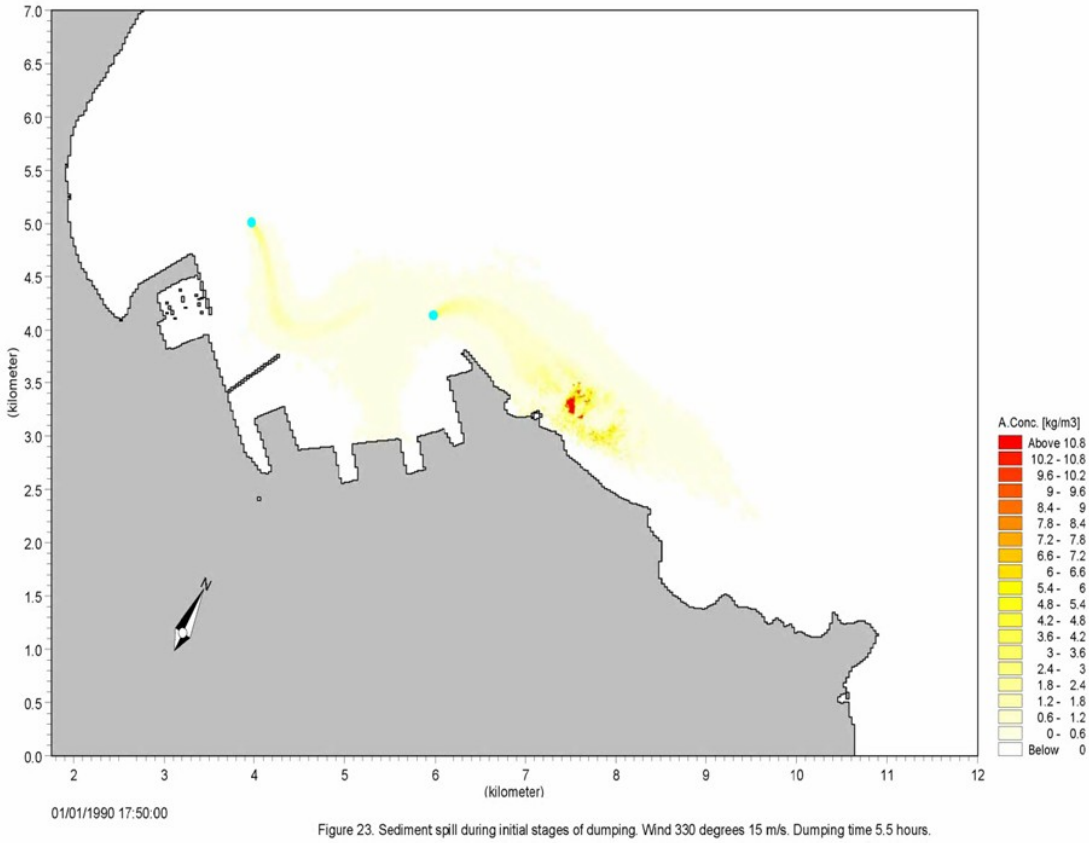


Figure 82 Sediment spill during initial stages of dumping. Wind 330 degrees 15 m/s. Dumping time 11 hours.

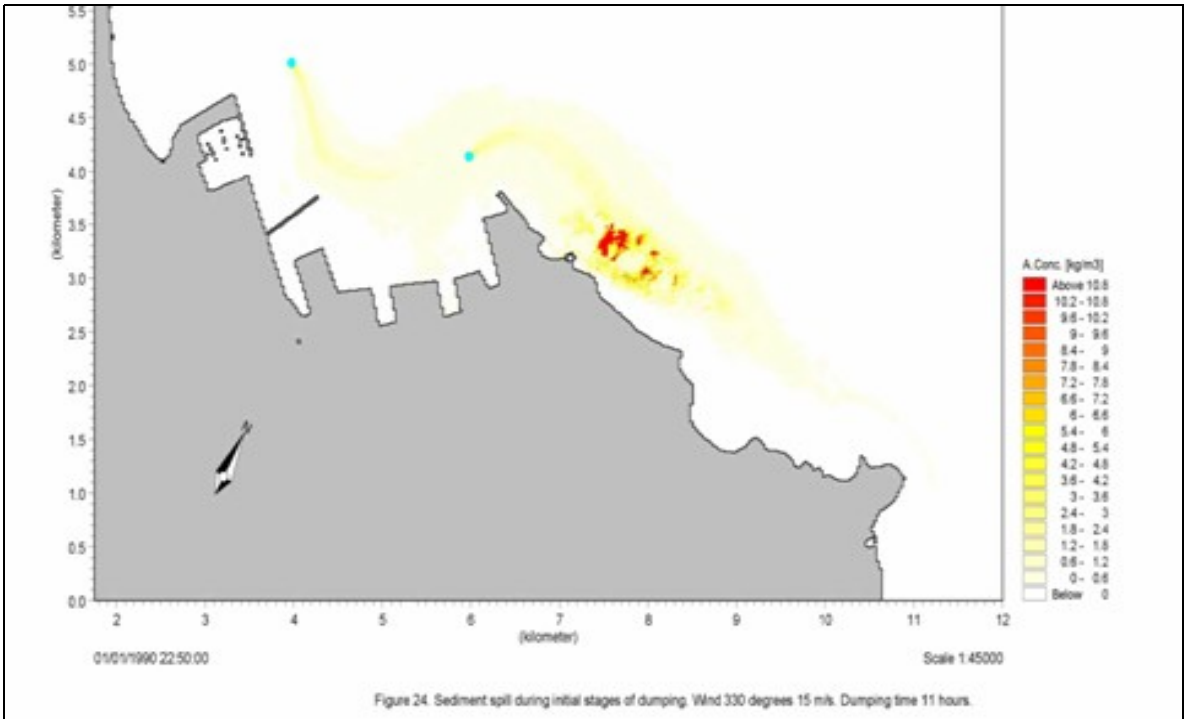


Figure 24. Sediment spill during initial stages of dumping. Wind 330 degrees 15 m/s. Dumping time 11 hours.

Final phase of the dumping

Figure 83 shows the situation after 5.5 hours of the material being dumped in the selected area. When the initial point is at the middle of the eastern breakwater, a local impact area with 1.5 kg/m^3 concentration spreads to east reaching the value of 5 to 6 kg/m^3 in the Saviranna area. From the western breakwater, a low concentration of 0 to 0.6 kg/m^3 impact area reaches the coal terminal.

Figure 84 shows that after 11 hours following the dumping, the eastern breakwaters midpoint high impact area having a concentration of 6 to 7 kg/m^3 stays at Saviranna. The impacted area of the dumping at the western breakwater,, spreads along the inside contours of the breakwaters and along outside contours until Saviranna coastline.

Figure 83 Sediment spill during final stages of dumping. Wind 330 degrees 15 m/s. Dumping time 5.5 hours.

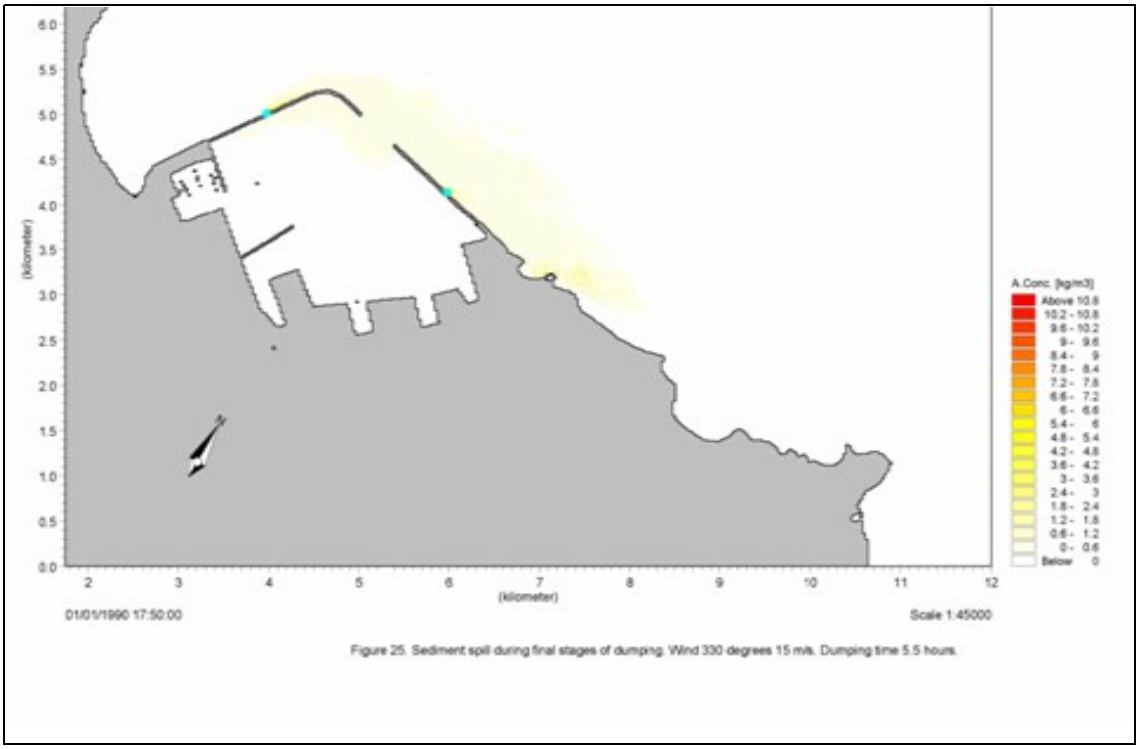


Figure 84 Sediment spill during final stages of dumping. Wind 330 degrees 15 m/s. Dumping time 11 hours

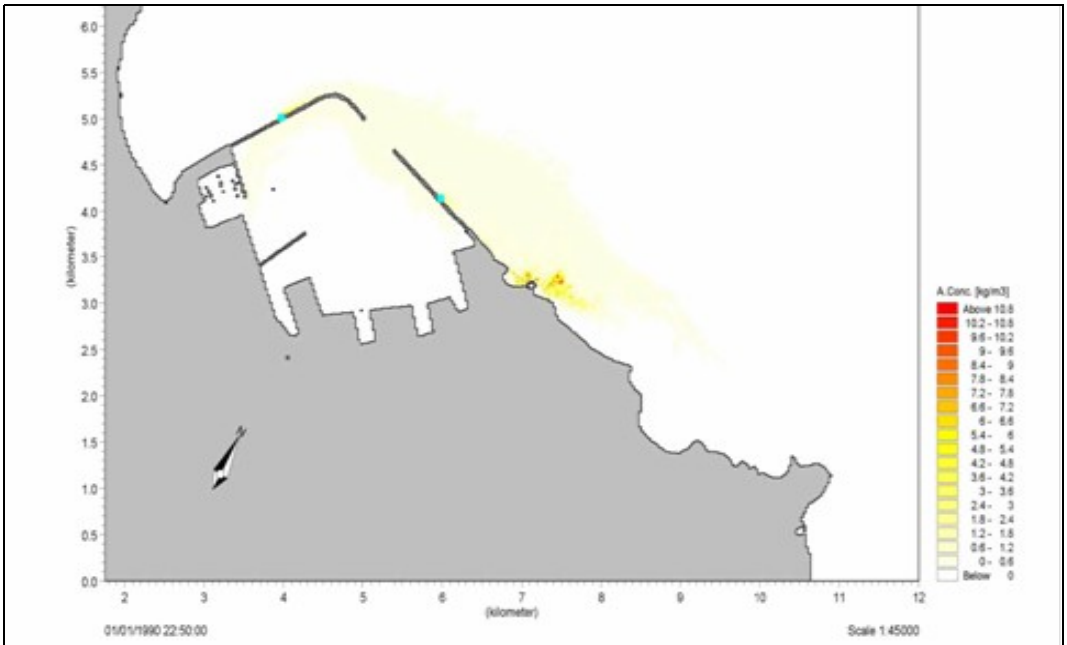


Figure 26. Sediment spill during final stages of dumping. Wind 330 degrees 15 m/s. Dumping time 11 hours.

Summary of the results of the sediment impact calculations

Measurements of the wind statistics indicate that the most frequent wind direction is the wind blowing from the Gulf of Finland at *under* 330 degrees. It is therefore essential the calculations are set at a maximum value of settling for the finest particles in the area of Saviranna.

The location of the construction equipment to the west of the breakwater may lead to a dispersion of very fine fractions of particles and their settling inside the oil terminal and in the surrounding areas.

It should also be emphasized that the dispersion of sediments described above, will be very similar for both Alternatives I and II, but less so for Alternative III.

5.3 IMPACTS ON SEASHORE PROCESSES AND PUBLIC BEACHE

There are no extensive and open sandy beaches to the east or west of the Port of Muuga and the construction site (including the lengthening of the breakwaters and broadening of the area between them) in the coastal area under investigation. Occasional small sandy beaches of local importance are present in Saviranna as well as Randvere district that are used by the people living in the areas.

Those sandy beaches are approximately up to 100m long and their width does not exceed 20m. There is no data about the thickness of the sand layer but Cambrian blue clay is visible at some places in less than 1 meter deep water. So the thickness of the sand does not exceed a couple of meters at the beach.

Considering the small extent of sandy beaches and not very active shore processes it is not likely that there will be any notable negative phenomena (decrease in the amount of beach sand) related to the planned activity. As there have not been carried out any researches of coastal processes and sediment movements in Randvere district it is recommended to carry out additional investigations as in Randvere, which would be the basis for further monitoring.

O-Alternative

There will not be any changes in Randvere area, because the extension of the Western Part of Muuga Port is not planned in nearest future. In the Saviranna area there may be some additional impacts on beach caused by the started already large enlargement of the Eastern Muuga Port. The transportation of the suspended sediments during the planned large amount dredging up to the Saviranna beach will be possible (ILAG-HPC-ESP-TALLMAC 2006).

