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IMPLEMENTATION OF THE NORTH EUROPEAN GAS PIPELINE PROJECT — DATA INVENTORY AND FURTHER NEED FOR DATA FOR ENVIRONMENTAL IMPACT ASSESSMENT

Matti Perttilä, Harri Kankaanpää, Aarno Kotilainen, Ari Laine, Jouni Lehtoranta, Mirva Leivuori, Kai Myrberg & Tapani Stipa

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IMPLEMENTATION OF THE NORTH EUROPEAN GAS PIPELINE PROJECT — DATA INVENTORY AND FURTHER NEED FOR DATA FOR ENVIRONMENTAL IMPACT ASSESSMENT

Working group: Matti Perttilä[1] (Chair), Harri Kankaanpää[1], Aarno Kotilainen[2], Ari Laine[1], Jouni Lehtoranta[3], Mirja Leivuori[1], Kai Myrberg[1], Tapani Stipa[1]

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INTRODUCTION AND GENERAL CONSIDERATIONS

Matti Perttilä, Jouni Lehtoranta & Tapani Stipa

A basic agreement on the construction of the North European Gas Pipeline (NEGP) through the Baltic Sea from Russia to Germany was signed on 8 September 2005. Due to the scale of the construction, the project requires Environmental Impact Assessment (EIA). Under the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo, 1991), Finland is both a Party of Origin and an Affected Party in the project as a section of the gas pipeline will cross Finland's Exclusive Economic Zone (EEZ). So far the extent of the possible EIA related to the construction and maintenance of the pipeline remains unclear.

As the bulk of relevant sediment, macrozoobenthos and water data collected by Finnish researchers in offshore areas of the Gulf of Finland is held by the Geological Survey of Finland (GTK) and the Finnish Institute of Marine Research (FIMR) and at least in part still remains in the research and preparation stage, the two research institutes, together with the Finnish Environment Institute (SYKE), established a working group aiming at:

- performing an inventory of the existence and availability of data required for the EIA process in Finland;
- assessing the need for new experimental data to ensure the reliability of the EIA;
- proposing EIA topics to ensure its reliability.

The environmental impacts of the gas pipeline can be divided into small- and large-scale spatial impacts as well as temporal impacts. Temporal impacts can be divided as follows: short-term impacts arising from preliminary investigations and the construction phase, and long-term and permanent impacts occurring after project completion. Preliminary investigations, which include sonar surveys and sampling, involve geotechnical investigations along the pipeline route prior to the construction phase.

The NEGP project developer launched pre-construction investigations in 2005, with anticipated completion in 2007. On the basis of these investigations, the developer will make the final decisions related to construction technology and assess the optimal route for the pipeline. The short-term construction-phase environmental impacts and the long-term post-installation impacts are likely to be highly dependent on the type of construction technology employed in the installation of the pipeline.

There are plenty of submarine gas pipelines around the world. Pipelines from the North Sea oil and gas fields are particularly numerous. The construction of long pipelines for high-pressure gas from gas fields off the Norwegian coast in the North Atlantic is currently underway. Construction of pipelines transporting gas from the Ormen Lange field to Norway is almost complete, and the world's longest gas pipeline for exporting gas from Nyhamna, Norway, to the UK is now under construction. The pipeline ("Langeled") will measure 1,200 km and is due to be operational in 2007. It is estimated to deliver 20 per cent of the UK's annual gas demand, around 70 million cubic metres per day.

The impact assessments made during the planning stage of the pipelines from the Ormen Lange field only provide vague descriptions of any possible impacts on the marine environment. This is likely to be partly due to the fact that this is a "genuinely" international sea area and therefore no party can demand a thorough EIA process through legal means.

However, the Baltic Sea has the potential for bigger problems. It is a virtually enclosed sea area, so substances possibly released into water from sediment masses that are discharged in trenching will remain in the basin for a long time (the calculated water retention time in the Baltic Sea is approximately 40 years as opposed to roughly 1 year in the North Sea). Consequently, sedimentation is practically the only outlet for almost all non-degradable waste burdening the Baltic Sea.

The Baltic Sea is a brackish-water basin, which means its biodiversity is low, narrow and permanently at risk for natural reasons alone. There is a great deal of variation in the seabed topography of the Baltic, especially in the Gulf of Finland. This is likely to necessitate much more intensive seabed levelling operations to enable pipeline construction than were necessary in the North Sea and North Atlantic.

The gas pipeline also brings up the risks posed by the chemical munitions dumped in the Baltic. There are two main dumping sites, and the amounts dumped are known in principle. Studies by bodies including the Baltic Marine Environment Protection Commission (HELCOM) have produced information according to which in reality there are several dumping sites and there is no documented data about the distribution of munitions between them.

The organisation administering the seabed beyond the limits of national jurisdiction, the International Seabed Authority (ISA) has issued recommendations mainly pertaining to EIAs to be carried out in connection with the exploitation of polymetallic nodules in the seabed. Since every Party of Origin related to the gas pipeline is a member of the ISA and have in this context adopted the EIA principles, these recommendations should, as appropriate, be used as a basis for the EIA negotiations related to the pipeline.

Taking the United Nations Convention on the Law of the Sea into consideration

The United Nations Convention on the Law of the Sea (UNCLOS) sets even more specific provisions than the Espoo Convention, including on national EEZs. Russia has ratified the UNCLOS and is therefore committed to monitoring the impacts of the described activities on the environment, ensuring through every possible measure that the activities will not cause adverse effects on other states' environment, and reporting on the results of such monitoring through the competent international organisations (such as HELCOM or IOC of UNESCO) to other states.

> Article 194
>
> Measures to prevent, reduce and control pollution of the marine environment
>
> 2. States shall take **all measures necessary** to ensure that **activities under their jurisdiction or control are so conducted as not to cause damage by pollution to other States and their environment**, and that pollution arising from incidents or activities under their jurisdiction or control does not spread beyond the areas where they exercise sovereign rights in accordance with this Convention.
>
> 3. The measures taken pursuant to this Part shall deal with all sources of pollution of the marine environment. These measures shall include, inter alia, those designed to minimize to the fullest possible extent:
>
> (c) **pollution from installations and devices used in exploration or exploitation of the natural resources of the seabed and subsoil**, in particular measures for preventing accidents and dealing with emergencies, ensuring the safety of operations at sea, and regulating the design, construction, equipment, operation and manning of such installations or devices;
>
> Article 204
>
> Monitoring of the risks or effects of pollution

1. States shall, consistent with the rights of other States, endeavour, as far as practicable, directly or through the competent international organizations, to observe, measure, evaluate and analyse, by recognized scientific methods, the risks or effects of pollution of the marine environment.

2. In particular, States shall **keep under surveillance the effects of any activities which they permit** or in which they engage in order to determine whether these activities are likely to pollute the marine environment.

Article 205

Publication of reports

States shall **publish reports** of the results obtained pursuant to article 204 or provide such reports at appropriate intervals to the **competent international organizations**, which should **make them available to all States**.

Article 206

Assessment of potential effects of activities

When States have reasonable grounds for believing that planned activities under their jurisdiction or control may cause substantial pollution of or significant and harmful changes to the marine environment, they shall, as far as practicable, **assess the potential effects of such activities** on the marine environment and shall **communicate reports of the results of such assessments in the manner provided in article 205.**

SEABED TOPOGRAPHY AND QUALITY

Aarno Kotilainen

The seabed topography in the EEZ of the Gulf of Finland is generally known reasonably well. Bathymetric data about the area is freely available but does not go into great detail, including **Seifert & Kayser (1995).** Bathymetric data as precise as possible is, however, required in order to identify and monitor the impacts of pipeline construction work, and the Finnish Maritime Administration (Juha Tiihonen) and its Liaison Unit have been contacted in this regard. If precise bathymetric data cannot be found or is not available for the planned gas pipeline route, the area will need to be scanned in great detail using multibeam echo sounders.

The Geological Survey of Finland (GTK) has small-scale (1:500 000) sediment maps of the route of the planned gas pipeline (**Winterhalter & al. 1981, BALANCE 2006 [http://maps.sgu.se/Portal/]**). These maps provide generalised seabed data (for example in the BALANCE maps on mud, hard clay, sand, complex hard bottom [till], bedrock). However, these maps are not precise enough to meet the requirements of the identification and monitoring of the impacts of gas pipeline construction. Such work would require large-scale (e.g. 1:20 000) sediment maps that so far have not been published for the planned construction area. Partially interpreted yet so far unpublished data is only available for areas of eastern Gulf of Finland covered by chart sheets 3014 03 and 06. Uninterpreted sonar data is available at least for chart sheets 2013 10; 2034 10; 3014 02, 04, 09 and 12. Consequently, seabed data required for the assessment of the environmental impacts of the gas pipeline still remains insufficient.

