Rambøll Danmark

Macrozoobenthos along the South route of the Nord Stream Pipeline in the Baltic Sea including the Kalbådagrund alternative in the Gulf of Finland

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Dansk Biologisk Laboratorium

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APPENDIXES

1 INTRODUCTION

1.1 Background

On request of Rambøll Denmark A/S DBL in cooperation with DHI have submitted reports concerning:

1. The north route of the Nord Stream pipeline based on data from the EEZ zones and territorial waters of Germany (2006 and 2007) and Denmark (2007), and the EEZ zones of Sweden and Finland in 2007 /1/

2. The Nord Stream pipeline in the territorial waters of Russia based on data in 2005 and 2006 /2/

3. The south route of the Nord Stream pipeline based on data from the EEZ zone and territorial waters of Germany (2006) and Denmark (2008), and the EEZ zones of Sweden and Finland in 2007 /3/.

New surveys of macrozoobenthos were done along a selected stretch of the planned pipeline route and along an alternative route at Kalbådagrund in the Gulf of Finland in May 2008 /4/.

This report concerning the south route of the Nord Stream pipeline includes the results from the Gulf of Finland in 2008 (sampling along the planned route and the Kalbådagrund alternative) and is based on data from the EEZ and territorial waters of Germany (2006), the EEZ and territorial waters of Denmark (2008), and the EEZ of Sweden (2007) and Finland (2007).

In this report, ***EEZ*** or ***EEZ Zone*** is used as a common denominator for *EEZ zone / territorial waters* (Germany and Denmark) as well as *EEZ zone* (Sweden and Finland) and *territorial waters* (Russia)(see figure 2.1).

1.2 Objectives of the report

The overall objectives of this report are:

- to present macrozoobenthos data collected along the south route of the Nord Stream pipeline in the Baltic including the alternative Kalbådagrund route in the Gulf of Finland

- to describe the communities of macrozoobenthos necessary for a subsequent Environmental Impacts Assessment,

- to compare the macrozoobenthos along the planned and the alternative Kalbådagrund route in the Gulf of Finland in 2008.

- to establish a basis for future monitoring of macrozoobenthos

2 MATERIALS AND METHODS

2.1 Number and location of sampling stations

Samples of the soft bottom fauna (in fauna) were collected at 265 stations located along the proposed alignment of the pipeline in the Baltic Sea. The bottom fauna investigations spread over 5 different investigations carried out by the countries involved, i.e. Germany, Denmark, Sweden and Finland. Data from the Russian territory are not included, as no species-specific data are available from this area. A summary of sampling along the planned pipeline route in the EEZ zones of Germany, Denmark, Sweden and Finland in 2006, 2007 and 2008 is presented in table 2.1. Sampling stations consist either of single stations along the line or stations grouped in transects perpendicular to the line.

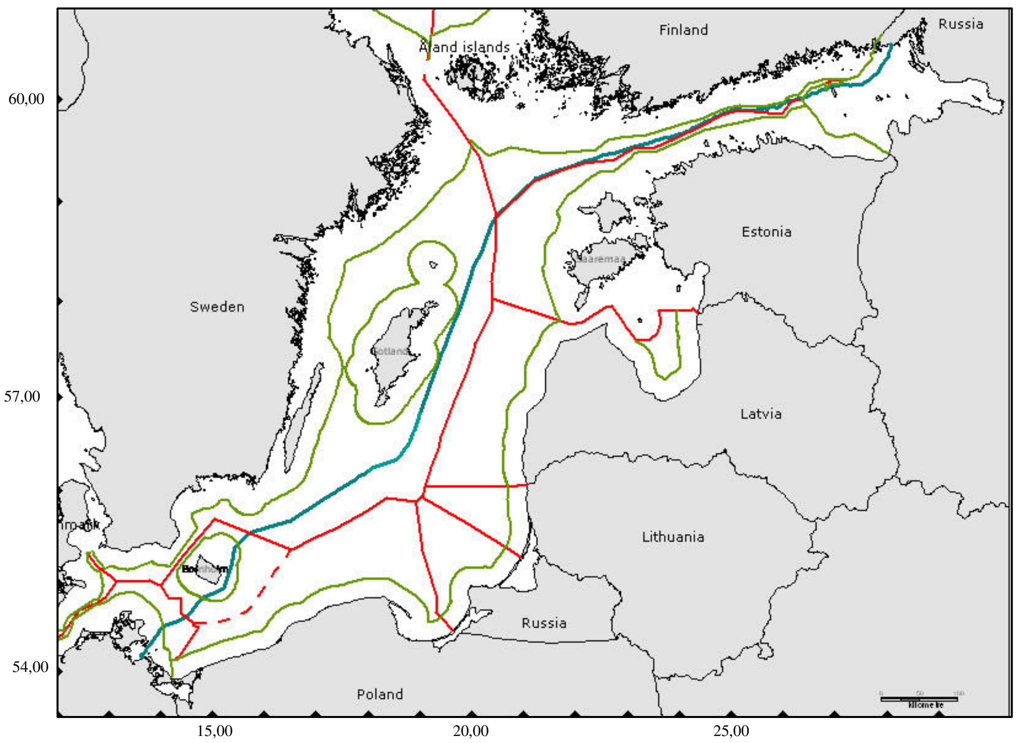


Figure 2.1 Alignment of the pipeline in the Baltic Sea. (= pipeline, = EEZ border = territorial border)

Table 2.1 Summary of sampling along the planed pipeline route in the EEZ zones and territorial waters of Germany (2006) and Denmark (2008), and in the EEZ zones of Sweden (2007) and Finland (2007 and 2008).

Issue	Germany	Denmark	Sweden	Finland-07	Finland-08
Year of sampling	2006	2008	2007	2007	2008
Month of sampling	May-Aug	May	Aug-Sep	Aug-Sep	May
Stations, total number	118	28	41	44	34
Depth range, all stations	1,0 - 30,0	29,8 - 91,4	38,0 - 179,0	49,0 - 176,0	46,0 - 82,0

2.2 Field procedures

Germany
The environmental investigations in the German EEZ zone / territorial waters in connection with the alignment of the pipeline south of Bornholm cover a total of 118 stations. The report covers investigations from 2006. At each station a quantitative Van Veen grab sample ($0.1m^2$) of the seabed were taken for analysis of macrozoobenthos. Sediment samples from these investigations were analysed for grain size, loss on ignition and silt/clay content. Oxygen concentration, temperature and salinity measurements were carried out in the water just above the bottom and in the surface layer.

Denmark
The environmental investigations along the pipeline route in the Danish part of the Baltic Sea covered 28 stations positioned along the pipeline southern route around Bornholm. The investigations were carried out in May 2008. At each station Van Veen grab samples ($0.1m^2$) of the seabed were taken, one for sediment analysis and one for macrozoobenthos analysis. The fauna samples were sieved onboard through a 1 mm-sieve, preserved in buffered formaldehyde and stored in plastic containers. Measurement of temperature, salinity (conductivity) and dissolved oxygen concentration from the surface to the bottom (CTDO profile) was carried out on each station, and oxygen concentration was measured one meter above bottom with a HQD-electrode.