Alternatives I and II

The impacts on the Saviranna beach during the construction of Eastern Breakwater as well, as on Randvere beach during the construction of Western Breakwater will be possible, but negligible (see 5.2). After the breakwaters will be established the impacts on Saviranna beach should be negligible. On Randvere beach they may be more noticeable but how much, is not predictable (see 5.1 and 5.3). In both cases, the impacts will not depended on this will the Alternative I, Alternative II or Alternative III be realized.

References

ILAG-HPC-ESP-TALLMAC. 2006. Technical Assistance for Extension of Muuga Port on the Trans-European Network, Eastern Extension of Muuga Harbour, Environmental Impact Assessment, October 2005

5.4. IMPACTS ON SEA BOTTOM PHYTO- AND ZOOBENTHOS COMMUNITIES

5.4.1 THE POTENTIAL IMPACTS FROM DREDGING

Small-scale dredging impacts (Muuga Port environmental impacts monitoring data)

When the dredging in Port of Muuga has been small-scale then the effect of dredging does not exceed the natural variability of the system. However, due to the regular human pressure in Muuga Bay during last few decades the benthic communities significantly differ between the bays at depths down to 20 m. Deeper down the differences are not significant. In general the zoobenthic communities of Muuga Bay are more variable and less stable. Besides, it is found that in Muuga Bay the share of larger specimens in communities is significantly lower than in Ihasalu Bay. Within Muuga Bay the most impacted communities are found in areas of Port basin and waterways.

As a result of the small-scale dredging activities both the abundance and biomass of zoobenthos was higher in Muuga Bay than in Ihasalu Bay. The filter-feeding species *Mytilus edulis*, *Balanus improvisus* and *Mya arenaria* dominate in abundance in Muuga Bay. Higher share of the filter-feeders can be explained by higher level of eutrophication in Muuga Bay. Increased eutrophication results in the higher pelagic productivity i.e. the food level of the filter-feeders. The proliferation of phytoplankton is usually connected to human activities such as dredging and wastewater inflows. The only invertebrate species that is more abundant in Ihasalu Bay is *Monoporeia affinis*. The latter is very sensitive to the organic pollution. On the other hand, the presence of some nectobenthic species as *Gammarus* spp. and *Jaera albifrons* in Muuga Bay gives reason to believe that the eutrophication level of this bay is moderate.

Similarly, the biomasses of invertebrate species are higher in the shallow waters areas of Muuga Bay than in Ihasalu Bay. The dominants by biomass are the bivalves *Mytilus edulis* and *Macoma balthica* and in Muuga Bay also *Balanus improvisus*, *Mya arenaria* and *Cerastoderma glaucum*. The higher biomass of the above mentioned species in Muuga Bay can be explained by the higher trophic level of bottom sediments in this bay.

When the dredging activities are carried out in areas with high hydrodynamics activities (resulted of currents, regular vessels transit etc) mostly the sedentary species inhabits the dredged sediment and the diversity is low. Only three species - *Hediste diversicolor, Hydrobia ulvae* and *Macoma balthica* are found in those areas. When the accumulation of organic matter in sediments is higher, then the diversity becomes much higher and the taxa such as *Oligochaeta*, *Hediste diversicolor*, *Corophium volutator*, Chironomidae, *Hydrobia ulvae, H. ventrosa*, *Cerastoderma glaucum, Macoma balthica, Mya arenaria* and *Mytilus edulis* are present.

Large-scale dredging impacts(Muuga Port environmental impacts monitoring data)

The drastic changes in zoobenthos communities follow the large-scale dredging. The restoration of these communities is longer. Even more, in some cases the new stable communities may establish. As a result of instability of bottom sediments in depths less than 1 m the benthic macroalgae are likely to disappear in the Eastern Muuga Bay. However in depths 2 – 3 m the green algae *Cladophora glomerata* becomes very abundant and cover almost 100% of hard bottoms. In depths of 3-4 m the algae is likely to decrease again. Further down in depths of 4–5 m the biomass and biodiversity of the algae will increase again. However, the communities are dominated by annual algae only.

As result of large-scale dredging all nectobenthic herbivorous species e.g. *Gammarus* spp. is likely to disappear. Dredging activities have severe impacts on macroalgal communities and therefore on benthic invertebrates living within the macroalgae. The most sensitive communities to dredging are located in the area close to Tahkumäe cape.

Soon after the large scale dredging the total abundance and biomass of zoobenthos increases in Muuga Bay and within the surrounding bays. So, in contrary to the small-scale dredging, the zoobenthos communities in Ihasalu Bay do not differ significantly from these in Muuga Bay.

The increase of total abundance and biomass of zoobenthos communities is mainly due to the proliferation of the two species of bivalves *Macoma balthica* and *Mytilus edulis.* It is likely that the densities of *Hediste diversicolor*, *Hydrobia ulvae Theodoxus fluviatilis* and *Balanus improvisus* is also increasing but their share to total abundance and biomass will not be high.

However, in areas with active hydrodynamics processes the zoobenthic communities become even poorer as compared to the small scale dredging. If the small scale dredging activities results in relatively diverse communities with *Macoma balthica, Hydrobia ulvae Potamopyrgus antipodarum, Hediste diversicolor, Corophium volutator* and also *Oligochaeta*, then after the large scale dredging only *Macoma balthica* is only to be found there. However, despite of the drastic decrease in biodiversity, the total abundance and biomass of zoobenthos will increase.

In depths below 30 m the impacts of large-amount dredging is not as clear as in the shallower areas both for the abundance and biomass of zoobenthos. The dredging induced variability of zoobenthos communities is likely not to be high in these areas.

5.4.2. THE PARTICULAR IMPACTS OF THE BREAKWATERS CONSTRUCTION ON BENTHIC COMMUNITIES

Due regard the 5.4.1 these impacts are as follows:

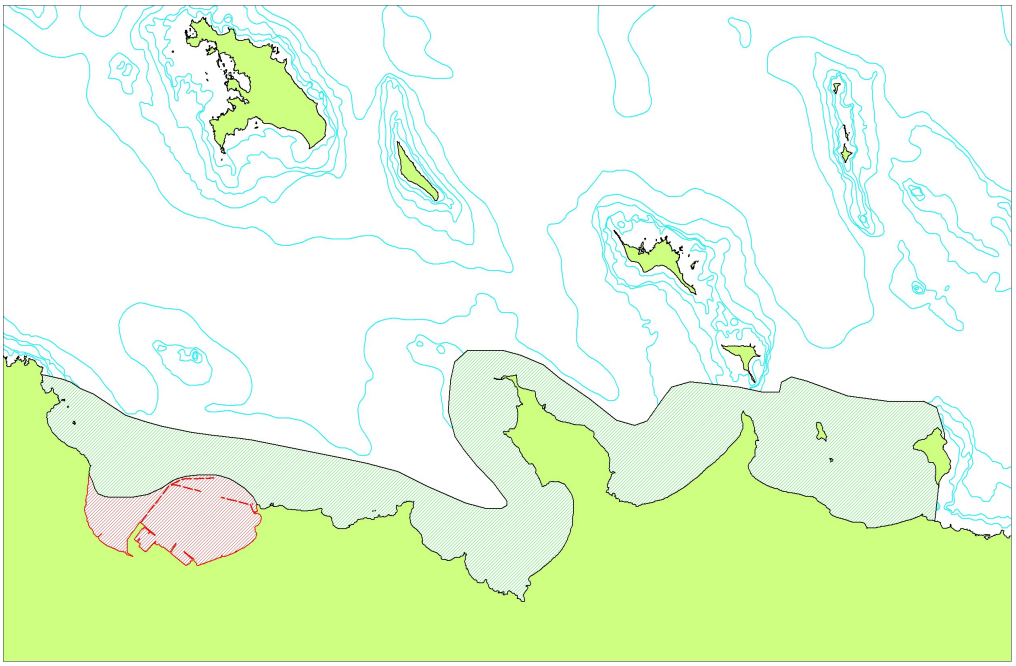
The fully destroying (mechanically) of the existing bottom communities within the sea bottom area straightly being under a rubble mound reef-breakwaters and also surrounding areas very close to those. Totally the area, where the bottom communities will be destroyed have a dimension of about 30-70 hectares depends on alternative.

During the construction of the breakwaters the organic content of the sediment is likely to be slightly increased. Soon the organic matter will be deposited to the deeper areas and following the improvement of feeding conditions the biomass of macrozoobenthos increases. The impacted area is between 10–20 m and the duration of impact is less than 2 years.

Following the construction of the breakwaters the type of substrate is changed. The addition of hard substrate will favor the establishment of annual filamentous algal and associated invertebrate species. Below photic zone the suspension feeding bivalves will establish at high biomasses.

The most important impact is the change in current directions and magnitude. The large amounts of organic matter will sediment within the new Port area. Sedimentation processes increase with the retention time of water in the basin. Following the accumulation of organic matter the oxygen condition of the sediment will deteriorate and in extreme case the development of lifeless zones of 5 km^2 is likely for Reference layout and of 4 km^2 for Budget layout (sees Section 2). Thus, it is important that the selected construction plan of breakwaters takes into account the dominating currents in Muuga Bay and results in maximum water exchange between the port area and the adjacent deeps in Muuga Bay. The impact of breakwaters outside of port area is harder to predict. It is likely that the eutrophication level will increase in the western parts of Muuga Bay resulting in the reduction of diversity and the prevalence of opportunistic species. Following the blooms of the filamentous algae, the densities of the herbivores *Idotea baltica*, *Idotea chelipes* and *Hydrobia* spp. increase. *Macoma balthica* will increase in biomass in sediments. In the eastern part of Muuga Bay the water transparency will reduce resulting in the impoverishment of benthic vegetation and associated invertebrates. The described impacts are irreversible.

Figure 85. The areas within it the macrozoobenthos potentially may affect. Red area – probably notable impacts and green area – impacts will be non- considerable



Conclusions

O-Alternative

When the breakwaters will not be built the area of pure bottom communities will probably also enlarged because the large extension of Muuga Port Eastern Part and it will not clear that this enlargement will be less then in case with breakwaters, especially to compare with Alternative II.

Alternatives I, II and III

As the main negative impact on sea bottom communities it should be highlighted the fully destroying of the existing bottom communities within the sea bottom area straightly being under a rubble mound reef-breakwaters (less then 12 m depths, Alternatives I and II) and also surrounding areas very close to those parts of breakwaters. Totally the area, where the bottom communities will be destroyed have a dimension of about 40 hectares for Alternative I and 30 hectares for Alternative II (see Section 2). This impact is not allowable to both, for mitigation and for compensation. For Alternative III the sea bottom area, where the bottom communities will be destroyed will be much less – about 10 hectares.

Following the accumulation of organic matter within the newly established Port Basin, the oxygen condition of the sediment will deteriorate and in extreme case the development of lifeless zones of 5 km^2 is likely resulted of breakwaters building when Alternative I was realized and of 4 km^2 when Alternative II was.

During the further exploitation of Muuga Port after the breakwaters will be built, the area with pure zoobenthos communities typical for Port basins (see Section 6) will be enlarged up to all sea area enclosed by Breakwaters.

The total impacts on phytobenthos and macrozoobenthos will probably not depend on this, will the Alternatives I or II used and will be significantly less when Alternative III will be utilized (see Section 2).

5.5 IMPACTS ON FISHERIES

The most sensitive stages during the fish life on the environment, including water quality, are the stages of eggs development and nursery, up to fish larvae grow up to the fry. Exactly dangerous for eggs and larvae development is the deficit of oxygen and/or decreasing the oxygen accessibility. This may be happened without any concrete impact by human activities due to essential hydrological processes. But often the oxygen deficit has generated specially by human activities. One of the most transparent cases is the substantial increasing of suspended sediments in water columns caused by dredging and dumping. The Alabaster and Lloyd (1984) declared that when the concentration of suspended solid materials are more than 5 mg/l above the level of essential for concrete water body concentration, the fish larvae become incapable to respire and may dead. In 1980s the development of Baltic Herring eggs covered by thin layer of mud was studied in situ (Eesti Mereinstituut, 2001). It was found, that when the thickness of mud layer achieved 0.2 mm or more, the 100 % of eggs was dead during certain time.

The fish living at the sea and reached the stage of fry or older, are almost not sensitive to the sediments suspension because they can leave the area impacted by dredging or dumping. Exception is the winter, when water is covered by ice.

In current case the most unwanted time for breakwaters construction, especially for dredging, is spring – the spawning time of most of the fish species in Gulf of Finland. The active spawning season of fish within the area probably being affected (Fig. 1.1.), get start when the sea water temperature reached $+5^0 – 6^0$ C. As average, it usually happened at the 3rd decade of April. Depend on the whether, the spawning season can continue up to the mid of June. The high abundant of fish larvae in the Central Gulf of Finland have usually been estimated up to the end of June.

The impacts on fishery of planned in current case the hydrotechnical works, included dredging/dumping can be described as indirect. They expressed through the reaction of fish on the suspended sediments and, also on the noise of dredging/dumping and others vehicles. The matured fish, being the subjects to fishery, can leave the areas close to dredging/dumping places. Gears, seeing to fish in those certain areas (were specially built) became not usable. Also, when the reproduction efficiency should be decreased due to negative impacts of all Muuga Port activities, the fished stocks conditions may substantially worsened and the catches of those species will be drop down. The recovering of damaged fish stocks depends on many factors and can be take some years, i.e. for herring it was estimated to be 2-4 years (Eesti Mereinstituut, 1997).

The significance of possible impacts on fish by alternates solutions of Muuga Port breakwaters construction (see Section 2).