NEAR-BOTTOM CURRENT FIELDS

Kai Myrberg

There is a tested hydrodynamic sea model available for the computation of mean circulation in the Gulf of Finland. Three-dimensional and non-linear, this model enables not only the forecasting of horizontal distribution but also that of vertical movements in the water body. Meteorological forcing (wind direction and speed, air temperature, cloud cover, humidity, etc.) is input from the atmospheric model.

The sea model developed by the FIMR (Andrejev & Sokolov 1989, Andrejev & al. 2004, Myrberg & Andrejev 2003, 2006) describes variations in salinity, temperature and current at several different depths as well as variations in water level. Accurate modelling of sea movements requires the use of a high-resolution grid (grid spacing at 1*1 NM or 1.7*1.7 km), whereby the grid in areas such as the Gulf of Finland includes around 10,000 points where model variables are computed at several different depths at approximately 30-minute intervals. In areas outside the Gulf of Finland covering the entire Baltic, a 5-NM grid has been employed, and this model provides the boundary conditions for the Gulf of Finland model in the west.

As an example of possible applications of the model, a 5-year simulation (1987–92) took place to obtain an idea of the mean current field of the sea area. Closer examination of surface layer circulation (at approximately 5 m) shows the complexity of the system: the current field consists of very small eddies. However, an obvious large-scale phenomenon that can be observed is the mean inflow at the Estonian coast: the direction of the flows is towards the east. Correspondingly on the Finnish side there is a strong outflow, but it should be noted that it is not found very close to the coast but rather 20–30 km offshore. This can be explained by the fact that the Finnish coast is shallow and rich in islands, so currents are slowed down by friction, and westward outflow proper occurs in offshore areas. The current field in the eastern part of the Gulf of Finland is quite complex and characterised by a lot of small-scale eddies. In the easternmost part there is a strong westward flow caused by the pronounced discharge of the Neva river.

The gas pipeline is likely to be located in the outflow area outside the Finnish coastal area but to the north of the central axis of the Gulf of Finland. In this zone, outflow is quite homogenous from the uppermost layers all the way down to depths of 30 m. Its width is approximately 10 km and typical speed 2–5 cm/s. Near the bottom the effects of bottom topography create a higher presence of eddies than is found in the upper layers. Circulation persistency is quite high, ranging between 50% and 70% in the surface layers and being at least as high near the bottom.

NEAR-BOTTOM WATER MASSES

Matti Perttilä & Jouni Lehtoranta

The widest-reaching interventions of the gas pipeline project will be carried out on the seabed. The seabed is the part of the ecosystem where solids found in water settle and accumulate. Some of the solids deposited on the sediment surface are buried while others undergo processes that transform them into soluble forms. The burying of solids removes major quantities of harmful substances and a considerable proportion of nutrients from the ecosystem. Manipulation of the seabed carried out during the gas pipeline project will reintroduce these buried substances both as solids and dissolved matter into water in quantities that would otherwise not occur. Seabed manipulation will result in particulate matter becoming resuspended and transported by currents until being redeposited onto the bottom when permitted by water current conditions. The sinking velocity depends on particle size. Consequently, in addition to the amounts resuspended, variation in particle size of the suspended matter results in major spatial and temporal variation in the impacts of the NEGP project on water quality.

Furthermore, sediment oxidation-reduction state differs considerably from that of water. In practice only a very thin surface layer (millimetres) of sediment is oxygenated while deeper layers are anoxic. Seabed manipulation will relocate reduced particulate and dissolved matter from sediment into oxygenated layers of water.

Undesirable impacts of sediment resuspension include the following:

- increased turbidity resulting from solids resuspension and resedimentation;
- environmentally harmful solids and dissolved matter released from sediment into water may enter the biological cycle;
- reduced compounds released into water deplete oxygen reserves of water and, as a direct and indirect result of oxidation, part of these compounds may become biologically available.

The Gulf of Finland is characterised by strong variations in near-bottom oxygen concentrations due on the one hand to interaction with the Baltic Proper and on the other to movements of near-bottom water masses. Major influxes of saline water into the Gulf of Finland quickly (in a few months) create anoxia in near-bottom layers of water as strong stratification prevents vertical mixing that brings oxygen into deep waters. Figure 1 shows the distribution of monitoring sites in offshore areas of the Gulf of Finland and Figure 2 illustrates a typical oxygen distribution in near-bottom layers of the Gulf of Finland.

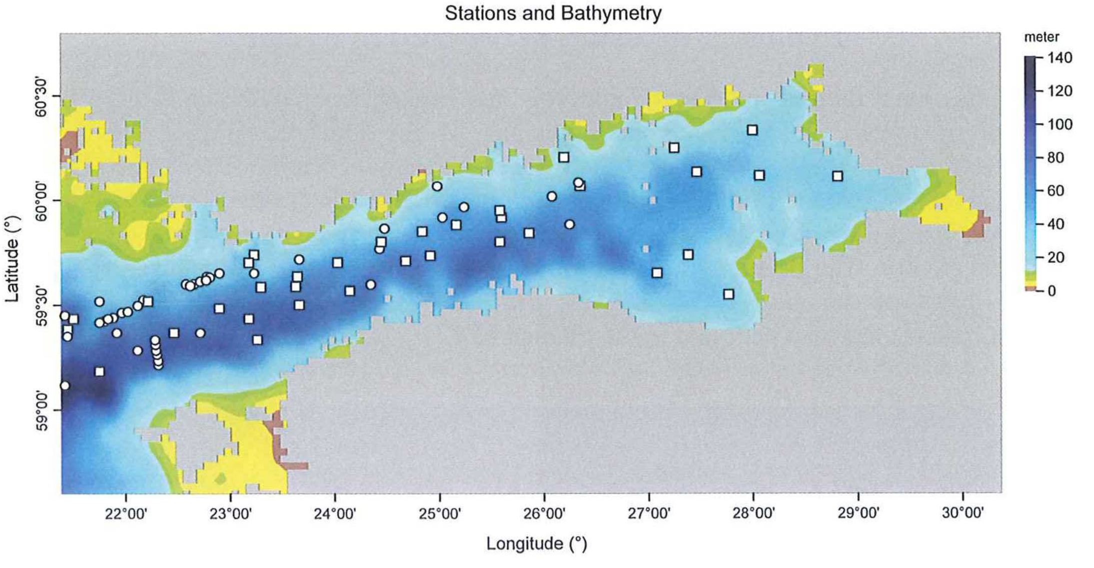

Fig. 1. FIMR monitoring sites in offshore areas of the Gulf of Finland (FIMR).

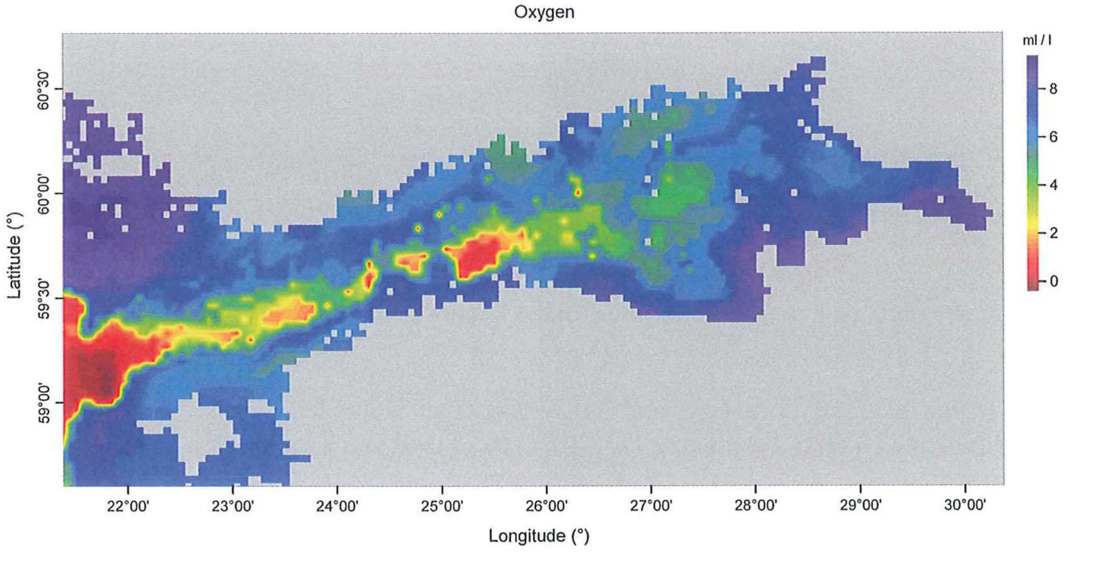

Fig. 2. Oxygen distribution in near-bottom water layers of the Gulf of Finland (FIMR).

Consequently, there is sufficient data on nutrients, salinity and oxygen/hydrogen sulphide for a pre-construction baseline study.

Anoxia in near-bottom layers of water results in changes in the chemical properties of the sediment, with phosphorus and certain heavy metals bound to the sediment becoming soluble. In our opinion intensive construction and ploughing of the seabed will change the oxidation-reduction conditions of the seabed down to depths of several metres. Therefore the amounts of phosphorus and metals bound to these sediments may pose a threat to water quality in the Gulf of Finland.