Sweden
The environmental investigations in the Swedish part of the Baltic Sea covered 41 stations positioned along the pipeline route. Samples for oxygen content of the bottom water, water temperature and sediment were taken along the positions for the pipeline route. If fauna were encountered in the sediment sample at the position of the pipeline additional samples were taken at both sides of the pipeline. The investigations were carried out from the vessel "Ocean Surveyor". At each station, Van Veen grab samples ($0.1191m^2$ or $0.1043\ m^2$) of the seabed were taken. The fauna samples were sieved onboard through a 1 mm-sieve, preserved in buffered formaldehyde with Rose Bengal and stored in plastic containers. Due to heavy winds and seas, it was necessary on some stations to use a box-corer ($0.0400\ m^2$) instead of Van Veen sampler. On some of the visited stations it was not possible to obtain sediment samples due to very hard gravel/clay. At all pipeline stations a bottom water sample was taken with a water-sampler for oxygen and temperature measurements.

Finland
The environmental investigations in the Finnish part of the Baltic Sea covered in 2007 44 stations positioned along the pipeline route. In addition to the actual stations in the pipeline route, substations laying perpendicular, 300 meters north and south of the mainline. In May 2008, a new survey of macrozoobenthos was done along a selected stretch of the planned pipeline route and along an alternative route at Kalbådagrund. At each station, Van Veen grab samples ($0.1120\ m^2$) of the seabed were taken. The fauna samples were sieved onboard through a 1 mm-sieve, and preserved in buffered formaldehyde. Oxygen, salinity and temperature were measured one meter above bottom. No CTDO profile measurements were carried out.

2.3 Laboratory analysis

The samples were sorted in the laboratory under a sorting lamp and all animals were picked up. The macrozoobenthos in the samples were identified and counted. The total biomass of the species including shells of gastropods and bivalves were determined as dry weight. The procedure used on the Danish samples included drying in oven at 105°C in 18-24 hours or until stabile weight was reached, followed by weighting of dry weight and determination of ash free dry weight after burning in muffle oven at 550°C for 2 hours.

In the Swedish investigation however, only wet weight was estimated with a balance with 0.1 mg accuracy. Wet weight data were afterwards converted to shell free dry weight data using the conversion factors for the Baltic Sea. In order to compare the Swedish data with data from the other countries, shell free dry-weight data of the bivalves *Macoma balthica* and *Mytilus edulis* have been converted into dry weight inclusive shells, using a conversion factor created on basis of the finish data (see appendix 6).

2.4 Database

In order to make the data from different investigations comparable and to easy the future work with the environmental data collected in connection with the pipeline in the Baltic Sea, an access-based database has been established. The database is a dynamic database, which means that data easily can be added as new data are available. In the following, comments are listed about the structure of the database, together with a description of how the data is presented and listed in the database.

Structure

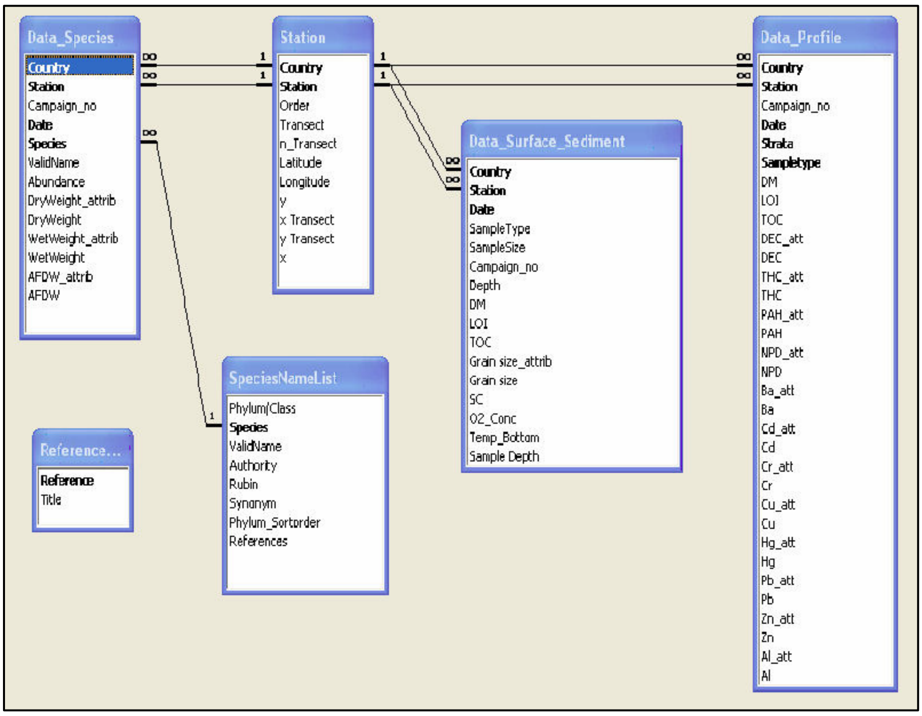


Figure 2.2 Structure of database

Station

The station-file consists of all the stations visited and the corresponding positions in geographically Decimal Degrees. The corresponding geographically Degrees (°) Minutes (') Seconds (") of latitude or longitude is also presented.

In the column "Order", a number is given for all stations in the database in the following way:

0	=	Station not included in the present investigation
1	=	Single station (primary station) placed directly along the alignment of the pipeline
2	=	Primary station placed directly along the alignment of the pipeline, and is a part of a chain of stations perpendicular of the mainline, or part of an aggregate of stations.
3	=	Secondary station not placed directly in the line of the pipeline, but is a part of a chain of stations perpendicular of the mainline, or part of an aggregate of stations.

Aggregated stations has been given a transect-number in the "Transect" column, and the number of stations (n) in an aggregation of stations is presented in column "n_Transect". Every aggregation of stations or every transect has been given a distinct set of geographically positions, corresponding to the positions of the primary stations mentioned above.

SpeciesNameList

This file contains all the fauna species found in the investigations from the different EEZ zones of the countries. The species name in the column "Species" refers to the scientific name given by the fauna specialist in a certain investigation. In order to standardize the nomenclature used by different authors, a second column "Valid Name" is used, where the correct scientific name is given according to ERMS - The European Register of Marine Species, which is an authoritative taxonomic list of species occurring in the European marine environment. A species name different from the correct scientific name is marked as a synonym in the "Synonym" column. In column "Authority" the name of the author who first published a valid description of the species is presented and in the column "Rubin", a specific code (Rubin Code) is given for each species.

Data_Species

This file contains all macro benthos data. Abundance of a species in a sample is given as number of individual's per m^2. Biomass (Wet Weight, Dry Weight or Ash Free Dry Weight) is likewise given in g per m^2. Be aware that this file only contains visited stations or positions, where it was possible to get a representative bottom sample. Samples from stations/positions where no fauna was found is marked as "No Fauna" in the species/Valid Name-column and marked with the number"99999" in the abundance and biomass columns.

Data_Surface_Sediment

This file shows the type of bottom sampler used in the different investigations, the area of the sampler (cm^2), depth (m), and sediment characteristics such as Dry Matter, Loss On Ignition, Total Organic Carbon, Grain Size and the fraction of Silt/Clay.

2.5 Statistical analysis

Multivariate analysis including classification and ordination was used to analyze the structure of the benthic community based on fourth root transformed abundance and biomass data and Bray-Curtis similarity using the software package Primer /17/. The importance of environmental factors (depth, physical and chemical variables measured in the sediment and bottom water) for the structure of the benthic community was analyzed using BioEnvir /17/. The environmental variables were transformed (log x+1) and the similarity calculated as Euclidean distance.

In addition to analyses of data from the EEZ of Germany, Denmark, Sweden and Finland combined similar multivariate analyses were also conducted on data from the planned and alternative Kalbådagrund route of the pipeline in the Gulf of Finland in May 2008. The position of the stations is shown in Appendix 7.