Presently, in current case for Alternatives I and II the significant amount (about 1 milj. m^3) dredging is planned in waters with depths less than 12 m. Because along the parts of Breakwaters having structure as rubble mound reef type, the replacement of soft soil will be needed. Furthermore, the same building of a rouble mound reef part of breakwaters can concur with some sediments suspension. The calculations of the transportation of suspended matter allow conclude, that the most potential spreading direction of sediments with high concentrations is to East – to coastal area of Saviranna (5.2). As it was found during the recent fish monitoring this area is already not fish spawning ground. Also, within this area the spreading of fish larvae is expected to be not high.

But, the possible impacts on nature of migratory of salmon and sea trout into Jägala River may be affected additionally and in cumulating with the others activities in the Port of Muuga. In particular, it may be actual during the Eastern breakwater will be constructed. It should be considered that salmon is the Natura 2000 species (see Section 3).

In the other side, it should be highlighted, that the navigation risks deducted significantly after the breakwaters will be built and so, the probability of pollution of fish spawning grounds in W from the Port (Tammneeme area) as well, as in coastal waters of neighbored bays will be decreased (see 4.2).

After the breakwaters will be built the area of Port basin will increase marketable. It may be forecasted that the volume of total feeding area of fish in Muuga Bay will be decrease due to worsening of zoobenthos communities (see 5.4) within the area enclosed by the breakwaters.

Conclusions

Alternatives I, II and III

The probability of growing significant negative impacts directly from breakwaters construction on fish communities would not be high, expect the impacts on fish migration pattern and in case, when the dredging will not done in April-June.

The mentioned exceptions are actually the only potential negative impact of breakwaters construction on fishery in Muuga Bay, also.

As main negative impact of further Port (with breakwaters) exploitation the decreasing of feeding area of fish in Muuga Bay should be pinpointed. However, it may be take place according the 0-Alternative also, because the substantial increasing of Port activities, due regard the large extension of Eastern Part of Muuga Port (see Sections 1 and 2).

As positive impact on fish communities, the substantial decreasing of the risk of sea pollution caused by vessels, visited the Port after the breakwaters will built, should be highlighted.

O- Alternative

Due to increasing the Port activities and risk of oil pollution the negative impacts on fish communities should be in future probably much higher then today.

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5.6 IMPACTS ON TERRESTRIAL PLANTS, BIRDS AND MAMMALS, AS WELL ON LANDSCAPE AND NATURA 2000 SITES

5.6.1. Birds

During the observations carried out in 2004—2006, 41 waterfowl species were recorded in Muuga Bay; of those the vast majority (41) is feeding in the area. Nine species were regular breeders, twelve species were passing migrants. Of the seventeen protected species, nine are listed in Appendix I of the European Union Bird Directive (79/409/EMÜ). These are: whooper swan, barnacle goose, osprey, spotted crake, bar-tailed godwit, broad-billed sandpiper, Caspian tern, Arctic tern and little tern (Table 8). The impact of planned breakwaters on the birdlife depends on several factors the most important being the movement of suspended matter that, however, may exert a different impact on birds with different feeding habits. If the suspended matter reaches the feeding area of birds in the coastal waters, its deposition may prove fatal to bottom vegetation and invertebrates living on these plants. This may hit hard small snipes and several duck species and other birds feeding on water invertebrates if the suspended matter reaches their feeding area unexpectedly during the nesting period. At other times, the impact is not significant because the diet of these birds contains also vegetarian food. The suspension impacts fish-feeders (mergansers, terns) hampering their feeding and reducing the fish stock in the bay. The impact is greater during the nesting period when the birds are, in a great deal, attached to a certain region. On the other hand, abundant suspension triggers massive development of *Mytilus edulis* community, and improves the feeding conditions of diving ducks – long-tailed duck, goldeneye and eider – feeding on mollusks (see 5.4.2).

0-Alternative

It was stated in the EIA of the Eastern Muuga Port extension that (ILAG-HPC-ESP-TALLMAC. 2006:

The filling works connected with the extension of Muuga Harbour have a negative impact on non-nesting terrestrial and water birds, which use the given area for eating, resting and/or staying overnight. Among others, the species, which nest in the vicinity, eat in the area and their nesting performance may depend directly upon the conditions prevailing in the area.

Thus, all the measures shall be applied so that turbid water would not be carried significantly farther from Muuga Bay and that the eating area to be damaged would be as small as possible.

So, as the extension of Eastern Muuga Port is running already the negative impacts mentioned above are effective during this year and will be thus until the extension will be finished.

Alternatives I, II and III

In high probability, the construction of breakwaters alone won't cause essential irreversible damages to birds in Muuga Bay and surrounding areas because the process is reversible and after the sedimentation of the suspended matter the water biota will probably start to recover outside the Port Basin (see 5.4). The impact caused by the construction of breakwaters may be magnified by the filling and construction works carried out at the same time in the Eastern Part of Muuga Bay and releasing a great amount of suspended matter. For this reason, it is important to take all the feasible measures to prevent the transport of suspension further from Muuga Bay and mitigate the joint effect of these contemporaneous activities as much as possible.

The impacts after the breakwaters will be built should not be noticeable.

5.6.2. LANDSCAPES AND MARINE MAMMALS

The construction of breakwaters will not exert a direct influence on the landscapes and marine mammals.

However, as the breakwaters enable to intensify the movement of ships in future in the Gulf of Finland, then theoretically, this may affect the seals giving birth to the young on the blocks of ice, but evidently this probability is not particularly important.

There will be almost not any impacts on the terrestrial plants and landscapes caused by construction of the breakwaters as well as during its further exploitation.

5.6.3. IMPACTS ON NATURA 2000 SITES

In some member countries of EU the special Impact Assessment (IA) on Natura 2000 sites are needed pursuant to the following European Union Directives:
1) Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora – Habitats Directive.
2) EEC Directive79/409/EEC of 2 April 1979on the conservation of wild birds – Birds Directive.
In the Estonian "Environmental Impact Assessment and Environmental Management System Act", became valid from 3rd April 2005 the § 29 stipulated that, if there are possibilities to impact on Natura 2000 object(s), those impacts should be assessed extremely careful within the EIA and the special public involvements as well the special adjustments should be done.
In our case the Islands Prangli and Aksi Natura 2000 site is potentially be affected and the requirements of Directive 92/43 EEC should be taken account, especially Article 6 entitled as "Conservation of natural habitats and habitats of species".
Actually, this Natura 2000 site may be affected by dumping only, because the dredging areas in Muuga Port located too far.
However, the dredging and building of breakwaters may potentially affect several species included into Annexes I and II of Directive 92/43 EEC:
1) Marine mammals: gray seals *(Halichoerus grypus);*
2) Fish: *(Cottus gobio)*, *(Salmo salar)* and also *(Lampetra fluviatilis)*,
3) Mollusks: *(Unio crassus)* and *(Vertigo angustior)*.

Also, some species of birds included into Natura 2000 list, may be affected: (see 5.6.2) *Cygnus cygnus, Branta leucopsis, Calidris alpina, Limosa lapponicus, Pandion haliaetus, Porzana porzana, Sterna albifrons, Sterna caspia* and *Sterna paradisaea.*
Cottus gobio is very rear in Estonian coastal sea and the probability to impact it is close to zero.
Lampreys spawning grounds located in Jägala River, to where the impacts from breakwaters building will probably not arrived.
Salmon. River Jägala has been one of the most important salmon river up to the 1930s, when the electric power station was built. Also, the pollution of the river by Kehra Pulp Mill Factory has been high during the second half of last century. Recently the health of the river was recovered and the programme of the salmon stocking into Jägala River started. The probability of transportation the sediments suspended during the breakwaters building up to the Jägala River is almost zero and the possibilities of negative impacts on salmon reproduction should be close to zero, also.
The potential negative impacts on birds (included Natura 2000 species) were described in subsection 5.1. and they were estimated to be inconsiderable.

Conclusions
Finally, it should be concluded that no significant impacts affecting the goals and integrity of both, Natura 2000 sites and species should be arise resulting the building and further exploitation of the breakwaters in Port of Muuga.

References
ILAG-HPC-ESP-TALLMAC. 2006. Technical Assistance for Extension of Muuga Port on the Trans-European Network, Eastern Extension of Muuga Harbour, Environmental Impact Assessment, October 2005

5.7 IMPACTS ON LOCAL HABITANTS

The several numbers of interest groups was defined in Section 1. They are:

- Port owners
- Port personnel
- Port clients: passengers, sailing boat owners, cargo and ship owners, etc.
- People living in port surroundings.
- Fishermen fished in Muuga Bay
- Surrounding municipalities
- From these the 4 and 6 groups can be fully or partly accounted into the category of "local habitants"

Negative Environmental and Social Impacts

Local habitants and Municipalities

The Muuga Port is located at the territory of three Municipalities: Jõelähtme rural municipality (Eastern Part), Maardu City (Central Part) and Viimsi rural municipality (Western Part). All those municipalities have included special items into their comprehensive and/or general plans considered the current activities and development of Muuga Port, because the negative impacts, sometimes serious on local residents and summer-houses owners, are already obtained wide publicity.

As it was designated in EIA Report of Eastern Extension of Muuga Port (ILAG-HPC-ESP-TALLMAC. 2006) the negative impacts of all activities of Muuga Port on local habitants can be mainly accompanied by: industrial and transport noise, noise from technological equipment; pollution of ambient air by fertilizers and coal dust and gaseous pollutants and potential pollution by oil products.

Concerning the breakwaters, the establishing of them will not cause directly the future expanding of the activities of Muuga Port, in difference to the Eastern Port extension. However, especially during the construction process, some additional impacts on local habitants are potentially possible. Furthermore, these negative impacts can cumulated with those caused by Eastern Port extension. As most marketable the ambient air pollution (dust, and noise) caused by direct construction operations and also, by building materials transport should be highlighted.

Air Quality

Construction activities of breakwaters in Muuga Port involuntarily do not caused any outside air contamination problems on the Port's territory or in its vicinities. However, during the process of building the breakwaters, some dust is emitted when building materials are loaded, stored and used on the construction sites. Exhaust gases of motor transport present another source of contamination.

It is not yet clear how the building materials will be transported. When land transport will be used, then dust will be emitted during several phases: putting the material into heaps, in days with strong wind and when removing the material from the heaps. Moving of loading equipment and trucks also causes dust emission. When marine transport will be used and materials will not be stored in land, then dust will emitted during loading the materials into the breakwaters frame and it may be substantial impact on local habitants and Port workers only with strong marine winds.

At loading the dry bulk building materials (as sand fill etc.), dust will emit into the atmosphere due to mechanical impact factors. In such cases the dust is classified as unorganized emission, because at the emission of dust the airflow's volume rate is not stable.

The amount of dust emitted at loading of dry bulk materials depends on the material turnover, time of keeping it in the heaps, material's moisture content, and the share of fine particles in the material.

The distance of spreading of dust particles depends on the height at which they were emitted and particles' dimensions. Results of investigations indicate that at wind speed 16 km/h the particles over 100 μm in diameter deposit at a distance of 6–9 m, and those 30–100 μm in diameter 60–90 m away from the place of emission. According to published materials, at loading of sand the intensity of dust emission is 0.5 g/s and of gravel – 2.7 g/s. The measurements made during loading of dry bulk cargo in Estonian harbours, mining in quarries and storing show that actual emissions are always smaller than those presented above. (ILAG-HPC-ESP-TALLMAC. 2006).

Estonian Ambient Air Protection Act (RT I 2004, 43, 298) establishes the requirement of noise map and action plan for reducing ambient noise levels.

In order to provide a general assessment or general forecast of the noise levels created by various noise sources, a strategic ambient noise map shall be prepared. A strategic ambient noise map shall include information on the noise sources causing the spreading of noise, the extent of the spread of existing or predicted noise, location of inhabitants and dwellings, data on the number of inhabitants and construction works, specific characteristics of the construction works and other necessary data.

It should be pinpointed that Port of Tallinn and Estonian Railways (AS Eesti Raudtee), as the noise sources in Muuga Harbour area, have not yet the corresponding strategic noise map as well, as an action plan for reducing the noise level.

It should be taken account by Port authorities, that in case of doing the constructions of new berths (and mainland objects) in Eastern Port basin and breakwaters, the noses caused by both can be cumulated.

Impacts on recreational attractively of the surrounding region

Those impacts can be caused mainly by suspended sediments arriving into the areas of public beaches. In current case, the probability of this situation will be very low (see 5.1 and 5.2).

Noise

Noise in port operation is usually caused by technological equipment of harbour facilities, cranes, loading processes etc. It must be followed that noise limits are not exceeded during construction works of breakwaters in working environment and in neighboring dwelling areas, especially in the nighttime.

Of course, the main noise source in the Muuga harbour area is railway and car transport servicing the harbour. Muuga railway station has a railway connection from Maardu station. The railway runs between the area of Muuga settlement and former flotation sand depository. Railway noise causes disturbances to the owners of the houses and the land units in Uusküla village that adjoin the railway station.

In connection with the breakwaters construction works more actually the impacts may be able during the building of the Eastern Breakwater because there are two houses at the distances of about 900 hundred meters (at another side of railway).

According to the regulation no 42 of the Minister of Social Affairs of 4 March 2002 the equivalent level of traffic noise may not exceed 60 dB(A) in the daytime and 55 dB(A) at night. In case of single noise occurrences related to traffic also maximum noise level is estimated, which can not exceed 85 dB(A) in the daytime and 75 dB(A) at night in dwelling land.

Fishermen

As the commercial fishery in Muuga Bay is not intensive (2.7) the possible negative impacts on commercial fishery (4.6) can be concluded as negligible. However, few numbers of non-professional fishermen, fished recently within the area being enclosed by future breakwaters, should be over located to fish in new areas.