HARMFUL SUBSTANCES IN SEDIMENT IN THE PRESUMED CONSTRUCTION ZONE

Mirja Leivuori & Harri Kankaanpää

Sediment research in the Gulf of Finland

Sediment studies have focused on metals, nutrients and organic compounds in the Gulf of Finland. Total content of metals and nutrients in sediments of the Gulf of Finland has been studied comprehensively over the past 15 years by the Finnish Institute of Marine Research (FIMR) and the Geological Survey of Finland (GTK). The locations of the offshore research stations are shown in Figure 3. There are quite a few stations in the EEZ and its near vicinity, but there are also plenty of areas yet to be studied. The deepest accumulation bottoms in the Gulf of Finland are concentrated on the southern parts of the Gulf. With a great deal of variation in bottom topography, smaller accumulation bottoms can also be found in the Finnish EEZ.

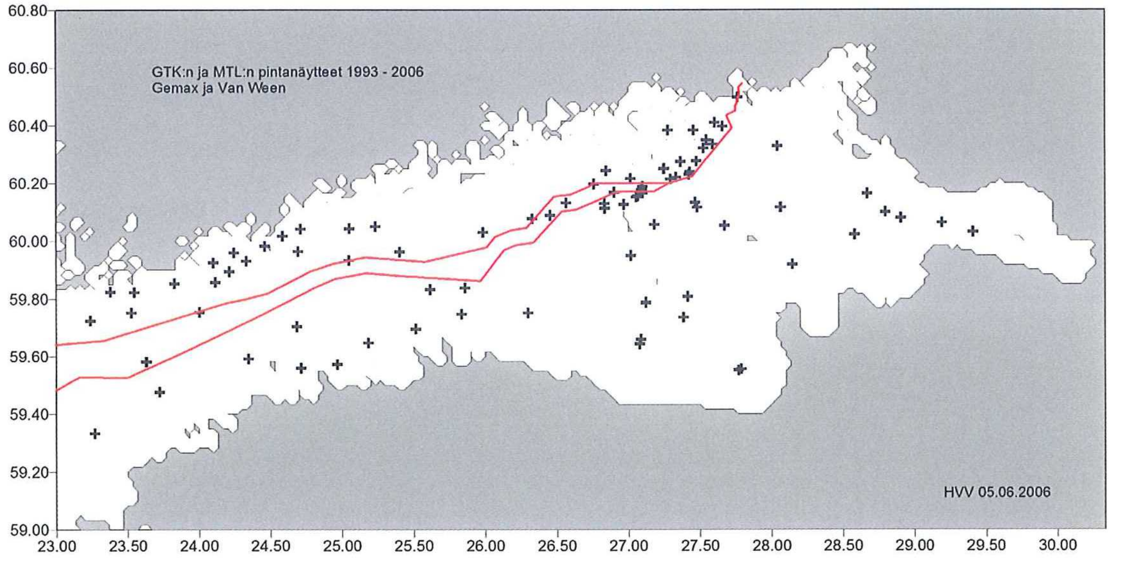

Fig. 3. Sediment stations in and near the EEZ of the Gulf of Finland in 1993–2006 (FIMR and GTK).

Research on topics including pore water and flux nutrient data is available at the FIMR and the Finnish Environment Institute (SYKE) (excluding the EEZ). The FIMR has data starting from the early 1990s that should be employable in the EIA for assessing variation because sediment pore water and flux data is specific to the prevailing environmental conditions of the different research periods and sites (e.g. Mäkelä & Tuominen 2003). The bulk of research stations from which nutrition data is available can be found in Figure 3.

Concentrations of metals in sediments of the Gulf of Finland

There is research data available from the Gulf of Finland on total contents in sediments of elements including aluminium, calcium, potassium, magnesium, sodium, iron, manganese, phosphorus, carbon, sulphur, nitrogen, cadmium, lead, copper, zinc, arsenic, mercury, cobalt, titanium and vanadium. Some sampling site findings apply to surface sediments (0–5 cm) and others to deeper layers (0–25 cm, some up to 60 cm).

Spatial distribution, historical development and sediment quality classification

Figure 4 illustrates the distribution of certain metals in surface sediments of the Baltic Sea. There is obvious spatial variation, with high concentrations of mercury, cadmium, lead, copper and zinc found in the Gulf of Finland.

The quality of sediments in the Gulf of Finland has been classified using the sediment quality criteria for heavy metals employed by the Swedish Environmental Protection Agency (Table 1. The Swedish Environmental Protection Agency, EPA, Naturvårdsverket 1999, Vallius & Leivuori 2003). According to this classification, the state of surface sediments in the Gulf of Finland was not satisfactory: sediments were "significantly" or "largely" polluted with heavy metals (Fig. 5).

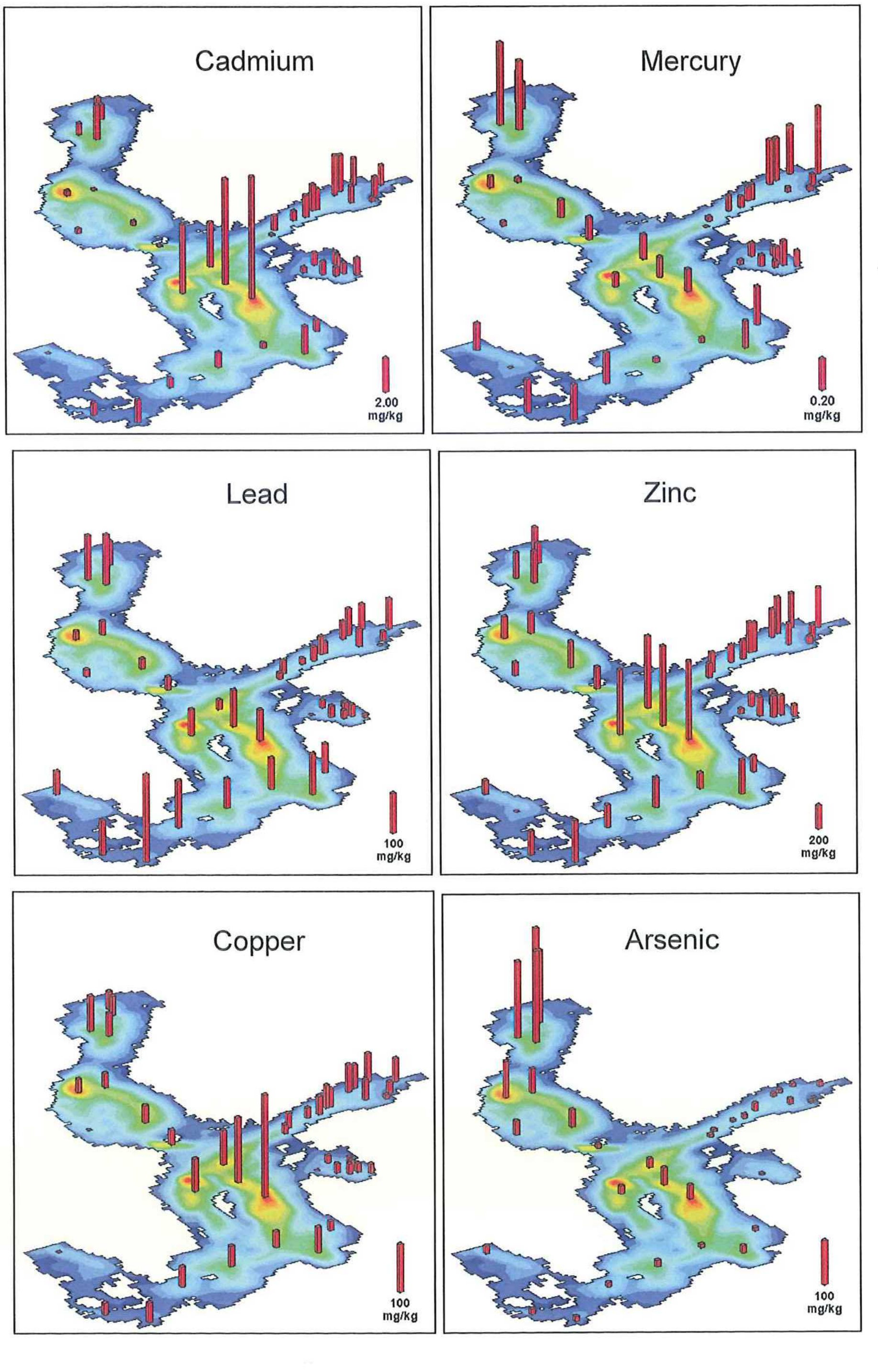

Fig. 4. Spatial distribution of heavy metals in surface sediments of the Baltic Sea (0–2 cm, modified from Poutanen & al. 2002, Albrecht & al. 2003).