The planned route includes stations both west and east of the alternative Kalbådagrund route and these stations are common for both alternatives. It means that only the 9 stations (stations 264-272) along the planned route and the 10 stations (stations 281-290) along the Kalbådagrund route are alternatives in a strict sense. Analyses and comparisons were based on all stations along the planned and alternative route. However, the data from the alternative stations in a strict sense have also been subject to analyses.

3 SALINITY AND OXYGEN

3.1 Introduction

This section is based on /5,6,7,8,9/ and results of measurements conducted along the Nord Stream pipeline in the EEZ of Denmark in 2008, Sweden in 2007 and Finland in 2008.

The alignment of the pipeline from Germany is planned to run south of Bornholm, east of Gotland and via the Gulf of Finland to Russia, cf. Figure 2.1.

The water depth along the alignment is highly variable. This reflects the bathymetry in this part of the Baltic Sea, which is characterised by a sequence of deeper basins (e.g. the Bornholm Basin and Eastern Gotland Basin) separated by shallower sills (Appendix 1).

The species richness, abundance and biomass of macrozoobenthos at a specific place and time are in general result of the interaction of a number of biological and environmental factors. However, the number of species is reduced in parallel to the decline in salinity at the bottom water from south to north in the Baltic Sea /7/. In addition to salinity, the concentration of dissolved oxygen at the seabed is an important factor for the species richness and the presence/absence of the soft bottom macrozoobenthos along the alignment of the pipeline.

3.2 Salinity

The salinity along the alignment and in the Baltic Sea in general is characterised by pronounced horizontal and vertical gradients due to inflows of marine water via the narrow Danish Belts (threshold: 17m) and inputs of freshwater from rivers. Major marine intrusions, which renew the bottom water in most or all deep basins in the Baltic Proper are infrequent and followed by prolonged stagnation periods. A major inflow in 1993-1994 ended the latest long stagnation period lasting since 1977. The latest major inflow was recorded in January 2003 /18/.

In addition to the south to north (latitude) declining trend in salinity, the stratification also affects the salinity at the bottom along the pipeline. The depth of the halocline is influenced by factors affecting the vertical mixing but a permanent halocline may typically be developed in the depth range between 50m and 90m.

The horizontal and vertical salinity gradients at selected sites along the pipeline are presented in Appendix 2 on the basis of average summer (June-August) and winter (December-February) data in 1900-2005. The average salinity at the bottom declines from about 16 psu south and east of Bornholm to 13 psu east of Gotland, 10-11 psu in the northern Baltic and 7-9 psu in the middle of the Gulf of Finland. The vertical stratification and development of a halocline is most pronounced south and east of Bornholm, where the halocline depth is about 50m below surface. The halocline is less pronounced in the deeper basins east of Gotland and in the northern Baltic and weak in the middle of the more shallow Gulf of Finland.

The long term horizontal average gradient in salinity may have some implication for the overall distribution of species with marine or limnic origin. However, the presence/absence of species may be determined by shorter terms changes in salinity and oxygen linked to intrusion of marine water, length of stagnation periods, freshwater input, vertical mixing and eutrophication.

Profiles of salinity, oxygen and temperature were only measured in the EEZ of Denmark. The profiles were recorded at the same time and at the same stations, where samples of macrozoobenthos and sediment were collected in 2007 and 2007 /16,19/. An example of a salinity and oxygen profile from May 2008 is shown in Figure 3.1.

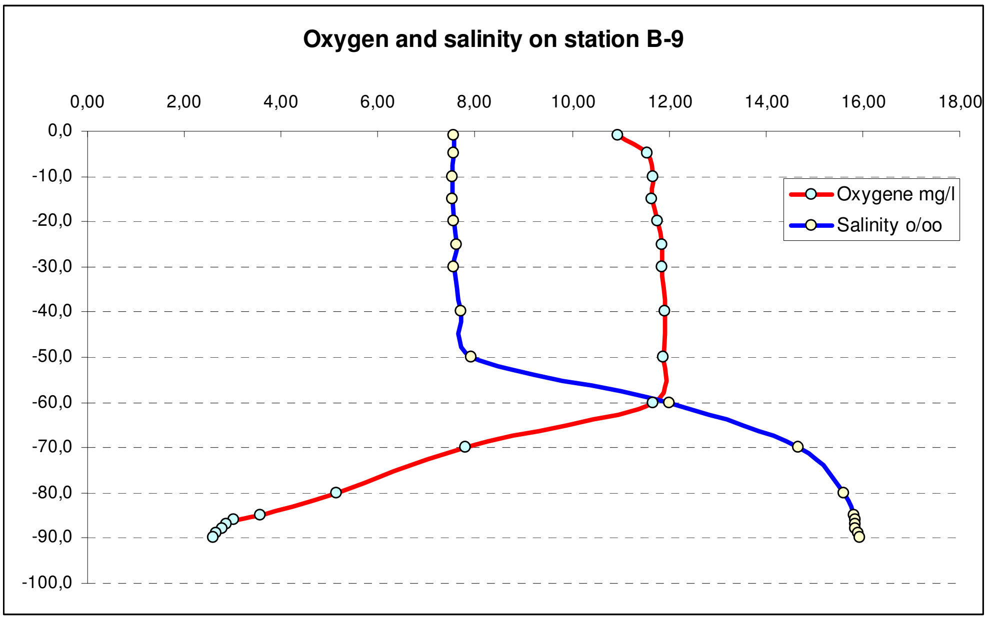


Figure 3.1 Profile of salinity and oxygen measured at station B9 in the EEZ of Denmark in May 2008.

Station B9 is located northeast of Bornholm and the water depth is about 90 m. A pronounced halocline is developed 50-60m below the surface. The salinity at the bottom is close to 16 psu and similar to the long term vertical salinity gradient in this area, cf. Appendix 2. The oxygen concentration declines rapidly below the halocline and the concentration is 2.59 mg/l close to the bottom at a depth of 90 m.