Positive Environmental and Social Impacts

It must noticed , that some possible effects on habitants of settlements will taken place, also.

At first, during the construction works up to 60 peoples can have an additional source of employment for three years. It may have a significant support for example the habitants of Maardu city, where not all people have a job today.

Secondly, the minimizing of the risk of oil pollution, what is potentially occur with Breakwaters establishing (see 4.2), has the positive results to the coastal settlements around the Muuga Bay and surrounding bays also.

All the impacts on local habitants, mentioned above in current sub-chapter will almost not depended on this, which from two alternative solutions of combined structural of breakwaters (Alternatives I and II) will be used.

When the fully piled structure of breakwaters will be used (Alternative III), the probabilities of atmosphere pollution with dust will be decreased significantly.

The additional affecting of local habitants will be absent, when breakwaters will not be constructed (0-Alternative).

References

ILAG-HPC-ESP-TALLMAC. 2006. Eastern Extension of Muuga Port. Environmental Impact Assessment

5.8 THE EVALUATION AND COMPARISON OF THE SIGNIFICANCE OF IMPACTS IDENTIFIED TO ACTUAL

Negative Environmental Impacts

The most important for current EIA is the evaluation of the possible negative impacts on marine environment. Because the negative impacts on local habitants as well, as on Natura 2000 objects will be not significant. (see 5.7 and Sections 2 and 3).

0-Alternative, without breakwaters

Concerning to marine environment the negative impacts of Muuga Port already existed many years, especially on the phytobenthos communities (see 5.4). Also, the negative impacts on fish communities were estimated during the last three years (see 5.5). In both cases the biodiversity in area close to the Port was decreased.

Furthermore, since the Muuga Port was built the elevated sea pollution risk have been under the question. A number of small oil pollutions inside the Port basin were occurred. In 26th of September 2000 the most noticeable oil pollution happened (ALAMBRA case) – about 200 hundred tons of heavy oil products were encountered into the sea (see 5.9). It resulted for example on marketable oil pollution of bottom algae's up to the Tahkumäe cape (TÜ Eesti Mereinstituut, 2003) Despite the oil pollution preventation system have been since continuously updated in Muuga Port, the fully avoiding of oil accidents was and will be probably not actually possible (at first due to human factor). In this case, the prompt and absolute liquidation of oil-spills has a top priority. Today, due to that Port basin is opened to the sea, this liquidation is sometimes (storm, heavy ice condition) very complicated.

Also, the obligatory and urgent leaving the berths by vessels, not fully ready to go to sea, concurred with additional risk of oil pollutions. But, without breakwaters it is the usual process in strong storm (see Sections 1 and 2).

Alternatives I and II

The potential during short term future negative impacts on marine environment will be not changed marketable, despite the dredging/dumping will be of relatively large amount. Because the amount of particular dredging should be marketable less, then the planned amounts of dredging/dumping for Eastern Port extension, running in parallel. The fully destroying of the existing bottom communities within the sea bottom area straightly being under a rubble mound reef-breakwaters and also surrounding areas very close to those, is the only exception. Totally the areas, where the bottom communities will be destroyed have a dimension of about 40 hectares for alternative I and 30 hectares for Alternative II. This negative impact is not allowable to both, for mitigation and for compensation (sees 5.4).

As it getting a clear from chapters 3 and 4 the new potential environmental impacts will be similar for both two layouts versions mentioned – Reference layout with width of entrance of 600 m and Budget layout (see Section 2). The impacts on the marine environment should be almost the same (see 5.1-5.6). The only two marketable differences may arise:

The Port Basin area will be marketable (about 25 %) less in case of Alternative II, what occurred with potentially less negative impacts on sea bottom communities, especially on zoobenthos.

The navigational conditions inside the Port Basin will be significantly better in case when Reference layout of breakwaters (Alternative I) will be realized and it resulted in smaller risk of sea pollution (see 5.9).

Alternative III

As in this case the dredging will be needed only in places of joining the Breakwaters with existing moles (piers) then the negative impacts occurred should be even more insignificant to compare with the impacts of the Eastern Port enlargement. The mechanical damages of sea communities will be noticeable less then for both, Alternatives I or II.

Positive Environmental Impacts

0-Alternative

No special positive impacts will be arising.

I-Alternative, II-Alternative and III-Alternative

The most marketable positive effect from the environmental point of view will be the significance minimizing of risks of navigation accidents resulted with decreasing the risks of sea pollution. However, despite the navigation simulation for Budget Layout (Alternative II) was not done during the preliminary planning, the navigation conditions in case when this alternative will realized will probably be much worse then in case of Alternative I or Alternative III, i.e. when the Reference layout of Breakwaters will be used. Because the Port Basin for these alternatives will be marketable larger which means that the navigation safety inside the Port will be higher.

Additionally, the construction of breakwaters solved the economical profits for Port of Muuga because the significant reduction downtime of vessels as well, as improving the vessels service quality in Port. Here, the little advantage of the Alternative I should be pinpointed, also.

5.9 ENVIRONMENTAL RISKS DURING CONSTRUCTION AND OPERATION OF THE BREAKWATERS

5.9.1 NAVIGATIONAL RISKS

0-Alternative

There will probably be a significant increasing of Port activities due to construction the new quays in the Eastern side in nearest future despite the breakwaters will not be constructed. The newly established eastern quays will not be sheltered from the N-NE storms (as also the existing berths 4, 7, 8, 9A, 10A and 11) and the number of vessels, obligatory leaved the berths in storm, will be much higher then it was described in Sections 1 and 2. It resulted, that the risk of accidents with vessels maneuvering inside the Port Basin may arise also. In this situation, the risk of accident pollution of the sea inside the Port Basin without breakwaters should arise correspondingly. Even more, the liquidation of those pollutions will be continuously complicated because the area polluted will not be enveloped.

Alternatives I, II and III

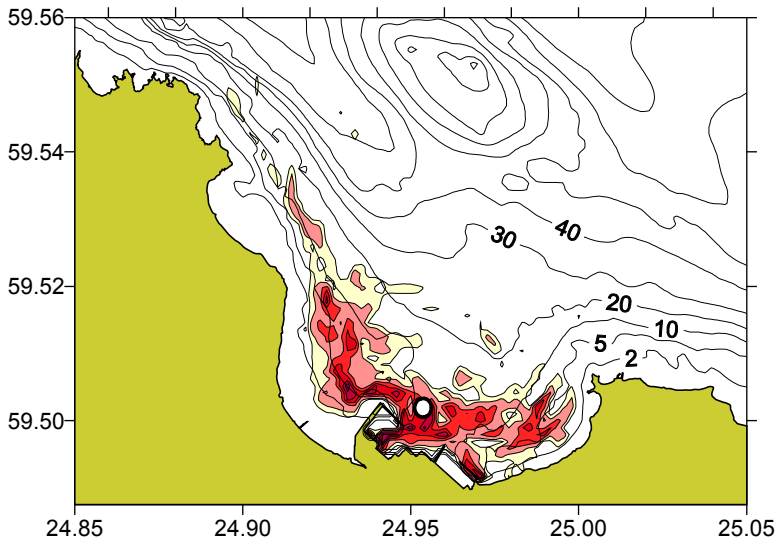
The both new (planned) and existing berths will be much more sheltered from winds and waves as well from icing. The number of vessels, obligatory to leave the Port will decrease marketable for all these Alternatives. As result, the probability of vessels accidents will decrease noticeable, also. However, due regard that newly established Port Basin for Alternative II will be much smaller (about 20 – 25 %) and there will be only one turning ring in Port Basin, the navigational risk for the Alternative II will stay with more high probability to compare with Alternatives I and III.

5.9.2 OIL SPILLS AND RELATED ENVIRONMENTAL RISKS

Methods for calculating the probability of spreading of the oil spills are described in 4.10, where the impact of breakwaters is analyzed.

The probability calculations for spreading of the oil spills at present conditions were done in the case where the pollution source is located in the vicinity of quays (Elken and Kõuts, 2001), in a region that will be surrounded in the future by breakwaters. The spatial probability map (Figure 85) shows, that within the long-term weather conditions used in the numerical experiments, the most probable oil spill spreading in 24 hours occurs about 2 km to the east. Spreading of oil spill is hampered by the vortex structures in the flow. Small transfer speeds favor localization and removal of oil. The most endangered coastal region is to the east from the harbor until the Tahkumäe cape.

Figure 85 **Spreading of oil spill in 24 hours after accidental spill. The pollution source is given by a circle. Isocline 0.05, 0.1, 0.2, 0.3 etc show the number of days during a year, when oil pollution may be found in the corresponding 1 ha area. Figure shows also depth contours.**



Spill of heavy oil that occurred from the tanker "Alambra" in September 2000 shows that smaller probability of spreading the oil spill to the west does not exclude such possibility. From the single-hull tanker "Alambra", staying at the Muuga Harbour, 250 tons of heavy oil leaked in 16 September 2000 (HELCOM, 2001). After discovering the leakage, the tanker was surrounded by harbour booms to minimize the spread of oil. About 60 tons of oil pollution reaching the Muuga Bay was recovered by the combating vessel. First signs of oil beaching in the Viimsi peninsula where recorded on 19 September. Recovery of coastal pollution was finished by 28 September.

Simulation of "Alambra" oil spill was done using the wind data measured in the Muuga Harbor automatic meteorological station with 5-min interval. Starting from 7 September, the wind direction rotated from the north clockwise until the full circle was done by 14 September. At the same time the wind speed oscillated periodically from 2 m/s to 10 m/s. From 15 to 20 September the wind speed was small (<5 m/s), whereas NE and SE winds dominated. This period includes discovery of oil spill on 16 September and first oil beaching on 19 September between Tammneeme and Leppneeme. Further spreading of oil spill towards the Viimsi Peninsula was amplified by the bursts of stronger (8-12 m/s, occasionally up to 15-16 m/s) easterly winds occurring on 21 September. The markers simulating the oil spill were released in the model experiments 16.09.2000 at 18:00 near the quay of the harbor. Spreading patterns of oil spill markers are given in Figure 86. Near the harbor, the currents were oriented alongshore towards the Viimsi Peninsula. During the period of calm winds the currents in the open bay area performed clockwise rotating oscillations as a result of earlier wind events. That is the reason why oil spill markers detached from the coastal area before reaching Leppneeme and formed mushroom structure at the head of spreading oil spill. Before re-beaching after 20.09.2000 the open sea oil tongue made clockwise rotation. The spill beached in Leppneeme in 19.09.2000 and continued spreading towards the tip of Viimsi Peninsula that accelerated in 21.09.2000 during stronger easterly winds. By the results from the oil spill simulation, the whole coastal strip from the Muuga Harbor to Leppneeme was polluted by 19 September. This simulation is in good agreement with the actual sequence of spill events.

As shown by the “Alambra” case, oil spill risks are significant at present harbor layout. The oil spill occurring at the harbor may spread relatively fast over large sea area. Therefore bounding and removal of oil spill is complicated, especially at stronger winds. Both eastern and western areas (relative to harbor) are exposed to the oil spill risk.

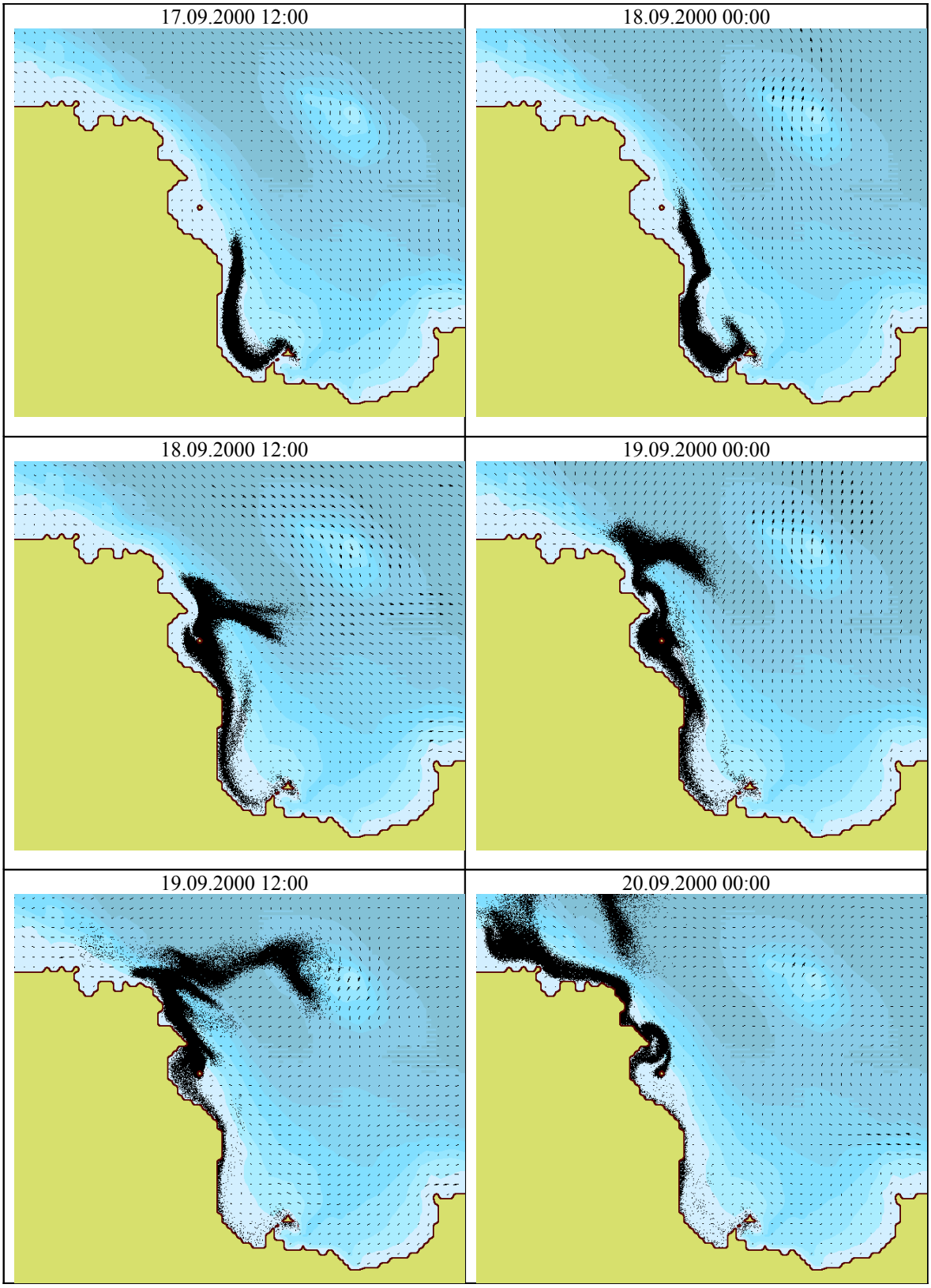
References

Elken, J., T. Kõuts (2001). Hüdrodünaamika ja meteoroloogia. 1 peatükk aruandest “Muuga sadama ehitusaegne seire 2000. aastal”, Eesti Mereinstituut, tellija AS Tallinna Sadam.