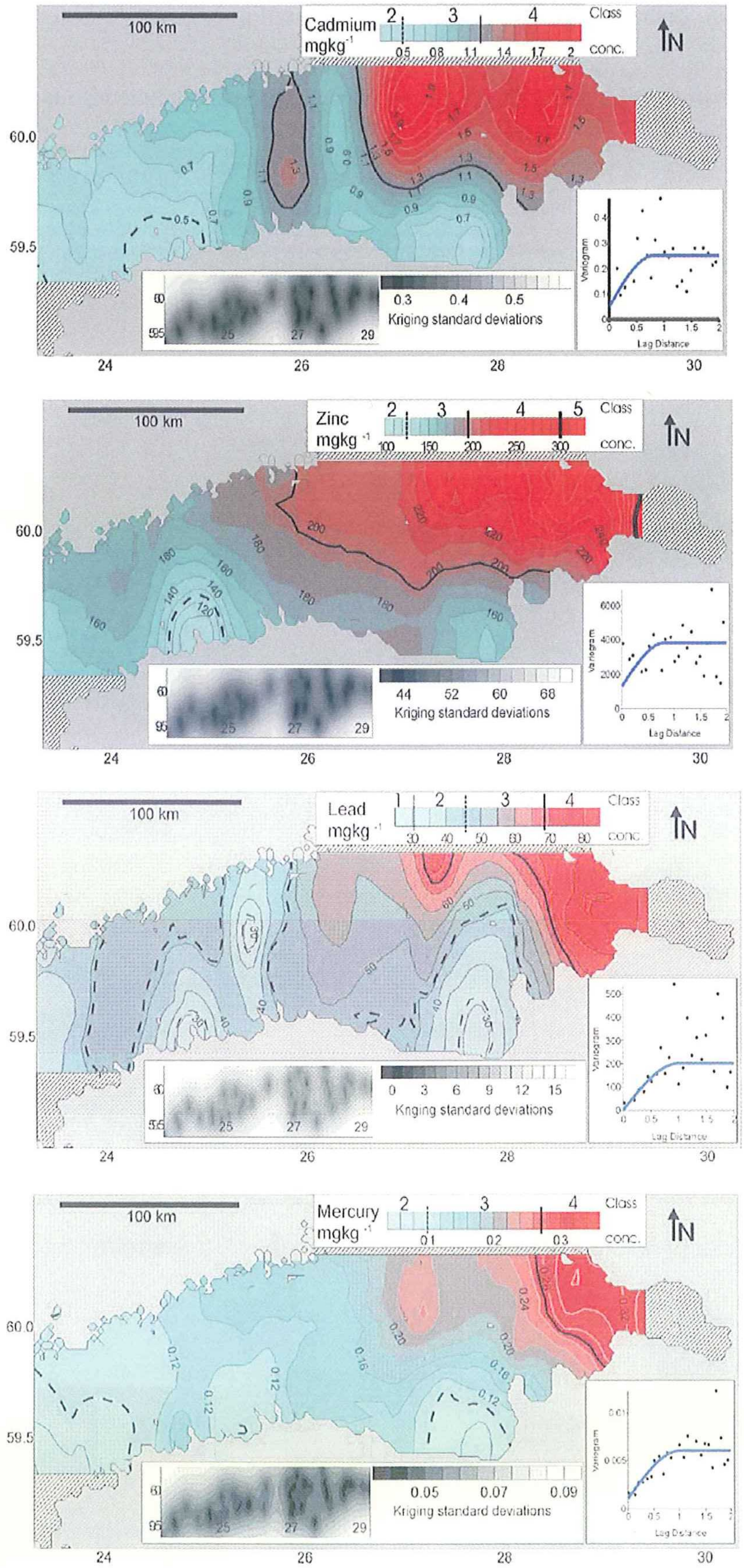

Fig. 5. Quality classification of surface sediments (0–1 cm) in the Gulf of Finland. Class 1 little or no contamination, 2 slight contamination, 3 significant contamination, 4 large contamination and 5 very large contamination. (Classification based on ranges used by the Swedish Environmental Protection Agency, EPA, Naturvårdsverket 1999, Vallius & Leivuori 2003).

Table 1. Sediment quality classification criteria (SEQC, mg kg^{-1} dry weight) based on Swedish values (the Swedish Environmental Protection Agency, EPA, Naturvårdsverket 1999) and, for comparison, US values (USEPA, United States Environmental Protection Agency) (Filgueiras & al. 2004).

	Swedish EPA SEQC					**USEPA SQC**		
Metal (mg kg^{-1})	Class 1 Little or none	Class 2 Slight	Class 3 Significant	Class 4 Large	Class 5 Very large	Not polluted	Moderately polluted	Heavily polluted
Pb	< 31	31–47	47–68	68–102	> 102	< 40	40–60	>60
Hg	< 0.04	0.04–0.10	0.10–0.27	0.27–0.72	> 0.72			
Cu	< 15	15–30	30–60	60–120	> 120	< 25	25–50	>50
Cd	< 0.2	0.2–0.5	0.5–1.2	1.2–3	> 3			
Zn	< 85	85–125	125–196	196–298	> 298	< 90	90–200	>200
Cr	< 80	80–112	112–160	160–224	>224	< 25	25–75	>75

Figure 6 presents vertical sediment profiles of certain metals in central and eastern parts of the Gulf of Finland. Metal concentrations have mostly decreased in topmost sediment layers, but some increased concentrations have also been found at certain easternmost sites (Vallius & Leivuori 1999). Comparison of the vertical profile concentrations with the Swedish marine sediment quality criteria shows "significant" or "large" (Class 3 and 4) contamination with mercury, lead and copper for almost all profiles studied. Cadmium concentrations show "large" or "very large" (Class 4 and 5) levels.

Highest concentrations of heavy metals have been deposited in deeper sediment layers. In the Gulf of Finland the highest concentrations of heavy metals were deposited in the 1970s and 1980s (Leivuori 2000). High concentrations have been buried in deeper layers as new organic and mineralogical material sinking through the water mass is constantly accumulating on the sediment surface. The high speed of sedimentation in the Gulf of Finland has been discussed by e.g. Kankaanpää & al. (1997) and Mattila & al. (2006). Studies of marine areas around Finland have found that annual heavy metal accumulation is highest in the Gulf of Finland. This is partly due to the high sedimentation rate and high total loads of metals (Fig. 5, Leivuori 2000). Thus sediments in the Gulf of Finland contain large deposits of heavy metals that in suitable conditions could be partially re-released into the cycles of the marine ecosystem. Over the years some of these metal deposits will be transformed into hazardous compounds (incl. organic mercury), so their release back into the marine ecosystem may result in very harmful effects.

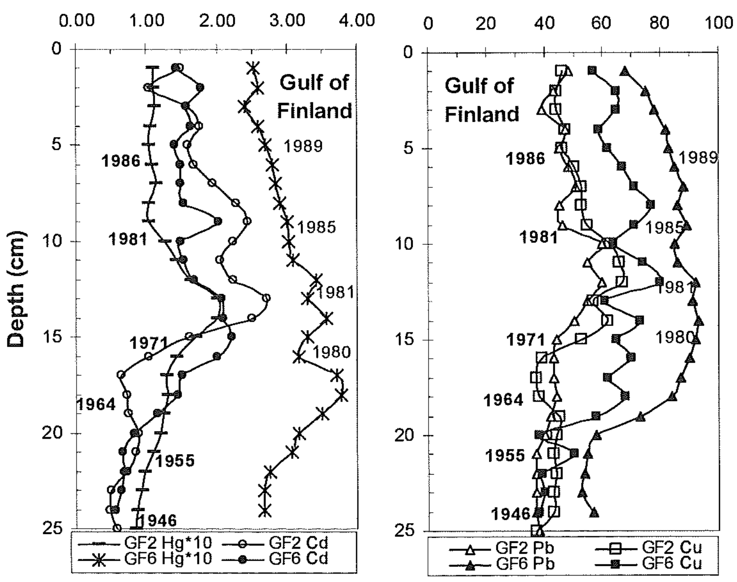

Fig. 6. Vertical profiles of heavy metals mg kg^{-1} dry matter in central (GF2 59°50.30', 25°51.59') and eastern (GF6 60°20.29', 28°00.29') Gulf of Finland (Leivuori 2000). The years indicate the age of the sediment layer.