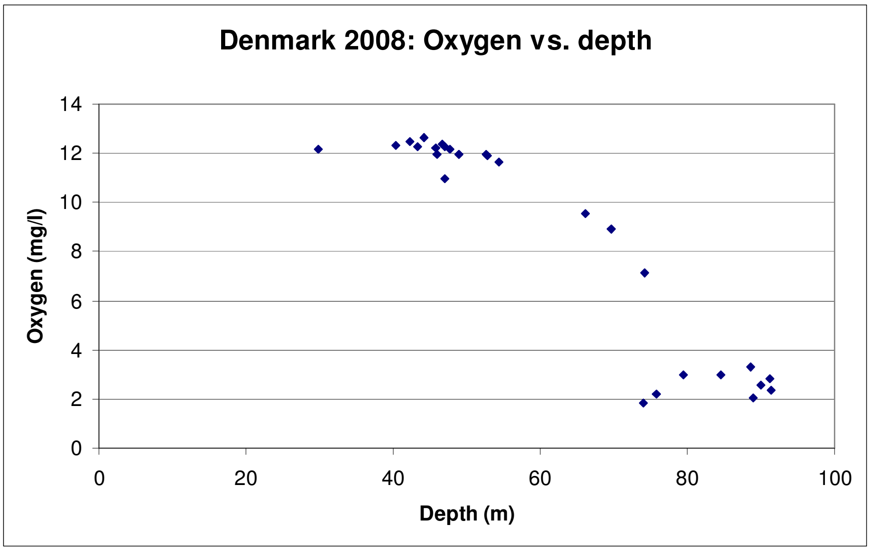
3.3 Oxygen

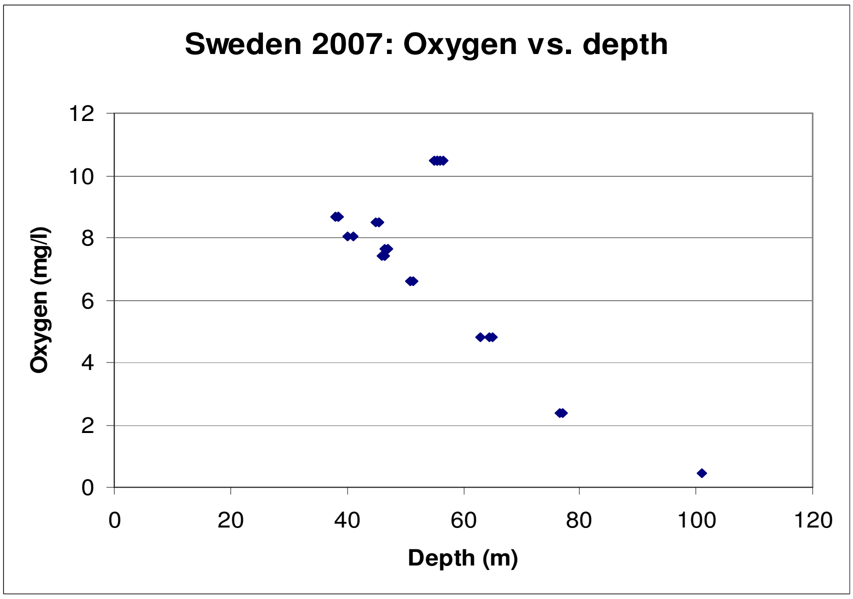
Dissolved oxygen is a prerequisite for the presence of macrozoobenthos. The tolerance to sub-saturated oxygen concentrations is in general species specific. However, the response of the species also depends on factors including rate of decline of oxygen, duration of the exposure for low oxygen concentrations and temperature affecting respiration of the animals. However, abundant populations of the few benthic species in the Gulf of Finland required minimum oxygen concentrations above 2 ml/l (2.9 mg/l) /5/. Oxygen below 2 ml/l (hypoxia) is increasingly critical for the fauna and development of anoxic conditions and release of toxic hydrogen sulphide prevent the existence of macrozoobenthos.

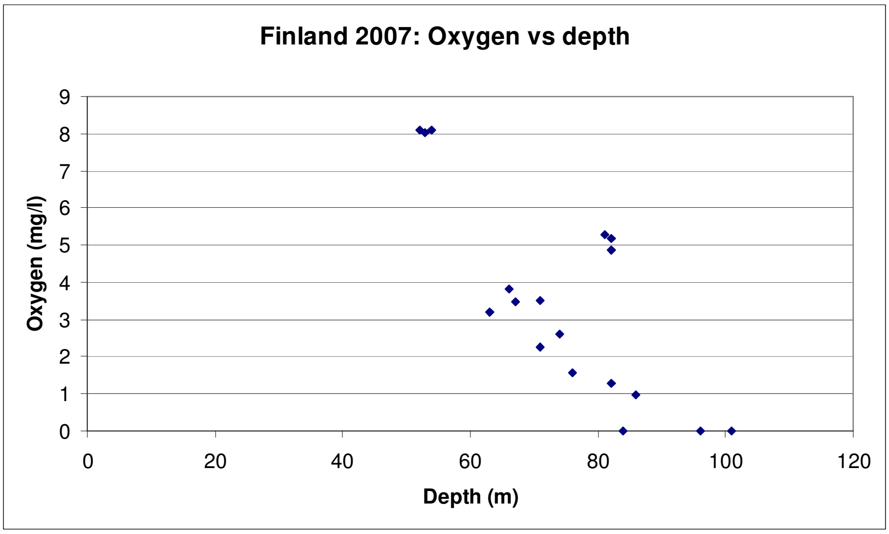
The concentration of oxygen at the bottom is in general affected by a balance between the oxygen demand at the seabed and transport of oxygen from the surface (photic zone) due to vertical mixing and/or horizontal transport (intrusion) of oxygen rich water.

The vertical mixing is hampered in deeper water in the Baltic Sea due to the saline stratification and intrusion of oxygen rich marine water is infrequent and irregular in duration and magnitude. The oxygen concentration will therefore decline below the halocline, cf. Figure 3.1.

The concentration of oxygen close to the bottom was measured during the sampling campaigns in the EEZ of Denmark in May 2008, in Sweden in August-September 2007 and in Finland in May 2008 (Figure 3.2).







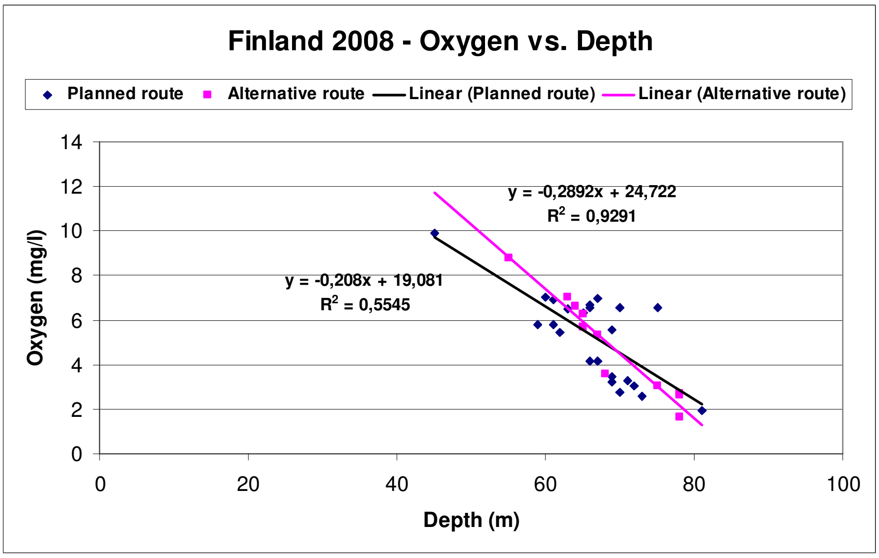


Figure 3.2 *Oxygen concentrations vs. depth measured in the EEZ of Denmark in May 2008, Sweden in August-September 2007 and Finland in May 2008. The measurements in the EEZ of Finland included the planned and the alternative Kalbådagrund route of the pipeline. The dots represent individual measurements of water depth and oxygen concentration measured approximately 1 m above the bottom.*

The oxygen concentrations declined rapidly below the halocline about 60m below the surface in the EEZ of Denmark. The oxygen concentrations were below 4 mg/l deeper than 74m. The lowest concentration of oxygen was 1.8 mg/l and measured at a depth of 74m.

The depth of the halocline was not measured in the EEZ of Sweden. However, the oxygen concentrations declined at depths more than 60m. The oxygen concentration approached 2 mg/l at 77 m and was below 0.5mg/l at a depth of 100m.