Elken, J., T. Kõuts, U. Raudsepp and L. Sipelgas (2004). Portable coastal operational oceanographic system to monitor the harbor-related environmental impacts in Estonia. Proceedings of the USA-Baltic International Symposium "Advances in marine environmental research, monitoring and technologies", Klaipeda, 15-17 June 2004, 6 pp. (CD-ROM).

HELCOM (2001). Report on the tanker Alambra accident. // HELCOM SEA 2/2001, 4.3b/5 (HTTP://www.helcom.fi).

Figure 86 Oil spill simulation from the tanker "Alambra", September 2000.



5.10 MITIGATORY MEASURES

0-Alternative

The risk of negative impacts caused by potential navigation accidents inside the Port basin has been recently not very remarkable, but was not close to zero. The most hazardous ALAMBRA tanker's oil disaster was happened in 26th September 2000, when about 200 tons of heavy oil was spilled inside the Port Basin and spreaded up to the Tahkumäe Cape (Figures 1.1 and 86). Approximately 2 kilometers of coastal lines was polluted, also. It must taken account that substantial volumes of oil products are at present being handled in Muuga Harbour at berths located in the south-western part of the port (Western Basin and Berths 7 and 8). Recently, the finger pier was extended for accommodating large oil tankers of over 300m at Berth 9A / 10A.

Although the Western Basin could be closed in case of an oil spill inside, this is at present not the case for Berth 7, 8, 9A and 10A which are all in open connection with the Muuga Bay.

Vessels berthed at present at Berths 4, 7, 8, 11, 12 and 33 experienced downtime during rough weather conditions. The all vessels (not only tankers), leaving the Port and anchored in the open Muuga Bay in strong storms will become an additional risk factor of sea pollution. Especially in winter time, when the moving block of ice are usual for Muuga Bay.

The following arrangements should be implemented:

1. For minimizing environmental risks during the Port exploitation the all relevant legislations acts will be needed to fulfil. The special needs of the loading and discharging of oil and oil products established in annex 1 to MARPOL (Marine Pollution) 73/78 to tankers must be followed carefully. The matter of training of crew and harbour personnel can be intolerably accepted. Also, the being in possession oil spill response materials and ready to immediate use. Harbour personnel should be trained how to use these materials. A new oil spill response plan should be prepared and implemented.

2. The next circumstances, settled in active today Port Rules of AS Tallinna Sadam will be fully executed:
   - In Muuga Harbour the moorage of vessels at berths no.7, 8, 9 and 10 is allowed in cases wind speed does not exceed 12 m/ s, at berths no.7 and 8 only in case of favorable weather forecast for the next 24 hours.
   - Upon receiving a storm warning (wind speed of 25 m/s and over) the captain of the vessel or chief officer will arrive at the vessel. In such a case vessels will be plugged off the electricity system on shore. The warning is forwarded by the Harbour Master's office, which will set the order of vessels leaving the port.
   - The aquatory of Muuga Harbour and inner roads are not protected from northwest, north and northeast winds. If the speed of such winds exceeds 17 m/s, the standing of vessels, especially at berths no. 4, 7, 8 and 11 will due to high sea become dangerous for the vessel. If the height of waves exceeds 1.5 m, the use of tugboats will be restricted. Then the captain of the vessel together with the Harbour Master's office will decide the leaving of the vessel.

3. The substantial replenishment of Port Rules must done due regard the navigation safety and environmental requirements, after the planned extension of the Eastern Port facilities will be fulfilled because this part of Port will be not sheltered to storms from NW-NE sector (see 4.1). The possibilities of icing of the vessels and berth in Eastern Port will be accounted also (see Section 1).

4. The environmental monitoring should continue due regard the existing monitoring programme (TÜ Eesti Mereinstituut 2005) and recommendations given in chapter 8.

I-Alternative

The recommendations no 1 and no 4 gave above for 0-Alternate should be in force.

Additionally, the next mitigation measures should be implemented.

5. During the breakwaters construction the prevention of the spreading of suspended sediments up to the Randvere and more western public beaches should be taken into account. For this purpose, the temporary layoff of the Western Breakwater construction should be foreseen in case of strong easterly winds and when the results of operative monitoring (see Section 7) will indicated that transportation of suspended matter to beaches will be actual.

6. The dredging should be not planned at the spring from mid of April until the end of June for minimizing the probability of negative impacts on fish communities in Muuga and surrounding bays (Figure 1).

7. For minimizing environmental risks during the Breakwaters construction the all relevant legislations acts as well as the GMP will be needed to fulfill. The matter of training of vessels crew and others people participated in construction can be intolerably accepted. Also, the being in possession of facilities of liquidation of oil etc. pollutions should be available and ready to immediate using astonishingly. The contractor should update an Environmental Management Plan and fulfilled it.

8. During the breakwaters construction the spill of constructions materials including the sand fill to the sea bottom surrounded, should be avoided.

9. The noise monitoring should be done during all the duration of the breakwaters construction due regard the cumulative effects of others Port activities included the Eastern Port extension works. When the equivalent level of cumulative noise will exceed the stated by the regulation no 42 of the Minister of Social Affairs of Estonia of 4 March 2002 noise norms: 60 dB(A) in the daytime and 55 dB(A) at night inside the dwelling land, the special measures should be taken and the relevant authorities must be informed. Those measures may include: the temporary layoff of works concurred with high level of noise (plugging, movement of heavy cars etc.) the coordination of breakwaters construction with others Port (construction) activities for regulation the cumulative noise level, the regulation of construction works (i.e. dredging and plugging) due regard the wind direction etc. Also, the recommendations of EIA Report of the Eastern Basin of the Muuga Port will be taken account.

10. During the further exploitation of the Muuga Port with breakwaters, the prompt and absolute liquidation of oil-spills must be a top priority of Port authorities continually. The fully closing of the breakwaters entrance by oil-barrier must be available despite the rough weather. The new Oil spills response plans of Muuga Port should be implemented, including materials and training.

II-Alternative

The mitigation measures no 1; 4; 5; 6; 7, 8, 9 and 10 mentioned above, are recommended to fulfill.

III- Alternative

The mitigation measures no 1; 4; 5; 6; 7, 8, 9 and 10 mentioned above, are recommended to fulfill.

Despite in this case the dredging amount will be not marketable (see Sections 2 and 3), it should not be recommended during the spring, due regard the possible cumulative impacts with other activities of Port of Muuga.

5.11. The compliance of Project with EU and Estonian legislation, regional development plans and detailed planning.

5.11.1. Estonian legislation.

"Environmental Impact Assessment and Environmental Management System Act" (RT I 2005, 15, 87).
The Developer engaged the EIA from Royal Haskoning (Netherlands), where the special temporary Expert Group was established by leading of licensed EIA expert Ahto Järvik (licence no 0028, valid up to 2011).
Expert Group compiled the Scope of EIA, what is crossed the required procedure of publicity and was approved by the Ministry of Environment in 21.06.2006.
The public meeting of the Scope was carried out in January 25 2006 in the office of the Port of Muuga.
The Report of EIA was ready for publicity in October 2006 and the public meeting was carried out in 20. November 2006.
Both, the Scope and Report of EIA have been available for public familiarization for minimum 14 days.
Expert Group can state that the law of EIA was fully filled.

"Water Act" (RT I 1994, 40, 655), and the further modifications (RT I 2000, 81, 514). The requirements of this law concerning the activities in the sea (including dredging/dumping) were found the computation in the designing of the Breakwaters construction and the special requirements needed to be called away during the construction process and also further, during the exploitation, will be written in the Permission giving to the Developer.
The law is taken account.

"Fishing Act" (RT I 1995, 80, 1384), and the further modifications (RT I 2000, 81, 514), (RT I 2004, 89, 609), etc. The established in § 20 the requirements of avoiding the negative impacts on the fish communities was taken account during the compilation of EIA and the special recommendations were done in chapter 4 for avoiding or minimization of these. Those recommendations will be taken account in Permission giving to the Developer.
The law is taken account.

"Ports Acts" (RT I 1997, 77, 1315), and the further modifications. The law is taken on basis of designing the Breakwaters configurations and construction, for planning the navigation systems etc. All project documentations will be fully adjusted be the special Estonian authorities required in current law, before its implementation. The construction of breakwaters will guarantee more high navigation safety and easier navigation in Port.
The law is taken account.

"Nature Conservation Act" (RT I, 26.02.2004, 9, 52). The requests of this Act were taken account in recommendations concerning the conservation of nature during the construction of breakwaters (chapters 2 and 4). Needed nature protection measures are recommended in subsection 4.11. These measures should be included into the Permission,

Waste Act (RT I 2004, 26.02.2004, 9,52). There are the waste treatment facilities in Muuga Port already.

Building Act (RT I 2002, 47, 297). The further enlargement and updating of Muuga Port is one of the main goals in State Strategic plan Estonia 2010 in chapter 7 (traffic systems).

Connection to others Estonian Acts occurred through these basic in current case Acts, mentioned above.

Muuga sadama lääneosa detailplaneering (Viimsi Vallavolikogu 11.06.2002.a. otsus nr.114)
Harju maakonna ”Maakonnaplaneering”, kehtestatud Harju maavanema 19.aprilli 1999.aasta korraldusega nr 1682.
Harju maakonnaplaneeringu teemaplaneering. 2003. Asustust ja maakasutust suunavad keskkonnatingimused. Seletuskiri.

The activities will not be in contrary to the existing Detail Plan of Port of Muuga.

5.11..2. International conventions

CONVENTION ON ACCESS TO INFORMATION, PUBLIC PARTICIPATION IN DECISION-MAKING AND ACCESS TO JUSTICE IN ENVIRONMENTAL MATTERS – the Aarhus Convention.
This conventions requests and recommendations were fulfilled. The publicity of both, Programme and Report were available for public reading for minimum two weeks.

The information about public meetings was given through the official channel of State Announcements, through the regional newspaper and the district government and Estonian Council of Environmental NGOs were informed by post mail also (see Annex 3).
The recommendations of HELCOM were taken account during the planning and performing of the estimation of the pollution of the sediments being dredged.
Additionally, during the further exploitation of the Port, the certain items of IMO should be taken account.

5.11.3. The EU Legislation

The most important EU Directives, which requests undoubtedly needed taken account, are: Directive 97/11/EC on the EIA, Directive 79/409/EEC on wild birds, Directive 92/43/EEC on the conservation of natural habitats.
As the Estonian law *“Environmental Impact Assessment and Environmental Management System Act”* accounted the mentioned above EU Directives, and current EIA is performs regarding this Act, then the EU Directives should be fulfilled.

6. The reasonable utilization of natural resources used for breakwaters construction due regarding the principle of sustainable development

Assessment to determine availability of construction materials

Various structural options have been developed (3.3., Royal Haskoning 2006a and 2006b). As construction materials like sand fill and rock are considered scarce and hence difficult to obtain and the piled breakwater is relatively expensive in shallow water, in June it is suggested to construct a rubble mound structure to the -12m CD contour line (Royal Haskoning 2006b). In water depths deeper than -12m CD it is suggested to implement a piled breakwater structure (Royal Haskoning 2006b paragraph). Referring to the Multi Criteria Analysis and the subsequent evaluation it is proposed to select the Reference layout with a wide entrance (600m) as a one preferred alternative and Budget layout as the second, the Reference layout with wide (same, paragraph 10.4). As comparison the Reference layout with narrow entrance of 300 m will also under discussion below. The others structural and layout options discussed in chapter 3 will not be particular as unrealistic. Table 21 summarizes the construction materials required for the one structural option as an example magnitude of the needs.