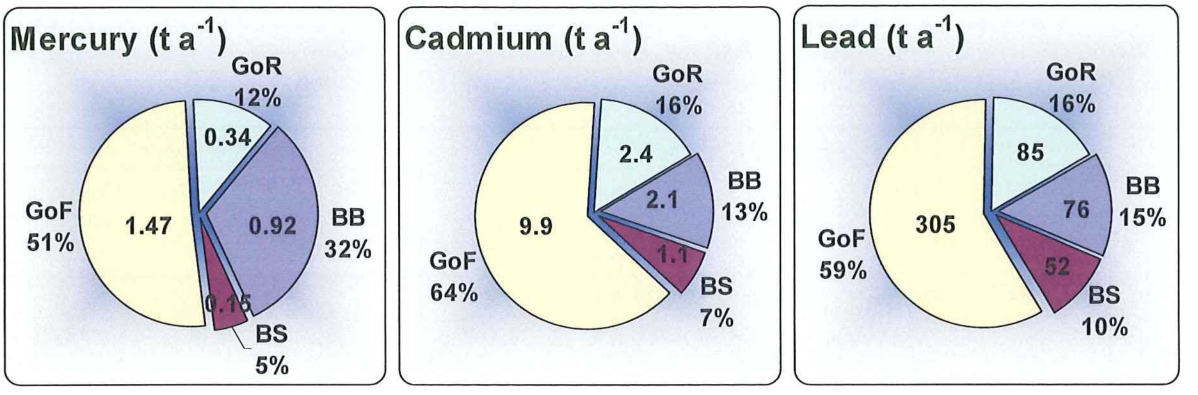

Fig. 7. Annual accumulation (ta^{-1}) of mercury, cadmium and lead in surface sediments of the Gulf of Finland (GoF), Bothnian Sea (BS), Bothnian Bay (BB) and the Gulf of Riga (GoR) (Leivuori 2000).

The annual accumulation of harmful metals in sediments is high in the Gulf of Finland (Fig. 7), and both surface sediments as well as deeper layers are obviously contaminated and large amounts of heavy metals are stored in sediments. Disturbance of such sediment deposits by methods such as ploughing poses a potential risk to the state of the Gulf of Finland. The findings presented are for surface layers (0–25 cm). There is no data available on metal concentrations in samples taken from deeper (including 3–5 m) sediment layers of the Gulf. Before any sediment intervention due to the installation of the gas pipeline takes place, a clear picture of the concentrations of metals, the related quality classifications and the transformation of metals into soluble forms should be acquired.

The priority substances of the EU Water Framework Directive include mercury, cadmium, lead and their compounds. Finland's national list of priority substances also includes chromium, copper and zinc. The EIA should cover at least these metals.

Measure to be taken: Assessing the concentrations of harmful metals and their harmfulness in installation site sediments.

Organic pollutants in sediments of the Gulf of Finland

Research into organic pollutants in offshore sediments of the Gulf of Finland has been unsystematic over the past decade (e.g. Perttilä & Haahti 1986). Research has mainly focused on nearshore areas with known sources of pollution (e.g. Kankaanpää & al. 1997a, Verta & al. 1999, Vatanen 2005) or on concentrations in surface sediments (0–5 cm) (Pikkarainen 2004). Organotin compounds (especially tributyl tin compounds TBTs) have been studied in recent years, particularly in areas near ports and fairways, but there is little research data on offshore areas (3 sites in the Gulf of Finland, Ministry of the Environment 2006). The level of TBT compounds should be studied before any major sediment intervention.

The most extensive study on organic pollutants in sediments of the Gulf of Finland to date is the Baltic Sea Sediment Baseline Study of 1993 (Perttilä 2003). Figure 8 presents the distribution of PCB and PAH compounds in surface sediments found in the study (Jonsson & Kankaanpää 2003, Jonsson 2000). High concentrations of these compounds can be detected in the Gulf of Finland, albeit not as high as levels found in other parts of the Baltic.

Studies conducted in 1993–95 detected major increases in levels of organochlorine compounds originating from the wood processing industry (pulp bleaching) in marine sediments of eastern Gulf of Finland, especially those off the Kymijoki river (Kankaanpää 1997). See Figure 9 for concentrations found. Levels detected were in the range of 100–1000 mg per kg of organic carbon. Estimated using the extractable organic halogen (EOX) sum parameter, total organohalogen compounds found in the area covering 500 km^2 off the town of Kotka was 9.6 tonnes in contaminated sediments (old and new layers).

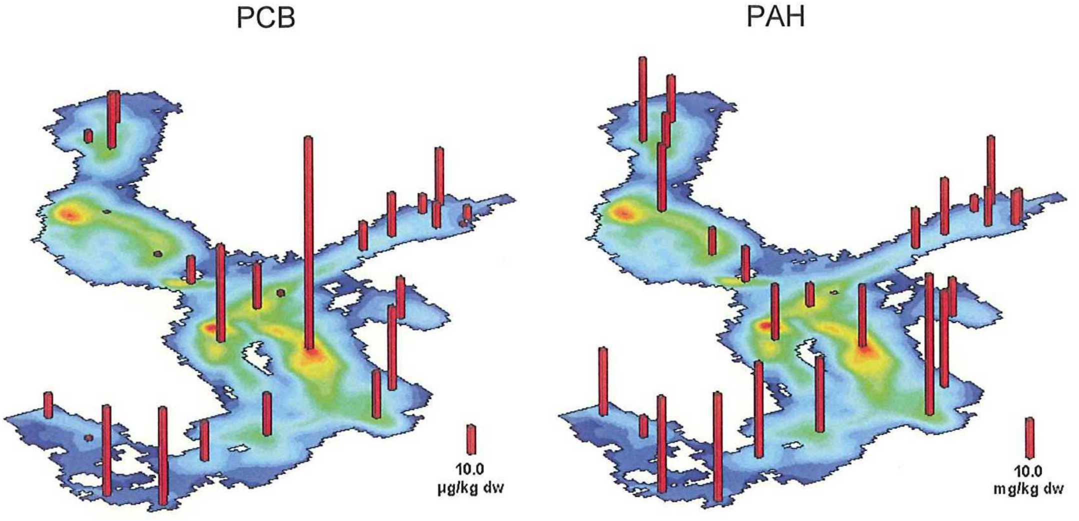

Fig. 8. Distribution of PCBs and PAHs in Baltic Sea surface sediments (modified from Andrulewicz & Poutanen 2002).

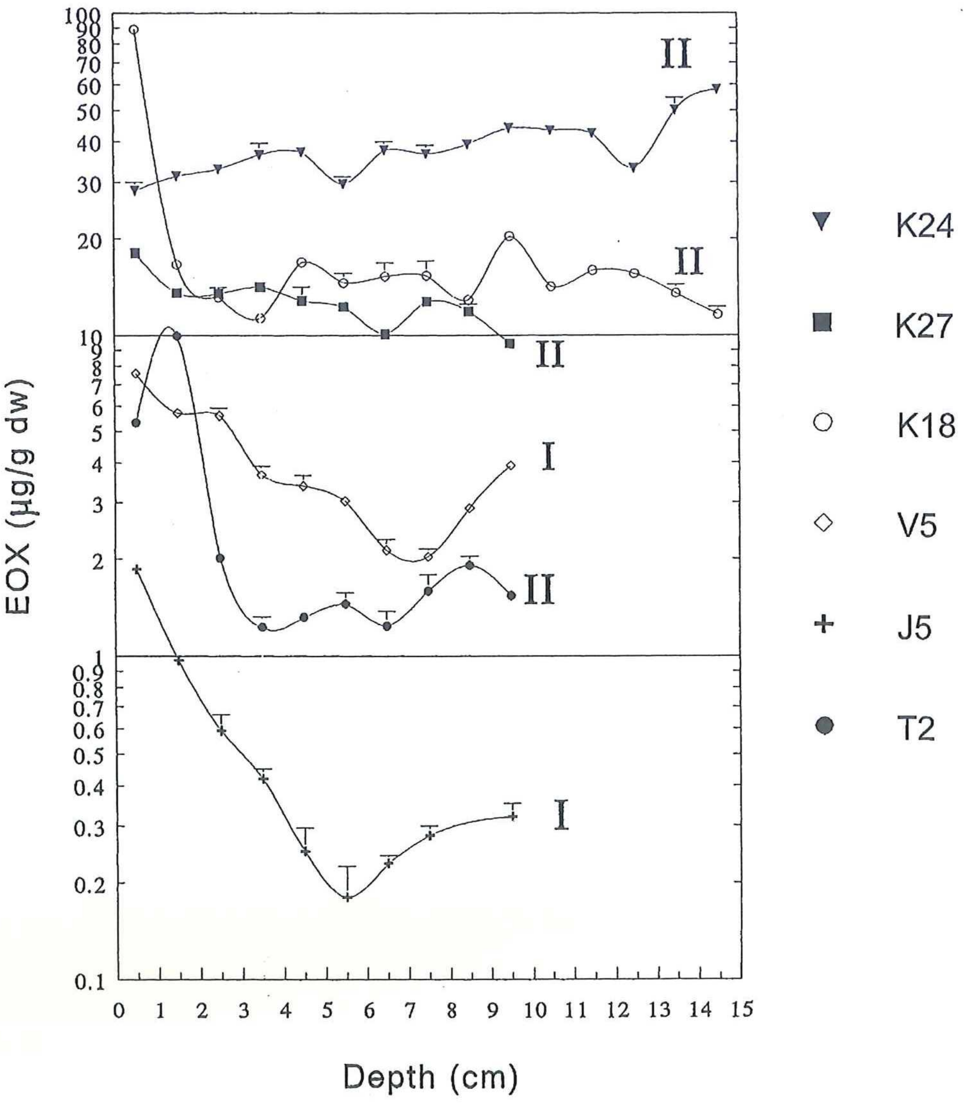

Fig. 9. Examples of vertical EOX distribution in cores from the polluted area (K24, K18 and K27) in sea area off Kotka (Kankaanpää 1997).