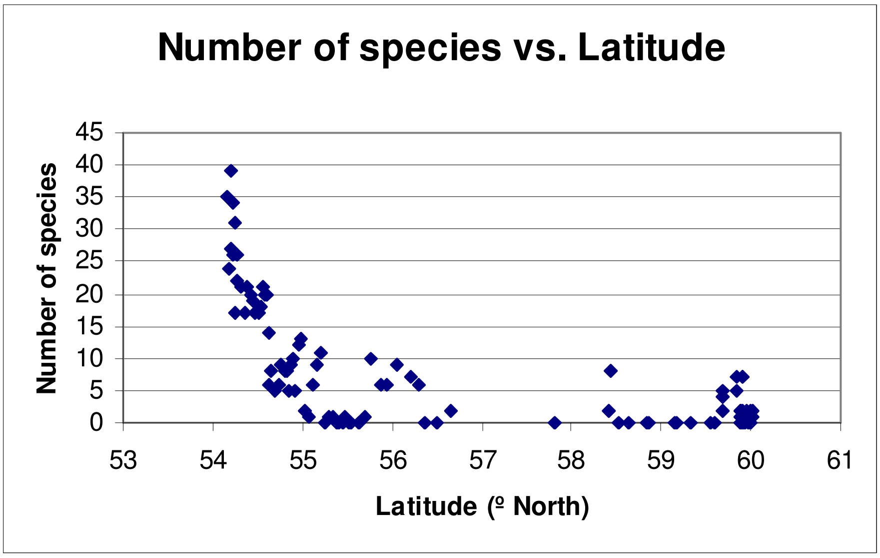
The depth of the halocline was not measured in the EEZ of Finland in 2007 and 2008. In 2007 the oxygen concentrations in general decreased at depths greater than 60m and approached 1 mg/l at a depth of 80m. An exception for this general trend was three stations (NS17N, NS17C and NS17S) where the depth was 81m to 82m and the concentration of oxygen around 5 mg/l. The bottom water was anoxic at depths greater than 90m.

In 2008 was the oxygen concentration in the bottom water not closely related to the water depth along the planned route. However, the lowest concentration close 2 mg/l was measured at the deepest station with a water depth close to 80m. The oxygen concentration at the alternative route was closely related to the water depth. The oxygen concentrations at the deepest stations (79m) were between 1.6 mg/l and 2.7 mg/l in May 2008.

4 SPECIES, ABUNDANCE AND BIOMASS OF MACROZOOBENTHOS

4.1 Species richness

About 67 species and higher taxa were recorded along the south route in 2006, 2007 and 2008. The number of species per station was highly variable but declined rapidly with Latitude mainly due to the trend of decreasing salinity from south to north in the Baltic Sea (Figure 4.1, top).



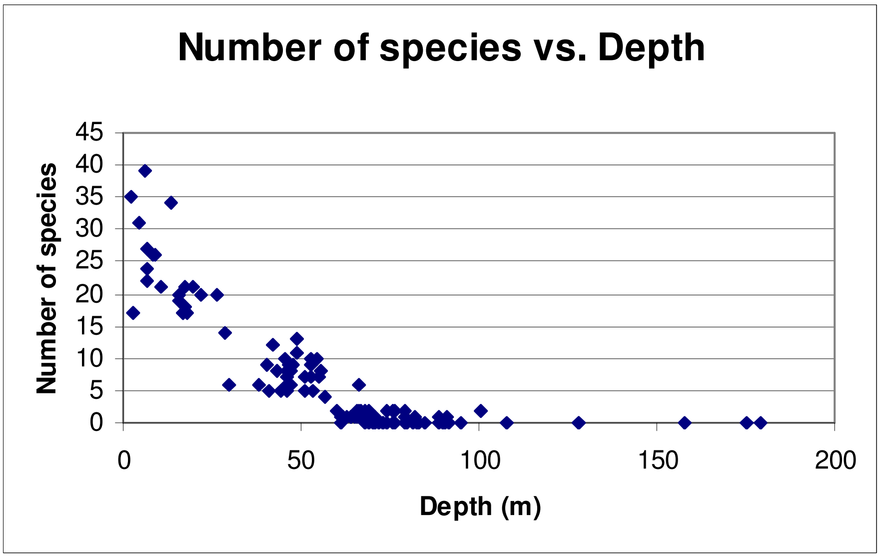


Figure 4.1 Number of species of benthic fauna per station along the south route vs. Latitude (Top) and vs. depth (bottom)

The decline in species richness was most pronounced between the EEZ of Germany where 55 species were recorded, and the EEZ of Denmark, where only 21 species were recorded. The number of species further declined to 14 species in the EEZ of Sweden. Eight (8) species were recorded in the EEZ of Finland in 2007 and 9 species in 2008 (Figure 4.2).

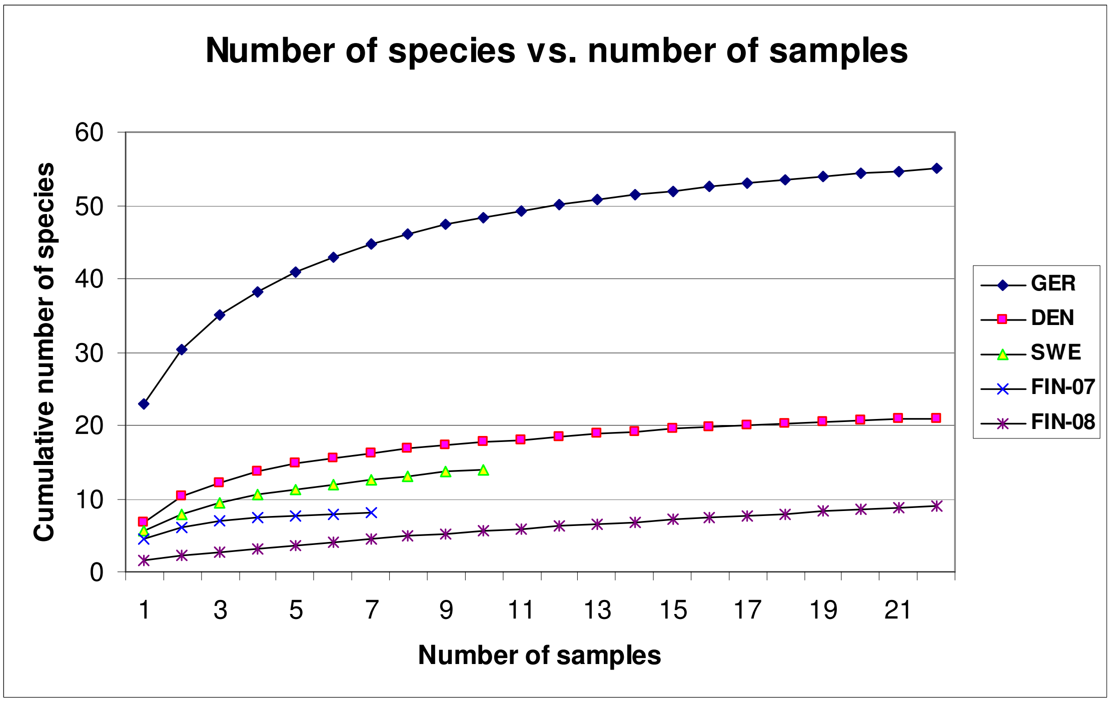


Figure 4.2 *Cumulative number of species vs. number of samples collected in the EEZ of Germany in 2006, Denmark in 2008, Sweden in 2007 and Finland in 2007 and 2008.*

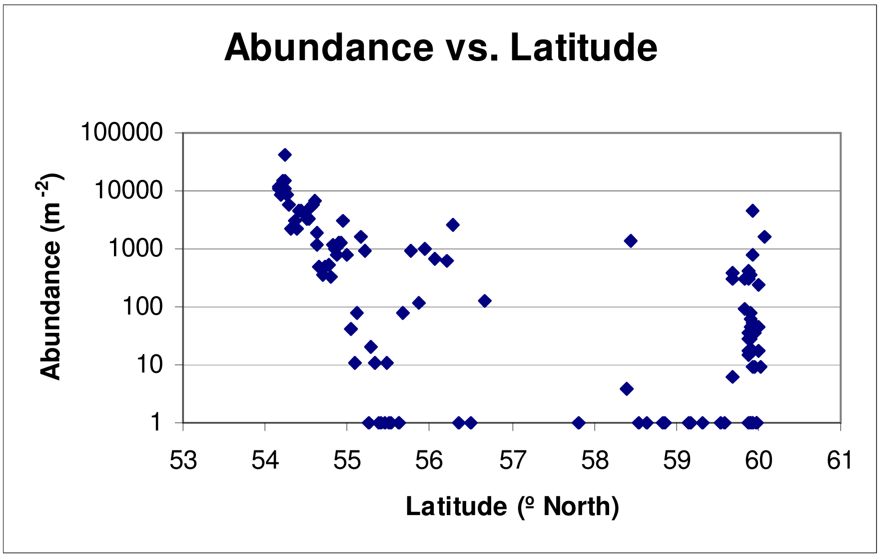
Most of the species in the Baltic Sea has a marine origin and only a limited number of species are able to cope with lower salinity and increasing stress. The profound decline in species richness between the EEZ of Germany and the Baltic Sea Proper including the northern Baltic and the Gulf of Finland in 2006-2008 is consistent with a recent review of the changes in species richness in the Baltic Sea based on HELCOM database /7/.