Table 21. Preliminary dredging amount and construction materials required for the Combined Structural Design of Rubble Mound Reef (depths less -12 m) and Piles (depths above -12 m) for Alternatives I and II with entrances of 300 and 600 m

Layout option	Alternative I with entrance of 300 m	Alternative I with entrance of 600 m	Alternative II with entrance of 300 m	Alternative II with entrance of 600 m	**Piled Breakwater, Entrance 600 m** 1A-600-P
Dredging (removing of soft layers)	1 248 670	926 696	1 004 468	878 732	
Quarry run bunds 1-300 kg	232 544	164 377	162 535	140 146	
Stones 0.3-1 tons	90 588	67 041	72 309	63 210	
Stones 1-3 tons	472 595	329 088	315 446	270 569	
Stones 3-5 tons	272 385	193 720	193 910	167 538	
Sand fill	1 594 745	1 300 327	1 632 063	1 456 855	
Geo textile	299 099	211 712	209 918	181 086	
Piles Ø1220x12,5 [ton]	27 586	19 568	12 773	10 734	45 691
Piles Ø1320x20 [ton]					13 871
Piles Ø1520x20 [ton]	4 352	4 352	5 583	4 273	4 352
Piles Ø1820x20 [ton]	15 116	9 479	3 033	3 033	9 479
Sheet pile PU 25 [ton]	2 484	1 729	1 069	901	3 404
Cast-in-situ concrete [m^3]	33 922	26 905	25 075	18 855	63 130
Precast concrete [m^3]	8 871	7 036	6 557	4 931	32 509x
Scour protection [m^3]	39 392	28 291	19 084	16 010	72 049

It should be highlighted that in case of using instead the rubble mound reef structural type the rubble mound structural type, dredging amounts needed will subsequently higher. For example, for Alternative I with entrance of 300 m the dredging of 2 419 591 m^3 will needed (M. Sillakivi, personal comment).

Sand fill

The annual need of gravel and sand in Estonia reaches 20 million cubic meters exceeding all other building materials together by amount. Reserves on mainland are initially sufficient but new sites have to be opened constantly and old ones reclaimed.
During recent years the need for filling material for hydro technical buildings has drastically increased in Estonia. Conveying large amounts of sand from mainland is not expedient. The solution is mining sand from the sea AS Port of Tallinn started financing sand investigations in 1994. During years 1994 and 1995 preliminary geological examinations was done on possible sand deposits in the area of Tallinn and Muuga bay [1 and 2]. The sand was needed for filling-works of a coal-terminal built north-east from Muuga harbour. The nearest place to get sand from was Prangli sand reserve, which was also used for that purpose. Now the reserve is exhausted. As the reserve was too small, alternatives had to be considered. The sea area located south and south-east from Naissaare had the most perspective. In 2004 and 2005 geological investigations were implemented in the shallow waters surrounding Naissaare. This area has been examined and the reserves affirmed in the range of many blocks. For Muuga Harbour some of them have also been tapped.
The marine-sands have also been examined away from the harbour of Tallinn. After ferry "Estonia" sank the idea was raised to cover the shipwreck with sand. For that geological investigations were carried out on a sand deposit located nearby Hiiumaa and the reserve was confirmed. It has not been used yet.
Many more little sea-sand deposits are located in Estonian coastal sea, which are located either too close to the coastline or their reserves are small from economical perspective.
The resources of most widely examined sand deposits in Estonian coastal sea [3] are described in the table 22.

Table 22. The resources of sea sand deposits in 2003

	Hiiumaa	Naissaare	Naissaare enlargement
Building sand (m^3)	2 435 000	4 303 000	984 000
Area (ha)	279	235	68
Earth-material (m^3)		2 622 000	
Area (ha)		111	
TOTAL(m^3)	**2 435 000**	**6 925 000**	**984 00**

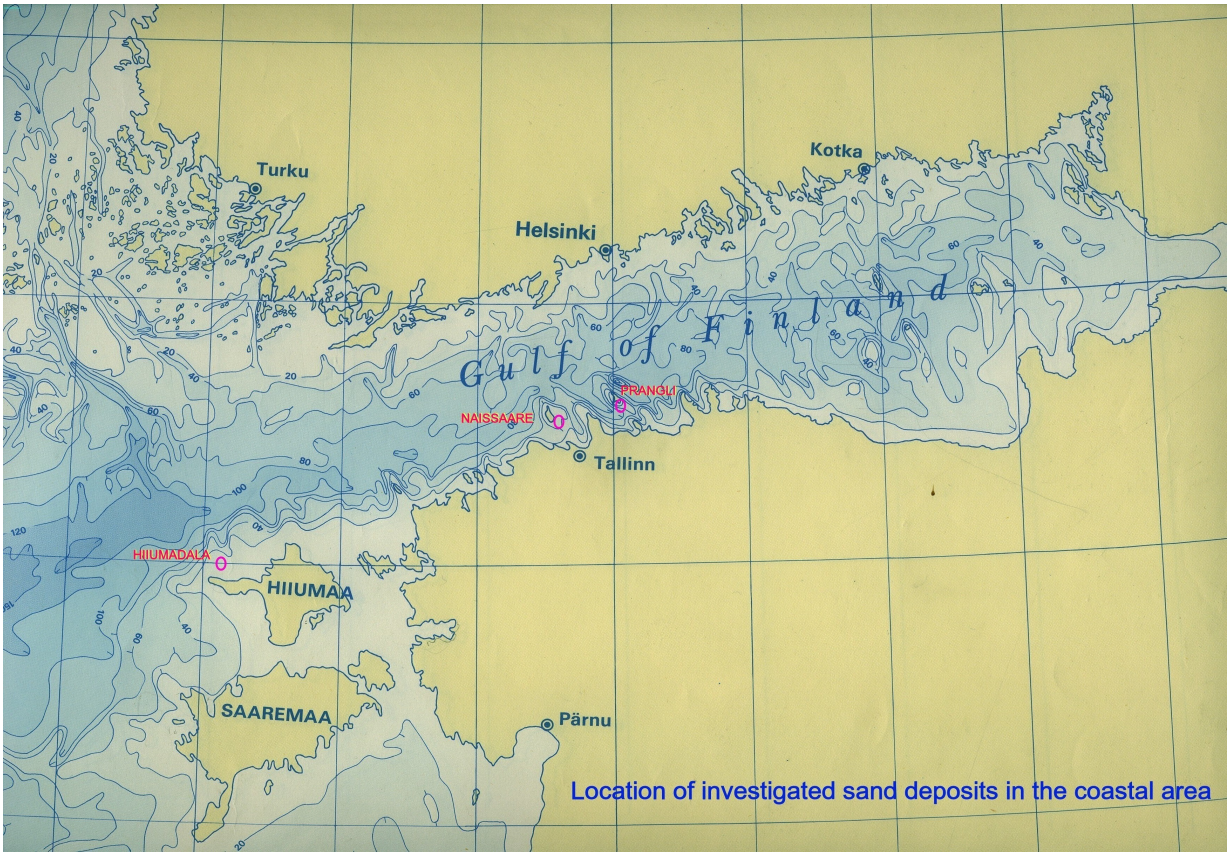
ROCK

Practically available amount of rock (limestone) in region close to Port of Muuga is approximately 200 000 m^3 and siftings **(**Paekivitoodete Tehas OÜ**,** Väo Quarry, Väo Qarry Maardu branch, AS Harku Quarry, also a new quarry Eivere nearby Paide), total volume approximately 1 million m^3. Igneous Rock from Uusikaupunki Finland will be available.

CEMENT

The only real possibility in Estonia is to use the production of Kunda Nordic Cement, loose and packed cement.
All cements can be used for production of constructional structures and ready-mixed concretes, for manufacturing concrete elements and in mortars.
The cements come packaged in 40 kg paper bags on wooden pallets with dimensions of 1000x1200 mm, covered with plastic film (40 bags with total weight of 1.6 t). 40 kg cement bags hold approximately 30 litters.

Figure 87. A scheme of the locations of bigger and examined sand deposits in Estonian coastal sea



STEEL PIPES

Ruuki Products AS is the main supplier of Estonian market with steel pipe-piles and steel pipes. Earlier pipes produced in Russia have also been used. Now, when the price difference is not so big any more and the quality is bad, they are practically not used on important harbour structures.

The offered steel-classes are S355J2H, X60, X65 and X70. The biggest wall thickness in class S355J2H is 18 mm and 16 mm for classes X60-X70. The biggest length of discontinued pipe is 32m. It is also possible to supply longer pipes with factory lengthening piece and also piles with reinforced ends.

References

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[4] Kask, J., Talpas, A., Puurmann, T., Suuroja, S., Fiske, M. Liiva ja kruusa uuring Hiiumaa põhjaranniku lähedal merepõhjas. Eesti Geoloogiakeskuse Meregeoloogia ja Geofüüsika osakond, Jebsens ACZ. 1996, Tallinn. 23 lk. (Investigations on sand and gravel near Hiiumaa north coast at the bottom of the sea.)
[5] Kask, J., Kask, A. Naissaarest lõunas asuva liivalasundi geoloogiline uuring. Käsikiri Tallinna Tehnikaülikooli Meresüsteemide Instituudis, Tallinn, 2003, 18 lk.
(Geological examinations of sand deposit located south from Naissaar.)
[6] Kask, A, Kask, J. Naissaarest kagus asuva liivalasundi geoloogiline uuring. Käsikiri Tallinna Tehnikaülikooli Meresüsteemide Instituudis, Tallinn, 2005, 32 lk.
(Geological examinations of sand deposit located south-east of Naissaar).

7. COMPARISON AND RANKING OF POSSIBLE ALTERNATIVE SOLUTIONS OF THE PROJECT DISCUSSED

It should be pinpointed that the breakwaters construction will be not the single large amount activities in Muuga Port in nearest future. The extension of the Eastern Basin is already started and concur with very significant environmental impacts on both marine and terrestrial environment as well as on habitants of living close to Port settlements (ILAG-HPC-ESP-TALLMAC. 2006).
As the construction works of breakwaters and their further exploitation will probably no concurred with marketable direct impacts on marine and, even more truly, terrestrial environment, then the indirect impacts would be taken account for comparison of realistic alternative solutions, described in sub chapters 3.3-3.5. In those sub chapters, the 3 alternative solutions were let for further environmental impacts assessment:
Alternative 0 – the breakwaters will not be constructed
Alternative I - Reference layout with a entrance of 600 m and combined rouble mound reef + piled structural
Alternative II - Budget layout with a entrance of 300 m and combined rouble mound reef + piled structural
Alternative III – Reference layout with entrance of 600 m and fully piled structural

7.1. Comparison of alternatives by navigational and technical aspects caused indirect impacts on marine environment

In chapter 4 it was found that one of the most substantial indirect impacts consists in the influence on the level of navigational risks and potentially concurred risks of sea pollution.
The navigational risks which are typical for vessels moored in Port mainly depended on the level of sheltering of the mooring place from winds, waves and also icing in winter time.
Furthermore, the economical efficiency of the Port depends distinguishable on the navigation conditions and safety of vessels visited Port.

Alternative 0.

The most potential risk of sea pollution is associated with oil spill and it is not accompanied only with tankers, but actually all vessels can taken as potential source of oil pollution of the sea.
Substantial volumes of oil products are at present being handled in Muuga Harbour at berths located in the south-western part of the port (Western Basin and Berths 7 and 8). Recently, the finger pier was extended for accommodating large oil tankers of over 300m at Berth 9A / 10A.
The moorage of vessels at berths no.7, 8, 9 and 10 is allowed in cases wind speed does not exceed 12 m/ s, at berths no.7 and 8 only in case of favourable weather forecast for the next 24 hours.
Also, currently small vessels experience difficulties while manoeuvring inside the harbour area during rough weather conditions as they are fully exposed to incoming waves.
Upon receiving a storm warning (wind speed of 25 m/s and over) the captain of the vessel or chief officer will arrive at the vessel.
The aquatory of Muuga Harbour and inner roads are not protected from the sector NW to NE winds. If the speed of such winds exceeds 17 m/s, the standing of vessels, especially at berths no. 4, 7, 8 and 11 will due to high sea become dangerous for the vessel. If the height of waves exceeds 1.5 m, the use of tugboats will be restricted. Then the captain of the vessel together with the Harbour Master's office will decide the leaving of the vessel.

- Up to 12 m/s – All small vessels with a length below 100m;
- Up to 17 m/s – All ballasted vessels;
- Up to 25 m/s – All vessels even with cargo.

Although the Western Basin could be closed in case of an oil spill inside, this is at present not the case for Berth 7, 8, 9A and 10A which are all in open connection with the Muuga Bay.
The number of days that vessels had to wait at anchorage locations, due to bad weather was (Royal Haskoning 2006a)

- 2002 – 125 days;
- 2003 – 77 days;
- 2004 – 45 days;
- 2005 – 28 days.

The new port development at the eastern side of Muuga Port has a number of port basins with vessels berthed in a NW – SE direction as well as with a number of NE – SW berths (Fig. 1.2). In particular the latter berths will be susceptible to considerable

It can be concluded:

- that currently the risk of sea pollution in Muuga Port is not at the wanted level. For avoiding the navigation accidents in Port the vessels should leave the Port. The last actions are not only economically harmful, but the vessels stands at the Road are continuously sources of elevated risk of sea pollution;
- the navigational conditions for vessels visited the Muuga Port are today not at the level wanted;
- today, the Port of Muuga, the ship-owners and the Ports operators all have marketable economical losses because the vessels are obligatory downtime in rough weather.