The use of elemental chlorine in bleaching has decreased considerably since the mid-1990s, so total EOX levels are unlikely to have increased significantly. It can be estimated that dredging in an area within a 30-km radius of the mouth of the Kymijoki river may release anything between hundreds of kilos to tonnes of EOX compounds.

According to a study conducted in 2000, PCDE/F compounds (dibenzo-p-dioxins and dibenzofurans) constantly enter the Gulf of Finland (Isosaari & al. 2002). These compounds originate from wood preservatives manufactured near the Kymijoki river. The highest concentrations of these compounds found were approximately 100 µg/kg (approx. 480 ng/kg in WHO-TEQ) dry weight. The highest accumulations of dioxins in the area were found in sediment layers created in the 1960s and 1970s, but dioxin levels in surface sediments still remained at up to 66% of the old maximum values. It was estimated that the impacted sedimentary area stretched to a distance of 75 km off the mouth of the Kymijoki river. The PCDD/F sum load was estimated at 1,770 kg (or approximately 12.4 kg WHO-TEQ). Extensive dredging in the area is likely to release a considerable proportion of the highly hazardous dioxins buried in the sediment. The above study also examined the levels of PCBs and found that the PCB load in the polluted area was 2,020 kg (or 0.14 WHO-TEQ). Increased chlorophenol levels were also found in this area off Kotka.

Organic pollutants are deposited in deeper sediment layers. Figure 10 presents the vertical profiles of levels of PAHs, PCBs and EOCls (natural and/or industrial organichlorine compounds) in sediments. Concentrations in surface layers are mainly lower than those in deeper layers, and concentrations increase towards the east in the Gulf of Finland.

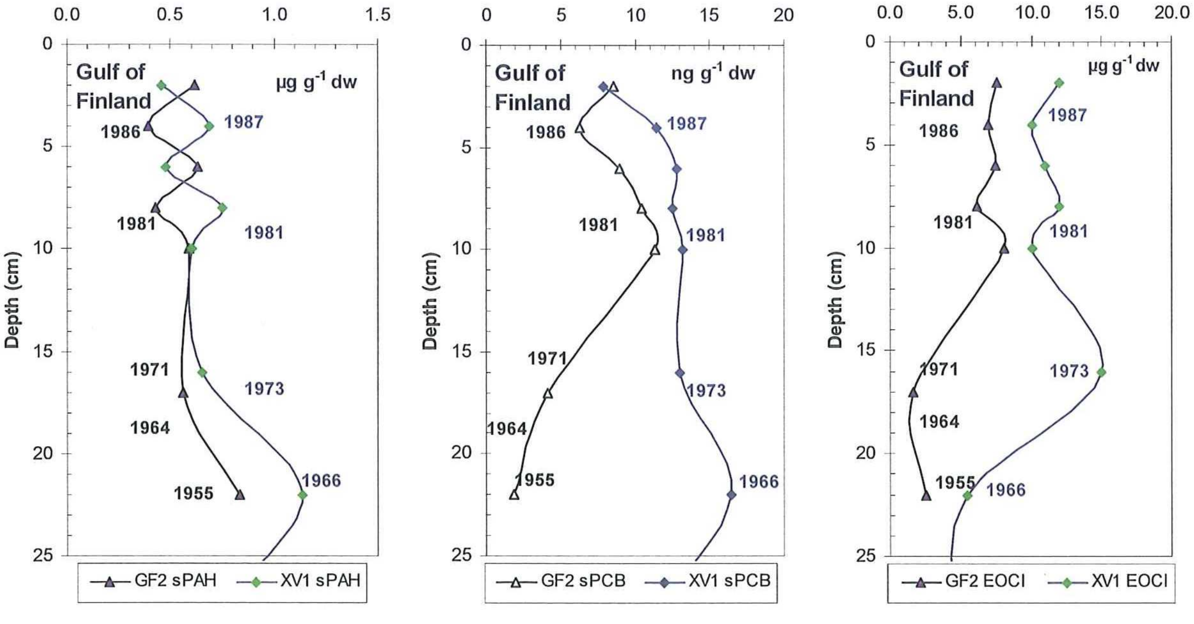

Fig. 10. Vertical profiles of certain organic compounds in central (GF2 59°50.30', 25°51.59') and eastern (XV1 60°14.16', 27°15.29') Gulf of Finland. (From the Sediment Baseline Study 1993, Jonsson & Kankaanpää 2003, Jonsson 2000). For the offshore site (GF2) the EOCl concentration illustrates the total of natural and industrial organochlorine compounds. The years indicate the age of the sediment layer.

For organic compounds, sediment quality can be assessed by comparing concentrations of PCBs, PAHs and EOCls in the sediments studied with the sediment classification criteria presented in Table 2 below. Sediments of the Gulf of Finland are significantly contaminated (Class 3) in the sediment profiles studied with PCBs and EOCls and slightly contaminated (Class 2) with PAHs. However, deeper sediment layers show significant contamination with PAHs too. The role of organic pollutants must also be assessed very carefully in the EIA process. The EU Water Framework Directive provides an extensive list of priority substances that are organic compounds. The entire list of compounds is not, however, relevant for EIA in offshore areas (for example highly volatile organic compounds).

Table 2. Sediment quality classification criteria (µg kg^{-1} dry weight) based on Swedish reference values (the Swedish Environmental Protection Agency, EPA, Naturvårdsverket 1999, http://www.internat.naturvardsverket.se/index.php3?main=/documents/legal/assess/assess.htm).

Substances	Class 1 Null	Class 2 Low level	Class 3 Moderate level	Class 4 High level	Class 5 Very high level
		µg/kg dry weight; corrected for 1% organic carbon			
PAH (sum of 11)	0	0 – 280	280 – 800	800 – 2500	> 2500
PCB (sum of 7)	0	0 – 1.3	1.3 – 4	4 – 15	> 15
Sum of DDT	0	0 – 0.2	0.2 – 1	1 – 6	> 6
EOCl	0	0 – 600	600 – 4000	4000 – 30000	> 30000

Radioactive substances in sediments of the Gulf of Finland

The easternmost part of the Gulf of Finland contains a considerable deposit of radioactive caesium (^{137}Cs) originating from the 1986 Chernobyl fallout which, in studies conducted in 1992–95, was detected in accumulation bottoms of the area at an average of 21 kBq/m^2 throughout the sediment profile (Kankaanpää & al. 1997b). Similar levels of activity were found in the late 1990s (Mattila & al. 2006). The highest levels of caesium activity were detected in the area between Suursaari island and the Kymijoki river and at the mouth of Vyborg Bay (Kankaanpää & al. 1997b). The average levels in the above-mentioned areas were 330–850 Bq/kg dry weight (in the 1986 sediment layer). Since the half-life of caesium is 30 years, the levels of ^{137}Cs still remain at more than 50% of those reported above. Soft-bottom dredging within the Loviisa–Suursaari–Vyborg area would probably release significant amounts (tens of gigabecquerels per square kilometre dredged) of mostly particle-bound radioactive caesium into the water column.

MACROZOOBENTHOS POPULATIONS IN THE PRESUMED CONSTRUCTION ZONE

Ari Laine

The structure of and variation in soft-bottom macrozoobenthos in central Gulf of Finland is known well on the basis of the data produced by the FIMR follow-up studies (e.g. Laine & al. 1997, Laine & al. 2006). The Estonian Marine Institute also monitors macrozoobenthos in the Gulf of Finland, and SYKE has data from the outer edges of the archipelago (Fig. 11). The area hosts 5 to 10 species of macrozoobenthos that live in the surface layer or on the surface of sediment. On the basis of monitoring findings, the number of species and individuals can vary a lot in the area (Fig. 12) and the status of macrozoobenthos populations in the deepest parts of the Gulf of Finland is largely dependent on the oxygen situation in near-bottom water and on changes in salinity (Laine & al. 2006). In good oxygen conditions the area has a diverse community typical of the Baltic Sea where the total population density is several thousand individuals per square metre.

The installation of the gas pipeline into the seabed will locally destroy macrozoobenthos in the areas where manipulation directly occurs. Moreover, installation will cause sediment resuspension and increased turbidity. This will result in wider-scale benthic disturbance in the form of increased sedimentation, which will affect macrozoobenthos at a distance from the actual pipeline (e.g. Schuchardt & al. 1998, Lewis & al. 2002). The ploughing of the pipeline into the seabed is an intervention similar to dredging and disposal. There are plenty of studies on their impact on macrozoobenthos (e.g. Newell & al. 2002, Boyd & al. 2004) and this data can be applied in the EIA. These studies have detected changes in macrozoobenthos up to 4 km from the actual site of work.