The number of species per station also declines with increasing depth (Figure 4.1, bottom). The species richness is variable but in general highest in shallow water. The range in number of species is narrower in deeper water. Mostly less than 5-10 species per station was encountered deeper than 50m, which is roughly equivalent to the position of the halocline. The sub-halocline decrease in species richness is caused by sub-optimal oxygen conditions at greater depth, cf. Figure 3.1 and Figure 3.2.

Live animals were recorded at all stations down to a depth of 60m. At stations deeper than 60m the number of species was very low and benthic fauna was absent at a number of stations. The maximum depth limit for live animals was close to 90m except for one station north east of Gotland, where 1 specimen of the amphipod crustacean *Pontoporeia* (*Monoporeia*) *affinis* was found in one of five replicate samples at a depth of 101m.

4.2 Abundance

The changes in abundance of the benthic fauna along the south route vs. Latitude and depth are shown in Figure 4.3.



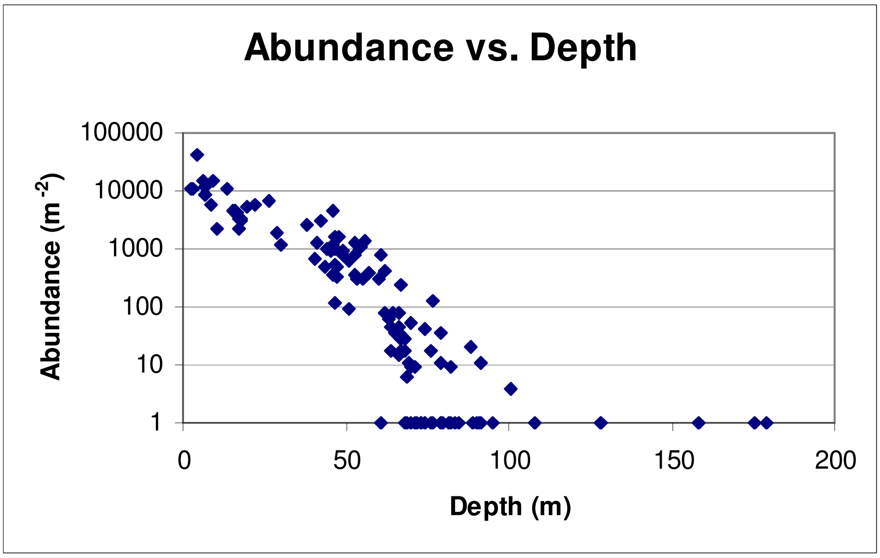


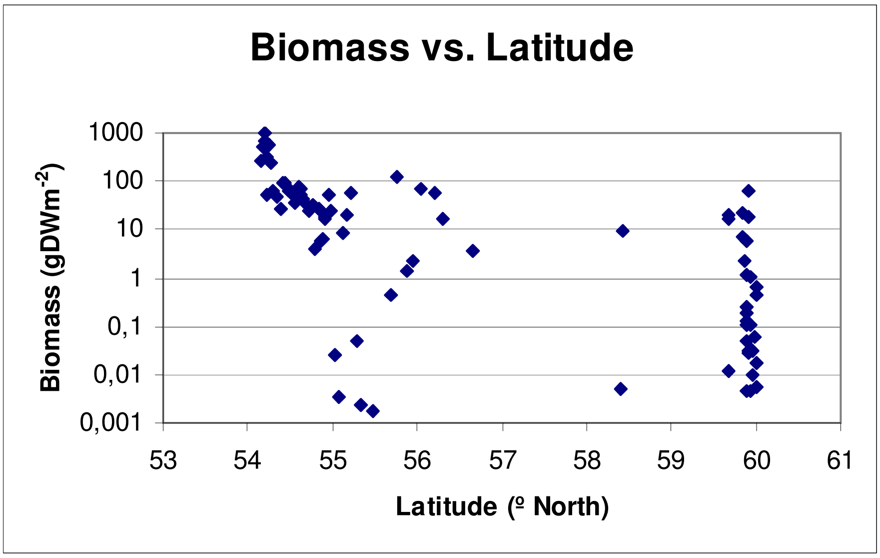
Figure 4.3 Abundance of the benthic fauna per station along the south route vs. Latitude (Top) and vs. depth (bottom). Please note the logarithmic scale. 1 on the abundance scale is equal to zero (0) animals.

The abundance of the benthic fauna was very high and varied around 10,000 m^{-2} in shallow water in the EEZ of Germany. The most common and abundant species were mud snails (*Hydrobia* spp.), the bivalves *Macoma balthica*, *Mya arenaria* and *Mytilus edulis* and the polychaetes *Pygospio elegans*, *Marenzelleria spp*. and *Hediste* (*Nereis*) *diversicolor* characteristic for shallow sandy bottoms. The range in abundance was mostly around 1000 m^{-2} or even as low as around 100 m^{-2} at higher Latitudes and in sub-halocline deeper water.

The decline in abundance in deeper water and especially below the halocline is a response of the declining concentrations of dissolved oxygen.

4.3 Biomass

The range in total biomass of the benthic fauna is highly variable both in relation to Latitude and depth (Figure 4.4).