Alternatives I and II

These alternatives, Reference layout (006-1A) with wide entrance (600 m) and Budget layout (008-3) with entrance of 300 m, have been preferred by Planners as technically easier and with acceptable costs (7.3) in June 2006 (Royal Haskoning 2006b).
The breakwaters should provide an opportunity of protecting berths 4, 7, 8, 9A, 10A and 11 in emergency circumstances mentioned above according to 0-Alternative. Also, when the new berths in Eastern Basin will be under the exploitation, they will be more sheltered from the rough whether, too. So, the navigation risks vessels moored at the berths will be minimized significantly when breakwaters will built.
However, it should be accounted, that the risk of oil spill will never be equal to zero because the human factor. Some probabilities of overflows, technical accidents etc. are potentially existed in such large ports as Muuga Port for ever. So, needs for the prompt and absolute liquidation of oil-spills, happened inside the Port basin (area enclosed by the breakwaters) and moved at surface, will be continual. During the preliminary planning process the Planner was studied the two different entrance width – 300 m and 600 m and concerning the Reference layout it was found by Planner that the entrance of 600 m is slightly preferred (chapter 3).
By the opinion of Expert-group is logical, that from the point of view of liquidation the oil spill inside the Port, the narrow entrance should be preferred.
On the other side, the entrance of 300 m, in principle, should cause some problems for navigation, especially for large vessels, included tankers with length of above 300 m (7.3). Also, when the vessels are using the tugboats, there may be more difficult to manoeuvre through the entrance of 300 m, especially in cases with strong northerly winds. However, the results of navigational simulations, performed by Planner, indicated that for Reference layout (Alternative I): "No particular problems were observed during arrivals and departures with Layout 6A and the simulations were completed with a satisfactory safety level both during passage of the breakwaters and during maneuvers inside the turning basin" (Royal Haskoning 2006b, paragraph 5.2.1). It should be marked, that simulations were done for Reference layout with entrance of 300 m (Fig. 8). Unfortunately, corresponding simulations were not done for Budget layout. By opinion of Expert-Group the navigation conditions inside the Port Basin should be restricted because the considerably less aquatory and only one turning circle of 700 m (Fig. 10).
It should be designated, that in part of Preliminary Project Report dated on 09th June 2006 in sub chapter 10.2.1. Planner was found that concerning the waves penetration the Reference layout with entrance of 600 m was estimated as worst (rank 7) the Reference layout with entrance of 300 m was given rank 4 and Budget layout rank 5. The best was Modified reference layout (Fig. 8), but this layout has had not good ranks by others criteria

Alternative III.
The configuration of this Alternative is the same as of Alternative I (Reference layout with entrance of 600 m), but all the breakwaters will built as piled structural. So, it may be concluded that from the navigational point of view, the Alternative III is the same as Alternative I.

Conclusions
- The prompt and absolute liquidation of oil-spills happened inside the Port Basin (area enclosed by the breakwaters) and moving at surface, will be technically possible by using the longer oil-barriers also in case when entrance is relatively wide (600 m), **even though the more efforts and proficiency of Port team will be needed, to compare with more narrowing entrance of 300 m;**
- From the navigational point of view Expert-group preferred the wider (600 m) entrance into the Port Basin, however the entrance of 300 should be acceptable also, due regard the results of navigational simulations;
- Construction of breakwaters allows minimize the needs for obligatory leaving of vessels from the Port Basins and standing at the Road. It occurs with significant economical benefits for Port of Muuga, ship-owners and Port's operators, and decreasing the risk of sea pollution outside the Port Basin, also.

7.2. Socio-economical impacts

The evaluation of socio-economical impacts done in sub chapter 5.6 didn't resulted that there will be not marketable socio-economical impacts caused by the breakwaters exploitation. So, below the impacts of breakwaters construction on local habitants and on interests of local municipalities will be under the discussion.
Today it was difficult to prognoses will the technology of construction of breakwaters depends on layout and due regard, that the Alternatives I and II will be structurally analogous (less then 12 m depths rubble mound reef and in deeper sea piled type), the impacts described below will mainly depended on duration of construction. In case of Alternative III the potential negative impacts on local habitants was expected to be less because the air pollution with dust should be much smaller as the filling with sand will not needed. Also, the dredging will be much less.

0-Alternative
The current situation with slightly insufficient risk level of sea pollution will not only continue, but may become worse due regard the extension of the Eastern Part of Muuga Port (1.1) (ILAG-HPC-ESP-TALLMAC. 2006). It concurred with that the small, but vital for local habitant's public beaches in Saviranna and Randvere areas (Fig. 1) will be under the risk to be polluted.

Alternatives I and II
The negative impacts on local habitants caused by breakwaters construction will be:
- Additional notice effect what, due to potential cumulating with notice from the others activities of Port, become harmful for human health. The realistic mitigation measures are done in sub chapter 5.10;

- Additional pollution of air in areas surrounding. In sub chapter 5.7 it was found that the air pollution caused by breakwaters construction will mainly consists in dust diffusion and should not be very unhealthy for local habitants because the nearest houses located at distance of 500 m or more.

The both alternatives will have some positive socio-economical effects also:

- The temporary generation of additional jobs, especially the low-skilled people from surrounding municipalities may have temporary employment during the breakwaters construction. The number of such jobs is not allowable to forecast today (5.7);
- the minimizing the pollution risk of shores, including public beaches due to sea pollution risk decreasing after the breakwaters will built (5.9).

Alternative III

The negative impacts on local habitants caused by breakwaters construction will be:

- Additional notice effect what, due to potential cumulating with noise from the others activities of Port, become harmful for human health. The realistic mitigation measures are done in sub chapter 5.10;

The Alternative III will also have the same positive socio-economical effects:

- The temporary generation of additional jobs, especially the low-skilled people from surrounding municipalities may have temporary employment during the breakwaters construction. The number of such jobs is forecasted by Planners to be equal of 60 peoples during three years (5.7);
- the minimizing the pollution risk of shores, including public beaches due to sea pollution risk decreasing after the breakwaters will built (5.9).

Conclusions:

- Concerning the minimum of negative impacts, the Alternative III will be preferred because potentially less construction duration and of minimum air pollution;
- Concerning the positive impacts the Alternative I should be preferred because the longer time for local people to having job.

Finally, it should be conclude that from the point of view the socio-economical aspects, the worst is 0-Alternative, the Alternatives I and II are equal and the best is Alternative III.

7.3. Comparison regarding the environmental impacts

The Expert-group found necessary for comparison of discussed above alternatives take account the all most important environmental components which potentially can be affected more or less substantially (Section 5) and which are specified in Table 23. The cumulative impacts of extension of the Eastern Basin of Muuga Port (ILAG-HPC-ESP-TALLMAC. 2006) and others activities which can occur the negative impacts on given environment is taken account, also.

The empty table was sent to members of Expert-group and all they filled the table separately and then the average for each criterion was calculated (be a servant up) by all versions studied.

Table 23 The comparison alternatives regarding potential environmental impacts

Layout Options		**1**	**2**	**3**	**4**	**5**
Essentiality of potential impacts	**Max Weight**	**0-Alt.**	**I-Alternative** (Reference layout), entrance 600 m	**I-Alternative** (Reference layout) entrance 300 m	**II-Alternative** (Budget layout) entrance 300 m	**III-Alternative**
Oil pollution risk	50	4	2	1	3	2
Water quality inside Port Basin	10	1	3	3	3	2
Sea bottom communities	10	2	2	2	2	1
Fish and fisheries	10	3	3	3	3	2
Natura 2000	5	1	1	1	1	1
Shore processes	5	1	1	1	1	1
Natural resources needed	10	0	3	4	2	1
Total score (max * rank number)	**100**	**270**	**220**	**220**	**260**	**180**

Ranks: 0 – impact failing; 1 – impact is inconsiderable; 2 – impact is considerable, but renewable; 3 – impact is considerable and non-recovering, but allowable to mitigation; 4 – impact is considerable and not allowable to mitigation.

Conclusions:
It can be stated that from the point of view of protection the sea environment:
1. Construction of breakwaters is necessary for minimization the risks of sea pollution and the 0-Alternative should be the worst solution.
2. From the point of view of marine environment protection the both versions of Alternative I are almost equal, however the version with entrance of 300 m is slightly more eligible. The Alternative II with entrance of 300 m was estimated as worst.
3. As the best solution the Alternative III was appointed.

7.4. Expert-group preferring

The Expert group found that from the point of view of all environments, navigational and socio-economical requirements the Alternative III (Fig. 88) is preferred. The Alternatives I and II were estimated to be worse, but also acceptable.
The 0-Alternative was rejected.

Figure 88. Reference layout 006-1A (Alternatives I and III)

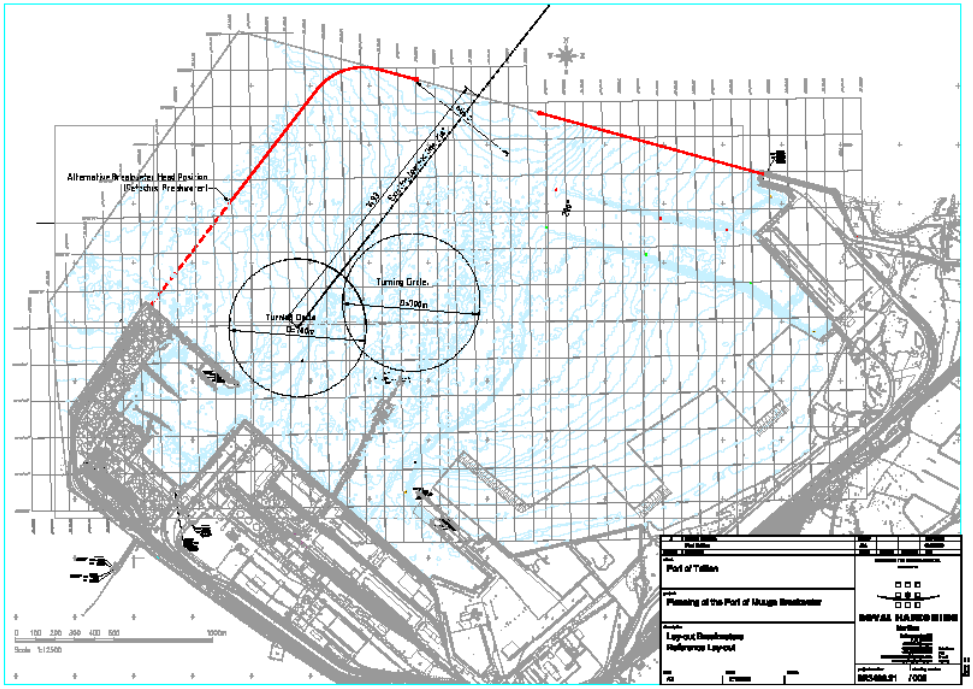
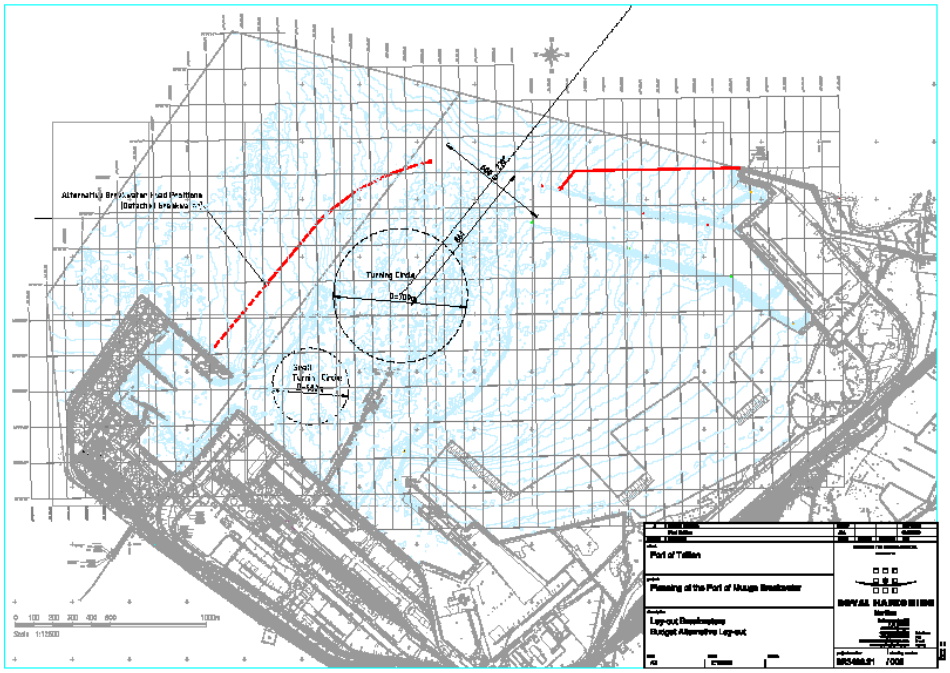


Figure 89. Budget Layout 008-3A (Alternative II)



References

ILAG-HPC-ESP-TALLMAC. 2006. Eastern Extension of Muuga Port. Environmental Impact Assessment

8. Environmental monitoring and auditing concept: determination of the objects of monitoring, the recommendations of methods of monitoring.

Geological (shore processes)

The designed seawalls and the extension of the harbour territory will not probably cause significant changes in the development of the coast west (Randvere district) and east (Saviranna district) from the harbour territory. Regardless of the fact that the regime of shore processes should not change significantly for example on the coast east from Tahkumäe cape the shore monitoring should continue at Saviranna and similar activity should be started at Randvere district to discover inestimable negative changes early.

Re-measurements within shore zone monitoring network should be carried out at least once a year until the construction is ready. In case of powerful storms advisedly even more often. Measurements should also be continued 4-6 years after completing the construction.

In the coast area of Saviranna probably the foot and/or the ledge of the cliff can be mapped with modern technical instruments (GPS etc.). More accurate methods for monitoring in Randvere district will be elucidated during the works of the first year.

Re-measuring of cross-sections in Saviranna district is necessary only in some parts because changes in cliff line can be significantly different in neighbouring areas because of collapsing blocks. It is important to follow changes in cross-sections in Randvere district because here are no clear erosion scarps.

Measuring the near-shore bottom on the monitoring area will not probably give additional information because tough Cambrian clays are visible here and there are almost no brittle loose sediments on top of them.
Re-measurements make it possible to discover even improbable changes in the development of the coast part located east from the harbour facilities and to elaborate necessary defensive measures.

Biological
As Expert-group presumed, that the monitoring of sea bottom and fish communities in Muuga Bay, which started in 1990s will be continue, and then the special monitoring of sea life organisms as well, as changing of monitoring methods used, will not be necessary, for both construction period and during the breakwaters exploitation periods.