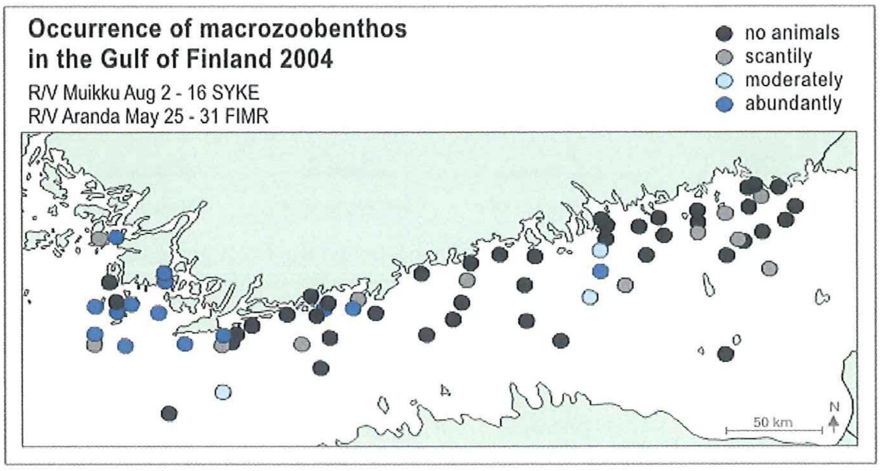

Fig. 11. Monitoring sites and status of macrozoobenthos in the Gulf of Finland in 2004 (Haahti & Kangas 2006).

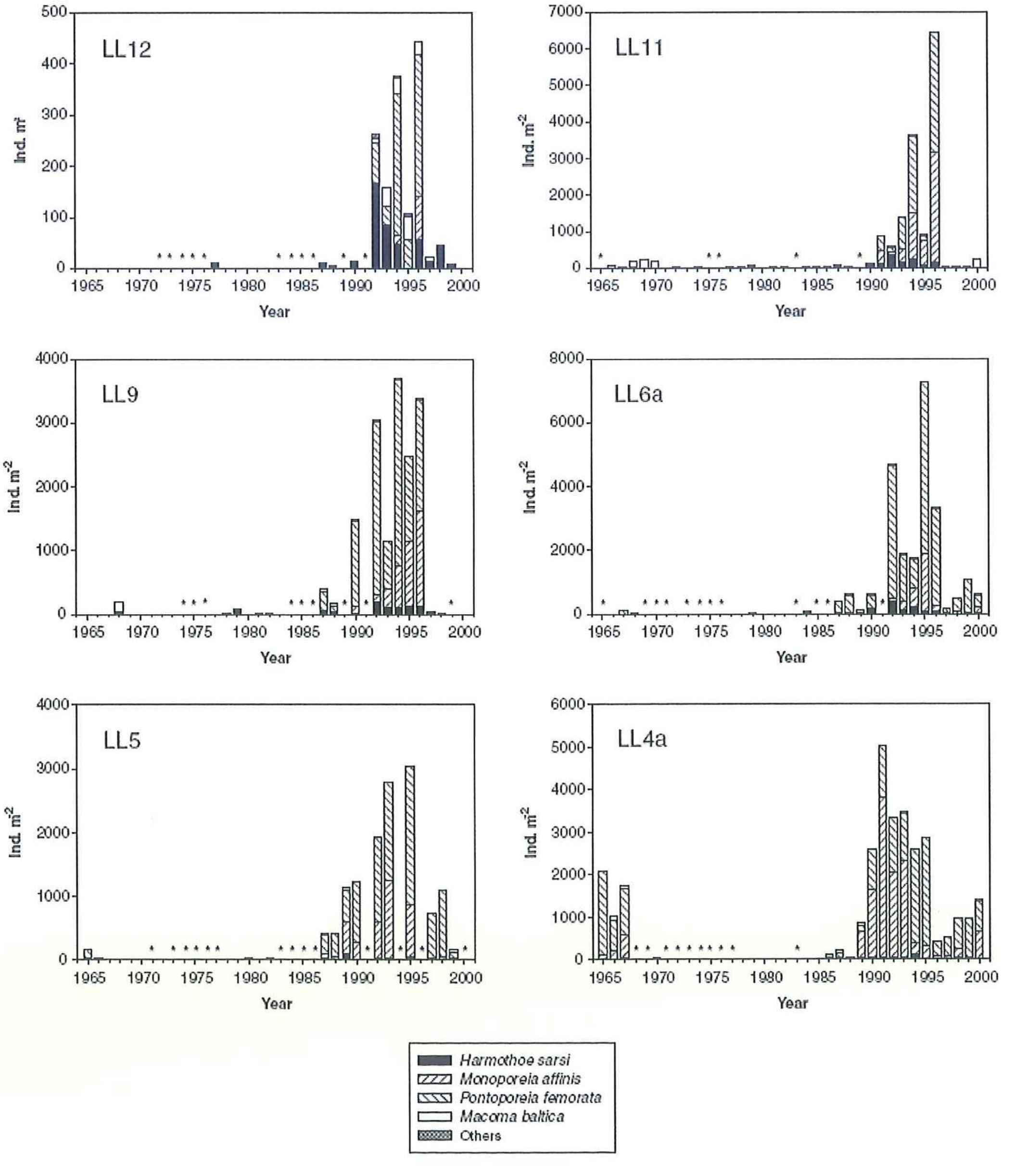

Fig. 12. Variation in macrozoobenthos communities at the Gulf of Finland monitoring sites in 1965–2000 (FIMR monitoring data, Laine & al. 2006).

Macrozoobenthos begin to colonise a disturbed seabed area quite quickly, but it may take up to five years for the structure of the macrozoobenthos community to recover (Bonsdorff 1983, Lewis & al. 2002, Boyd & al. 2004). The speed of the recovery process depends on the scale of the disturbance, the propagation capacities of the species and the status of nearby macrozoobenthos communities. Pipeline installation will alter sediment structure locally and may also affect near-bottom currents, which may influence sediment structure over a larger area. Permanent changes in sediment structure are also highly likely to be reflected in macrozoobenthos communities, with possible permanent changes in community structure.

To assess the impacts of pipeline installation, macrozoobenthos and sediment monitoring zones or areas that are transverse to the pipeline should be set up, covering all of the different disturbance zones. Pre- and post-construction comparison samples should be taken from these sites to study the spatial and temporal extent of the impacts of pipeline construction work. Macrozoobenthos species, density of individuals and biomass should be used as monitoring parameters. Further background parameters required for sediment are content and grain size of organic material.

DUMPED (CHEMICAL) MUNITIONS

Tapani Stipa

The Baltic Marine Environment Protection Commission (Helsinki Commission, HELCOM) has gathered data both from the Contracting Parties (states bordering on the Baltic Sea) and HELCOM observers (the UK, the USA, Norway) on chemical munitions dumped into the Baltic Sea after World War II. The dumping sites identified can typically be found at depths of tens of metres. There are three main dumping sites (east of Bornholm, north-east of Gotland and in the Little Belt) and the amounts dumped are significant (totalling approximately 40,000 tonnes of chemical munitions containing approximately 13,000 tonnes of chemical warfare agents). It is also known that some of the material was dumped while in transit from the port (Wolgast) to the dumping site. Since some of the chemical munitions were packed in wooden crates, they are likely to have drifted and been distributed arbitrarily. The precise theoretical assessment of the condition of the munitions is not possible. Some munitions casings have been found totally intact while others have become totally corroded and no longer contain any hazardous substances. Germany has reported that it has carried out a comprehensive mapping of the areas in which it dumped WWII munitions. Germany has also carried out an extensive mapping of the area between the dumping site and the port of Wolgast and located metal objects (not known to have been studied earlier) in the seabed. HELCOM has been informed of these studies.

No chemical munitions are known to have been dumped in the territorial waters of Finland. Through the NATO Partnership for Peace Programme, the Finnish Navy has access to information about all known munitions dumped in the Baltic Sea. However, the gas pipeline is planned to cross through or near known dumping areas. Many chemicals in these munitions quickly degrade into more innocuous compounds, but for example viscous mustard gas, Clark I and Clark II as well as Adamsite are very poorly soluble and slowly degradable. Through hydrolysis, mustard gas can remain practically unchanged for decades. Many other compounds (Clark I and II and Adamsite) contain toxins including arsenic. Therefore Finland should also take an interest in the release of chemical warfare agents from sediments in dumping sites outside Finnish territorial waters and call for compliance with UNCLOS 194.2.