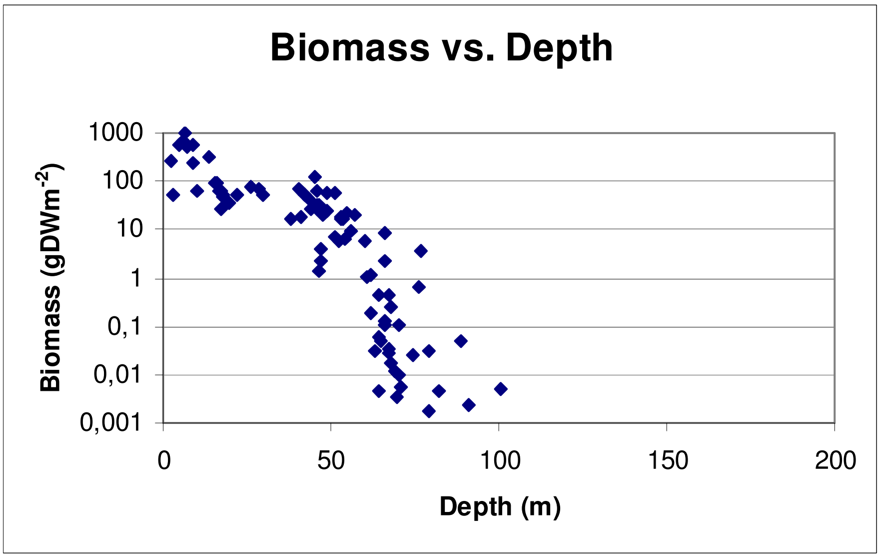


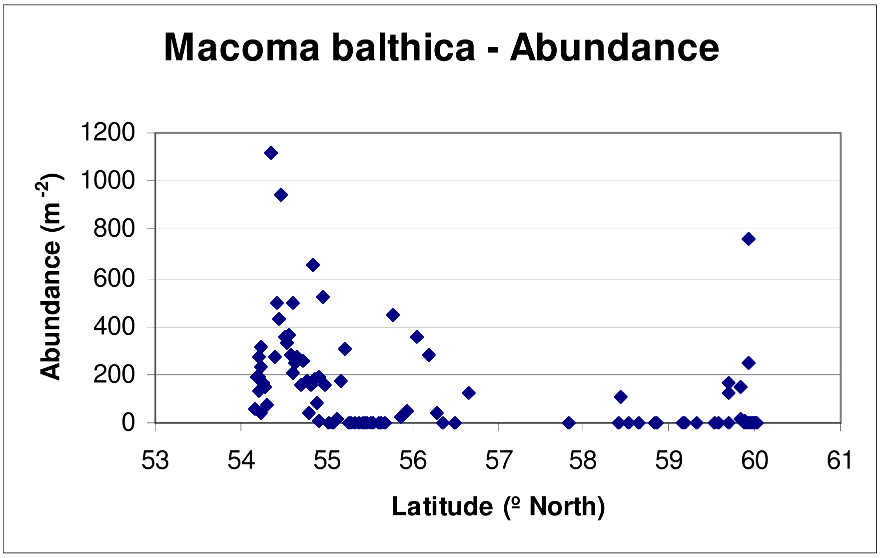
Figure 4.4 Biomass of the benthic fauna per station along the south route vs. Latitude (Top) and vs. depth (bottom). Please note the logarithmic scale. Stations with no benthic fauna are not included in the Figure.

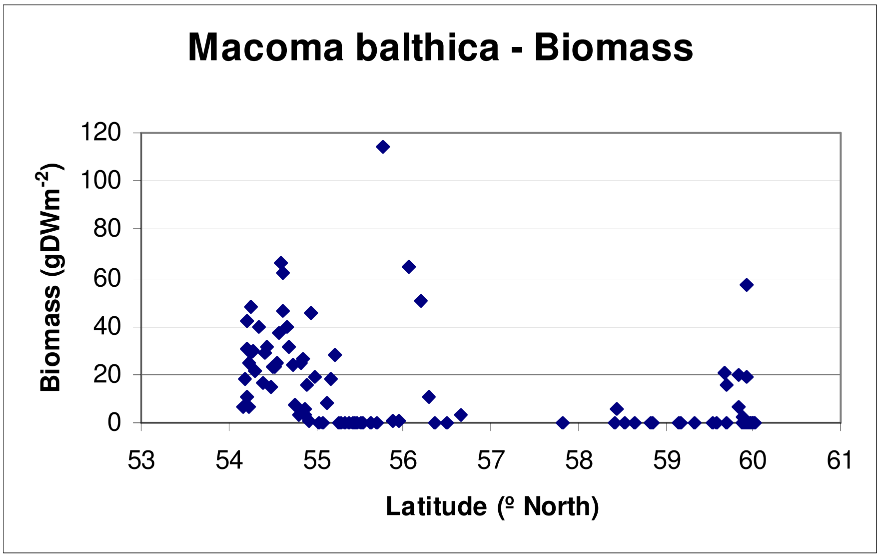
Bivalves are in general a dominant component of the benthic biomass due to the large size of the species and because measurements of total biomass includes the shells. The benthic biomass was highest in shallow water in the EEZ of Germany, where the fauna is abundant and includes the bivalves *Macoma balthica*, *Mya arenaria*, *Mytilus edulis* and *Cerastoderma glaucum*, which together accounts for 95% of the average biomass in the EEZ of Germany. The benthic biomass was highly variable but in general lower at higher Latitudes and deeper water where the benthic fauna was less diverse. The biomass at higher latitudes was largely affected by the presence of the bivalve *Macoma balthica*, the crustaceans *Pontoporeia (Monoporeia) affinis* and *Saduria entomon* and the polychaetes *Bylgides sarsi* and *Marenzelleria spp*.

5 DISTRIBUTION OF CHARACTERISTIC SPECIES

5.1 Bivalves

The bivalve *Macoma balthica* has a wide distribution in the Baltic Sea and is one of the most abundant species and a dominant component of the benthic biomass in the low saline Eastern Gotland Basin and the Gulf of Finland (Figure 5.1, top). The biomass of the species is in the same order of magnitude both in the shallow EEZ of Germany and the deep EEZ of Sweden and Finland (Figure 5.1 middle). The range in average biomass of *Macoma balthica* is approximately the same and the size distribution and the maximum size of the species appears to be independent of Latitude, cf. Figure 5.1, bottom.





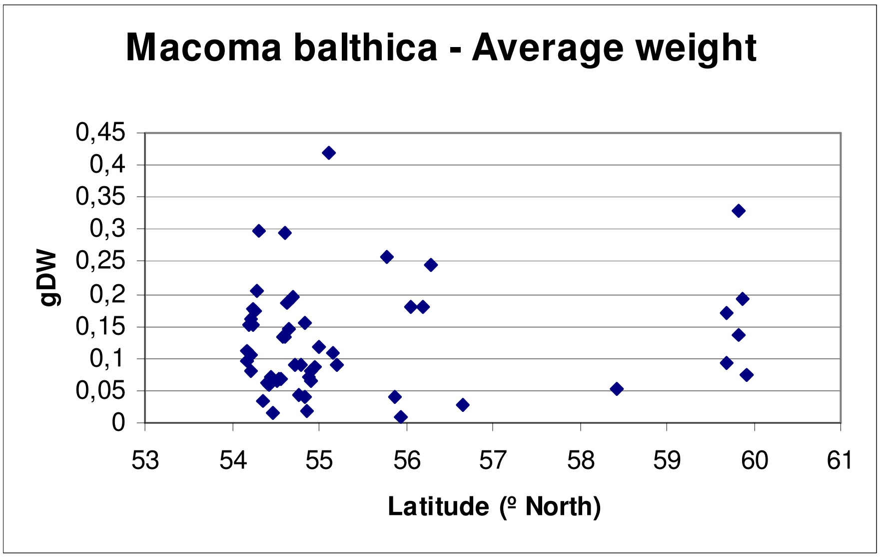


Figure 5.1 Abundance (top), biomass (middle) and average weight (bottom) of Macoma balthica vs. Latitude.

The common mussel *Mytilus edulis* is an epibenthic suspension feeder, which is widely distributed in the Baltic Sea especially in shallow water with solid (rocky) substrates. *Mytilus edulis* is common and locally abundant in the EEZ of Germany and Denmark but scarce or absent in the EEZ of Sweden and Finland (Figure 5.2). The lower salinity limit of *Mytilus edulis* is about 5 psu /7/. The limiting factor for the distribution of *Mytilus edulis* at higher Latitudes is not salinity but probably lack of suitable substrate for attachment in the deeper water with soft bottoms.