Water quality monitoring
Watermass surrounded by new breakwater form closed basin instead of open waterbody. Because of very limited water exchange water quality inside harbour basin will be worse than nowadays. It is very difficult to foresee precisely the changes, but still water quality should stay on acceptable level. To monitor water quality changes in harbour basin in comparision with situation today, monitoring programme should be carried out, consisting:

- Measurements of currents (water exchange) before and after construction (both twice) of breakwater in 3 stations, each measurement period about 1 month.
- Water quality measurements (oxygen content, turbidity, concentration of suspended matter) in about 10 stations inside harbour basin and outside should be carried out on monthly basis during 2 years after construction of breakwater.
- Automatic hydrometeorological station operating nowadays on quay 10A could be complemented with sensors of water quality, like oxygen, turbidity as together with current measurements. Upgraded weather station allow observe water quality changes in harbour basin in real time at harbour office, which allow in earliest time take care of mitigation the water quality lowering.

9. Publicity of EIA, the overview of remarks, recommendations and other public suggestions received, the taking those into account

The Scope of EIA was available for public familiarization during two weeks, as it was settled by Estonian legislation. The information was done through the Estonian Official Announcement available for everyone by Internet. The Jõelähtme and Viimsi districts, Maardu City Government, Harju County Government and several relevant state authorities as well, as Estonian NGO have been informed also by post mail. Also, the special announcement was published in wide-spreading newspaper “Postimees”.

The public meeting of discussion on EIA Scope was taken place in Muuga Port office in April 21st 2006.

No any remarks concerning the EIA Scope before the public meeting were received. In public meeting have been participate the representatives from Jõelähtme district Government, from Maardu City Government and several Operators of Muuga Port. No one surrounding residents was participating.

The information concerning the EIA Report public hearing has been done as the same what is described above for EIA Programme.
The public meeting of discussion on EIA Report was taken place in Muuga Port office in November 20th 2006. No any remarks concerning the EIA Report before the public meeting were received. In public meeting have been participate the representatives from Jõelähtme district Government, and several departments of Muuga Port. No one surrounding residents was participating. All the questions were fully answered during the meeting.

After the public meeting the EIA Report was presented to the Ministry of Environment for final supervision. The department of the Environmental Management and Technology has some additional requests (Impacts on Natura 2000 objects etc.) which were taken account in final version of the EIA Report submitted to Ministry for decision making in December 21st 2006.

Section 10 Short summary of EIA report

Current EIA is completed in accordance with Estonian applicable Legislation, in particular the "Environmental Impact Assessment and Environmental Management System Act" (RT I 2005, 15, 87), and its sub acts. The principles of Council Directive 97/11/EEC of March 1997 amending Directive 85/337EEC of June 1985 on the assessment of the effects of certain public and private projects on the environment were taken account, also.
Special attentions are given on EEC Directive 92/43/EEC of 21 May 1992, and Methodological guidance on the provision of Article 6(3) and (4) of the Habitats Directive 92/43/EEC is taken account, because some probability of impacts on Natura 2000 site of Aksi Island as well, as on some species, included in Annexe's II and III of this Directive, will be applicable.
The subject of this EIA is: "**The Construction of Breakwaters in the Port of Muuga**" and the Developer is the owner AS Tallinna Sadam belonging to the Estonian State. The current activity is a part of large plans of upgrading the Port of Muuga facilities by Developer. According to this, the results of some another's EIA were taken account and the possibilities of come into being the cumulative environmental impacts were evaluated.

Port of Muuga was built in 1985 and is today the largest commercial port in Baltic Sea and it is one of the major potential sources of pollution of the sea. At present, there are some safety navigation problems which may cause the elevated risk of ships accidents, especially with strong NW to NE winds. To minimize this potential risk, vessels are bind to leave the Port and go to high sea road. It of course caused noticeable economical losses, but additionally,

the anchorage vessel in open part of Muuga Bay, where the waves can reached up to 4 m is continually a source of high risk of sea pollution. **The construction of the breakwaters assured that almost not any vessel will be obligatory leave the Port due to bad weather.**

Furthermore the navigation safety inside the Muuga Port will be noticeable higher after the breakwaters constructed what **even more mitigated the risk of sea pollution.**
Therefore the construction of breakwaters contributed to minimizing the risk of sea pollution and upgrading the Port facilities.

In parallel to EIA, the planning of the breakwaters were run and the by Royal Haskoning and the mean time's reports as "Layout Options Report" (dated 31 January 2006) and "Preliminary Project Report" (09.06.2006) were the basic documents for the EIA.

During the preliminary study of the Muuga harbour breakwater layouts seven different layouts were selected by Planners for detailed numerical calculations (Figures 8 – 11):

Reference layout 006 option 1A;
Reference layout wide entrance 006 option 1A;
Modified reference layout 006 option 1B;
Eastern port entrance 007-2A;
Eastern port entrance 007-2B;
Budget layout 008-3;
Western Port entrance layout 009-4.

Also, the three alternative technical solutions of construction the breakwaters were assessed. It was concluded during the preliminary planning that the composite- and (piled) cellular cofferdam alternative are both not feasible in terms of construct ability and likely settlements underneath the structure. Hence the technical evaluation focuses on the next structural constructions of the breakwaters (Royal Haskoning, 2006b).

1. Rubble Mound Breakwater
2. Rubble Mound Reef Breakwater
3. Piled Breakwater

All those layout's and structural choices were described and shortly evaluated in Section 2 of Report.
In June 2006, the Planner and Developer were selected out the following two breakwaters layout options as basic due regard the results of multi-criteria analyses:

1. Reference layout with entrance of 600 m; 006, option 1A;
2. Budget layout (with entrance of 300 m)

Additionally, the two versions of Reference layout are under the further treatment: with entrance width of 300 m and 600 m.

Also, it was agreed by Planner and Developer that up to depths of 12 m the Rubble Mound Reef Breakwater type and in deeper sea the Piled Breakwater type will be constructed, because the very high costs of piled type breakwaters building in shallow sea.

The last decision means, that the dredging and dumping will be needed because the soft soil should be replaced where the Rubble Mound Reef Breakwater will be built, i.e. in depths less than 12 meters.
Finally, in August 2006 the Planner and Developer agreed that also the fully piled type construction of breakwaters is acceptable because the arising of the costs of stone and sandfill.

The Expert-Group, after having the results of waves and oil-spill modeling (Sections 4 and 5), accepted that mentioned two breakwaters layout options as well, as combined rubble mound reef-piled structural type are the best from the technical and economical points of view and found that there will be not principal differences between the all 7 preliminary layout options due regard the environmental impacts, expect the natural resources amounts needed. In this case the next three alternatives have been the objects of full assessment:

0-Alternative, breakwaters will not be built

I-Alternative, Reference layout option (Fig. 8) with rubble mound reef structural type in areas less then 12 m depths and piled structural type in deeper sea

II-Alternative, Budget layout option (Fig. 10) with rubble mound reef structural type in areas less then 12 m depths and piled structural type in deeper sea

III-Alternative Reference layout option (Fig. 8) fully with piled structural type.

Additionally it was taken account that I-Alternative foreseen the two versions of entrance width: 600 m and 300 m. Those versions were evaluated separately where it was needed.

The Programme of EIA has been crossed all the publicity procedures, required by Estonian legislation and was approved by Ministry of Environment of Estonia in July 2006. The public meeting of consideration of Scope has taken place in April 21st 2006. No any remarks and solutions against the plan of construction of the breakwaters in Muuga Port have been received.

The EIA Report has been crossed public hearing in November 2006. No any remarks and solutions against the plan of construction of the breakwaters in Muuga Port have been received.

As it is elementary, such large-scaled hydrotechnical works as Breakwaters construction, including relatively large amount of dredging and dumping (Table 21) will occurred with negative environmental impacts. In current case the most important negative impacts were estimated to be as follows.

The physical destroying of the sea bottom communities in area being under the breakwaters was found to be **the most important irreversible negative impact** on environment originated by breakwaters construction and it will be more major in part of breakwaters where the type of rubble mound reef breakwater will be used (less then 12 depths areas) because dredging of soft soil and then the filling with sand the underlay of breakwaters will be needed. The sea bottom area covered with Piled Breakwaters will not be

dredged and even affected so largely. Totally the sea bottom communities will be destroyed in area of 39 hectares in case of Alternative I and 32 hectares in case of Alternative II (5.4, Section 7). In case of Alternative III the replacement of soft soil will not needed and the dredging will be needed in sites of joining the breakwaters to the existing piers.

The **second substantial source of negative environmental impacts will be the enlargement of Port Basin area**. However, as it was described in Section 3, the sea bottom as well the fish communities have been under the high pressure of Muuga Port during two decades and these communities were changed already. The new impacts fore side in case of breakwaters will be established will not be caused significant worsening of the environment condition for sea bottom and fish communities within the area being inside and close to the Port.

The negative impacts caused by relatively large amount on the occasion of the Alternatives I and II (close to 1 million m^3, see Section 6) dredging/dumping will be the third by importance. However, in current case, these impacts occurred actually much less damages on marine environment because the sea areas becoming under the serious affecting (Muuga Bay surrounding the Port, Northern Ihasalu Bay and Aksi spoil ground area), are already today characterized as with non-essential, heavy damaged biota. It should also taken account that in parallel the extension of the Eastern Part of Muuga Port would be run and including much larger amount of dredging and dumping. Concerning the Alternative III the amount of dredging will be significantly resulted with less negative impacts on marine environment.

There will be **probably no significant negative impacts on the terrestrial ecosystem** neighbouring to Muuga Port as well on local habitants and Natura 2000 objects. Nevertheless, the Port Authorities should be taken account, that in parallel the extension activities of the Eastern Port facilities would be done and some impacts of Breakwaters construction may cumulate with impacts caused by mentioned above activities. Especially, the noise level in nearest dwelling houses should be pinpointed here (see Sections 3 and 5)

The Expert-Group highlighted that due regard the high economical and sociological importance's of Muuga Port and, in the other side, the existing problems with navigation safety as well, as accident sea pollutions risk inside the Port Basin, the construction of Breakwaters in the Port can be classified as activity, socio-economically legitimate and environmentally required.

The all, Alternatives I, II and III will substantially minimize the navigation risk inside the Port of Muuga Basin. But the Alternative III was estimated, as preferred due regard the all environmental, navigational and socio-economical requests. From the point of view of liquidation of accident pollution of the sea in Port Basin the version of Alternative I with entrance of 300 m should be estimated as the best. However, from the point of view of navigation conditions and navigation risks, the Alternative I with entrance of 600 m can be estimated as better to compare with entrance of 300 m. And, due regard the principles of the Sustainable Development (see Section 6, utilization of natural resources) the Alternative III was preferred (Section 7).

Finally, The Expert-group, due regard the all mentioned above results of evaluation of Alternatives found that as the best the Reference layout fully of piled structural type – Alternative III with entrance of 600 m should be taken as the basic (Subsection 7.4).

For minimization of the occurred potential negative affects on environment, the Expert-group recommends introduce the next obligatory mitigatory measures into the Special Water User Permit for Developer:

1. For minimizing environmental risks during the Port exploitation the all relevant legislations acts will be needed to fulfil. The special needs of the loading and discharging of oil and oil products established in annex 1 to MARPOL (Marine Pollution) 73/78 to tankers must be followed carefully. The matter of training of crew and harbour personnel can be intolerably accepted. Also, the being in possession oil spill response materials and ready to immediate use. Harbour personnel should be trained how to use these materials. A new oil spill response plan should be prepared and implemented.

2. During the breakwaters construction the prevention of the spreading of suspended sediments up to the Randvere and more western public beaches should be taken into account. For this purpose, the temporary lay-off of the Western Breakwater construction should be foreseen in case of strong easterly winds and when the results of operative monitoring (Section 8) will indicated that transportation of suspended matter to beaches will be actual.

3. The dredging should be not planned at the spring from mid of April until the end of June for minimizing the probability of negative impacts on fish communities in Muuga and surrounding bays during the spawning and nursery stages of fish (Fig. 1).

4. During the breakwaters construction the spill of constructions materials including the sandfill to the sea bottom surrounded, should be avoided.

5. The noise monitoring should be done during all the duration of the breakwaters construction due regard the cumulative effects of others Port activities included the Eastern Port extension works. When the equivalent level of cumulative noise will exceed the stated by the regulation no 42 of the Minister of Social Affairs of Estonia of 4 March 2002 noise norms: 60 dB(A) in the daytime and 55 dB(A) at night inside the dwelling land, the special measures should be taken and the relevant authorities must be informed. Those measures may include: the temporary lay-off of works concurred with high level of noise (plugging, movement of heavy cars etc.) the coordination of breakwaters construction with others Port (construction) activities for regulation the cumulative noise level, the regulation of construction works (i.e. dredging and plugging) due regard the wind direction etc. Also, the requests written in EIA Report of the enlargement of the East Basin of Muuga Port would be taken account.

6. For minimizing environmental risks during the Breakwaters construction the all relevant legislations acts as well as the GMP will be needed to fulfil. The matter of training of vessels crew and others people participated in construction can be intolerably accepted. Also, the being in possession of facilities of liquidation of oil etc. pollutions should be available and ready to immediate using astonishingly. The contractor should update a Environmental Management Plan and fulfilled it

7. During the further exploitation of the Muuga Port with breakwaters, the prompt and absolute liquidation of oil-spills must be a top priority of Port authorities continually.

The fully closing of the breakwaters entrance by oil-barrier must be available despite the rough weather. The oil spills response plans of Muuga Port should be Oil spill response plans should be implemented, including materials and training.

8. The special environmental monitoring should be established during the construction of breakwaters as well, as during its further exploitation (Section 8).