Funded by the EU under the INCO Programme and coodinated by the FIMR, the main objective of the MERCW project is to model the migration of toxic compounds in marine sediments and ecosystems as well as the resulting ecological and societal risks. For this purpose, focused research and development work is carried out on three dumping sites in the Baltic Sea. The final goal is to assess the ecological safety of the ecosystem and people of the coastal states near the dumping sites. The sites were chosen for investigation because they are highly representative in terms of hydrographical and sedimentological controls:

The Bornholm site is located east of the island of Bornholm. More than 35,000 tonnes of material was dumped in depths ranging between 70 and 120 m. The munitions dumped contained approximately 11,000 tonnes of toxic agents.

The Gotland Deep site is located in the northeastern part of the Deep. At least 2,000 tonnes of chemical munitions (approximately 1,000 tonnes of chemicals) were dumped in the site. There are strong indications near the site that part of the cargo was dumped during transport to the site.

Approximately 5,000 tonnes of chemical munitions (containing approximately 750 tonnes of chemicals) were dumped in the Little Belt area. At least some of the munitions were dumped inside vessels that were sunk.

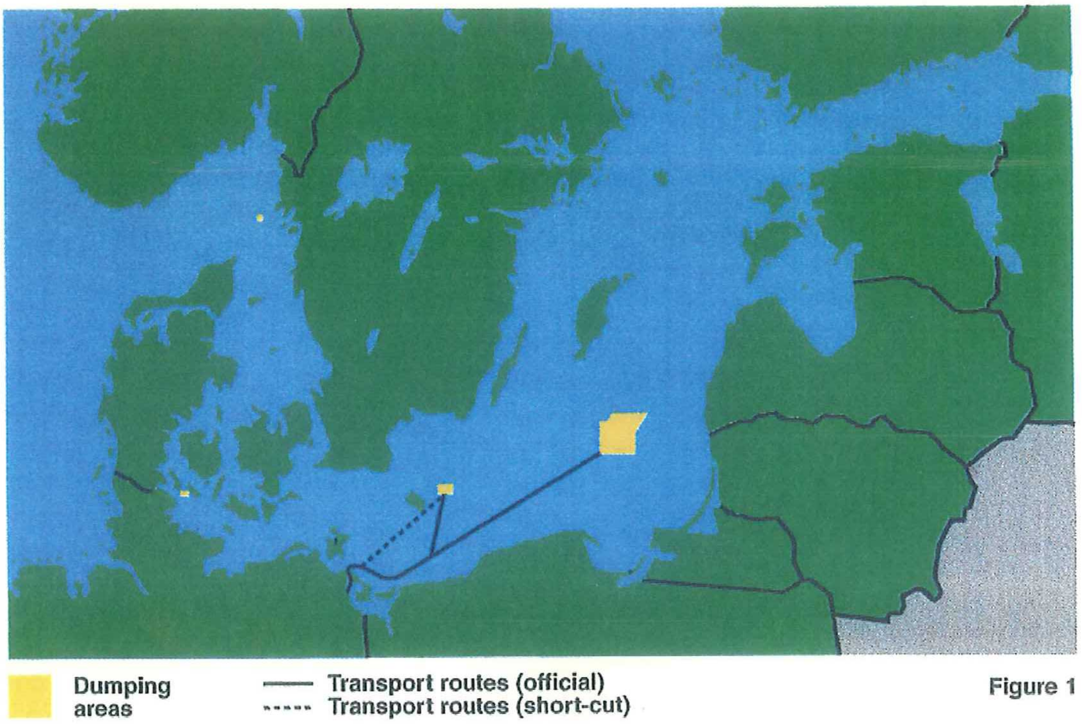

Fig. 13. Dumping sites of chemical munitions in the Baltic Sea (HELCOM).

According to Russian investigations already carried out in the Bornholm area, increased levels of arsenic, and in some few cases mustard gas, possibly originating from sunk vessels have been detected.

BASELINE STUDY AND IMPACT MONITORING

Entire working group

The sediment data presented in this inventory is for offshore areas mainly from the mid-1990s. Some of these sediment sites have been studied again during the 2000s (unpublished data). The bulk of data for nearshore areas and the easternmost Gulf of Finland is unpublished data gathered in the 2000s. Since this inventory covers a lot of unpublished research data, its availability for the EIA must be ascertained.

Because Finland's Baltic Sea Protection Programme does not cover the monitoring of harmful substances in marine sediments, national sediment monitoring has not been possible due to limited resources. Regular sediment monitoring has also not been found necessary as concentrations of metals and persistent organic compounds change slowly under normal conditions and in most cases can be studied afterwards if necessary.

If the gas pipeline will cross the Finnish EEZ, sediment monitoring in active sedimentation basins located in the area should commence quickly, and pre-construction sediment status should be studied. Due to variation in sedimentation rate between sedimentation basins, new material will have accumulated at a rate ranging between 5 and 15 cm since previous studies, depending on the site. Since the installation of the gas pipeline will result in major mixing of sediment layers (especially if ploughing takes place), the historical aspect of sediment monitoring in the installation zone will be lost as the annual sediment layers will be mixed. Follow-up studies will, however, be very important in the areas (sediment+water) to monitor the amounts of any harmful substances released from disturbed sediments in varying environmental conditions.

Most of the existing chemical data is on surficial sediments only (max. 0–50 cm). Dredging will probably go a lot deeper. Deep-sediment samples have already been collected from a few locations, but funding for their analysis and any further sampling and analysis necessary should be guaranteed in conjunction with the EIA process.

The priority substances of the Water Framework Directive include mercury, cadmium, lead and their compounds. Metals added to Finland's national list of priority substances include chromium, copper and zinc. The EIA should cover at least these metals.

Because no precise data is available as to the route upon which the pipeline will be constructed, there is no certainty about the sufficiency of the above descriptions. However, it is quite obvious that the areas covered by the construction route will include those upon which there is not enough data available to assess the pre-construction situation or to predict the impacts of construction through modelling.

To identify and quantify the impacts, experimental observations must comprise of three sets of activities:

A Baseline study on pre-construction seabed. The environmental impacts of the gas pipeline planned for the Baltic Sea will depend largely on the solutions employed. There is, however, hardly any information available about them at the moment. In the absence of such information our opinion, based on our general knowledge of the Baltic, is that at least the following factors should be considered in the baseline study to be conducted:

- precise seabed topography in the construction area and the precise pipeline route;
- description of near-bottom current fields;
- estimates of volume, mass, structure and spatial coverage of sediment masses to be relocated;
- identification of macrozoobenthos populations within the pipeline impact area;
- assessments of the quality of the relocated sediment masses and the seabed;
- assessments of environmental pollutants and nutrients in the sediment, including their solubility in potentially changing chemical conditions (oxidation-reduction);
- identification of any dumped munitions in the construction area.

The baseline study must cover at least the above-mentioned topics as well as any new experimental observations to the extent that may prove necessary due to insufficiency of existing data. The collection of such new observation material as well as the related impact area assessments based on modelling should naturally take place at the expense of the pipeline developer and be carried out in cooperation with Finnish experts.

B Continuous monitoring of changes during construction. This includes monitoring of quantity and quality of substances released from the sediment as well as operational assessments, based on the circulation and stratification situation, of the migration and sinking of released substances for later follow-up. It should also be assessed whether adverse impacts of construction could be reduced by setting the requirement, for example, that pipeline installation may only take place in fully oxic or anoxic conditions or only when the current field is weak so that material released from the seabed will not migrate far. In practice this could mean restrictions such as focusing construction work on a certain season.

C **Long-term monitoring (5–10 yrs?) of changes in the construction impact area.** The impact area will be assessed using particulate matter migration models. When selecting observation sites, expert knowledge of representative sedimentation areas in the Gulf of Finland as well as any existing sites in the impact area must be taken into consideration. To detect any changes, the pre-construction baseline study must be utilised wherever existing material proves insufficient. Long-term monitoring should cover both chemical changes in the impact area (migration and accumulation of released environmental pollutants in sediments and macrozoobenthos) as well as biological impacts (impacts possibly resulting from e.g. water turbidity and amount of particle mass). To assess the impacts of pipeline installation, macrozoobenthos and sediment monitoring zones or areas that are transverse to the pipeline should be set up, covering all of the different disturbance zones. Pre- and post-construction comparison samples should be taken from these sites to study the spatial and temporal extent of the impacts of pipeline construction work. Macrozoobenthos species, density of individuals and biomass should be used as monitoring parameters. Further background parameters required for sediment are content and grain size of organic material.

There are very many excellently preserved shipwrecks from over the centuries at the bottom of the Baltic Sea. These wrecks are a significant part of the cultural heritage of the Baltic Sea. The locations of the wrecks are not known well, particularly on the outskirts of territorial waters. Pipeline installation work could result in irreversible damage to this valuable cultural heritage. Once the route of the pipeline becomes known, an independent assessment of the cultural heritage of sites along the route must be set as a requirement.

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IMPLEMENTATION OF THE NORTH EUROPEAN GAS PIPELINE PROJECT
— DATA INVENTORY AND FURTHER NEED FOR DATA FOR ENVIRONMENTAL IMPACT ASSESSMENT

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