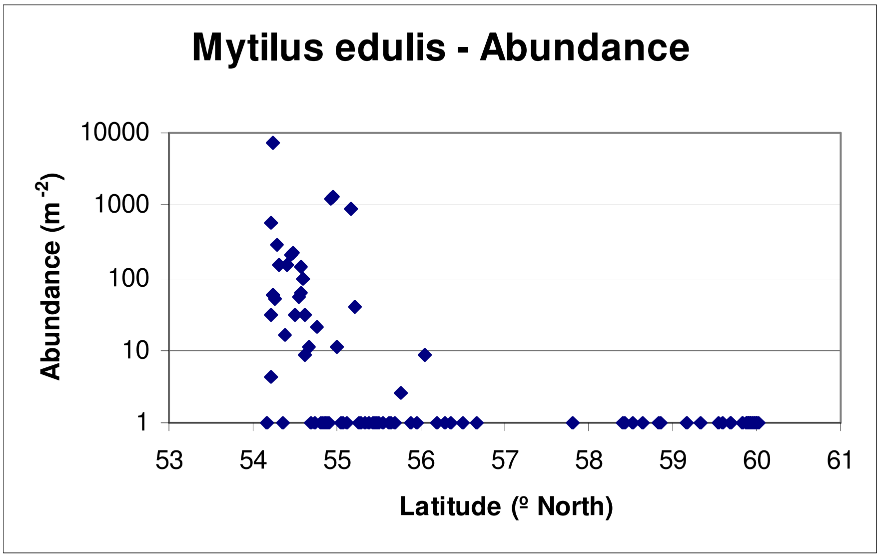


Figure 5.2 *Abundance of Mytilus edulis vs. Latitude. Please note the logarithmic scale. 1 on the abundance scale is equal to zero (0) mussels.*

5.2 Crustaceans

The amphipod crustacean *Pontoporeia affinis* and the isopod crustacean *Saduria entomon* are characteristic for low saline areas in the Baltic Sea including the Bothnian Gulf. The distribution of the two species along the pipeline is mostly similar (Figure 5.3 and Figure 5.4). *Pontoporeia affinis* is in general the most abundant species but *Saduria entomon* is larger and contributes often more to the benthic biomass.

Both species were most abundant in the EEZ of Sweden. *Pontoporeia affinis* was scarce in the EEZ of Germany, Denmark and in Finland both in 2007 and 2008. *Saduria entomon* was present both at lower and higher Latitudes.

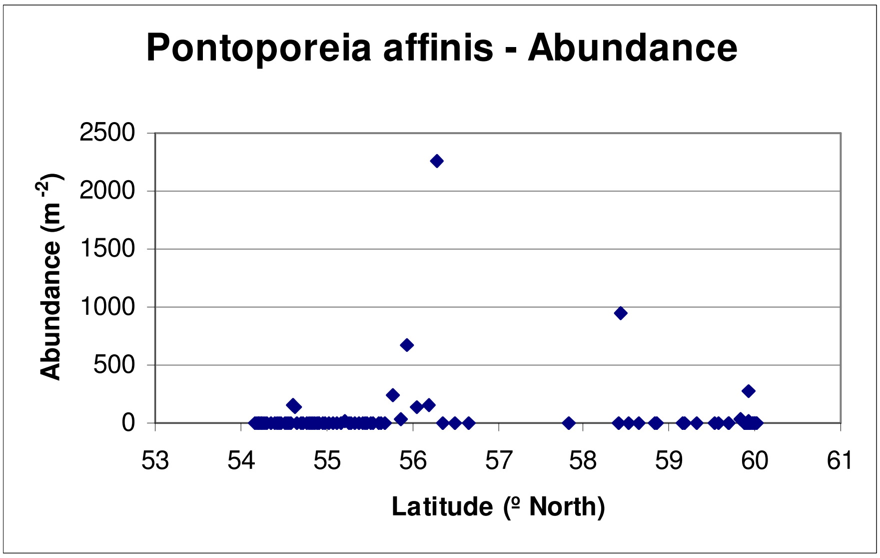


Figure 5.3 *Abundance of Pontoporeia (Monoporeia) affinis vs. Latitude.*

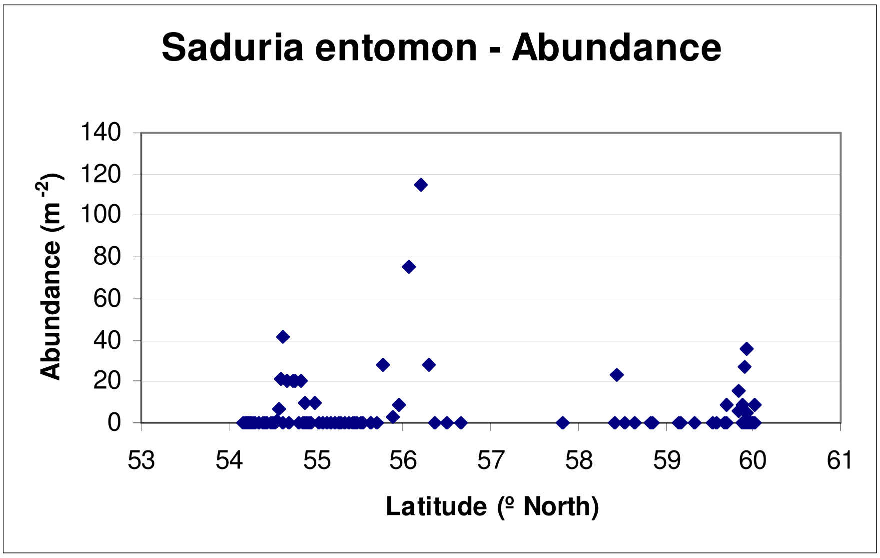


Figure 5.4 Abundance of Saduria entomon vs. Latitude.

The most abundant crustaceans in the EEZ of Germany were the amphipods *Bathyporeia pilosa* and species of *Corophium* and the isopods *Jaera albifrons* and *Cyathura carinata* in shallow water. The most common crustaceans in the EEZ of Denmark were the amphipod *Pontoporeia femorata* and species of cumacean *Diastylis lucifera* and *Diastylis rathkei*.

5.3 Polychaetes

Polychaetes are in general a diverse and species rich taxonomic group in marine waters but very few species are distributed in the low saline waters in the Baltic Proper and the Gulf of Finland.

The most abundant species in 2006, 2007 and 2008 was the spionid polychaete *Marenzelleria*. *Marenzelleria* is a non-indigenous (alien) species introduced in European waters in recent year probably via ballast water from the core area at the east coast of America. *Marenzelleria viridis* was first recorded in England in 1979 and in Holland in 1983 /14/. Since the first appearance in the southern Baltic in 1985 *Marenzelleria viridis* has dispersed rapidly and was recorded in the Gulf of Finland in 1990 and in the Åland archipelago in 1993 /8,10/.

The Genus *Marenzelleria* was revised in 2004 and a new species *Marenzelleria neglecta*, distributed in low saline estuaries in the southern Baltic, the North Sea, Canada and the Pacific coast of America, was described /12/. Another species, *Marenzelleria arctica*, hitherto only found in arctic waters, has also been found in the Baltic Sea /13/.

Both *Marenzelleria viridis* and *Marenzelleria neglecta* has been identified in the samples from the EEZ of Germany, but most individuals were only identified to Genus level. The morphological characters of the two species were overlapping in Danish samples from the western Baltic /15/. Until the taxonomic uncertainty is resolved and the distribution in the Baltic Sea is clarified the species is collectively named *Marenzelleria spp*.

Marenzelleria spp. was locally very abundant in shallow water in the EEZ of Germany and locally also abundant in the EEZ of Finland. The species was present, but in lower numbers in the deep water in the EEZ of Denmark and Sweden (Figure 5.5).

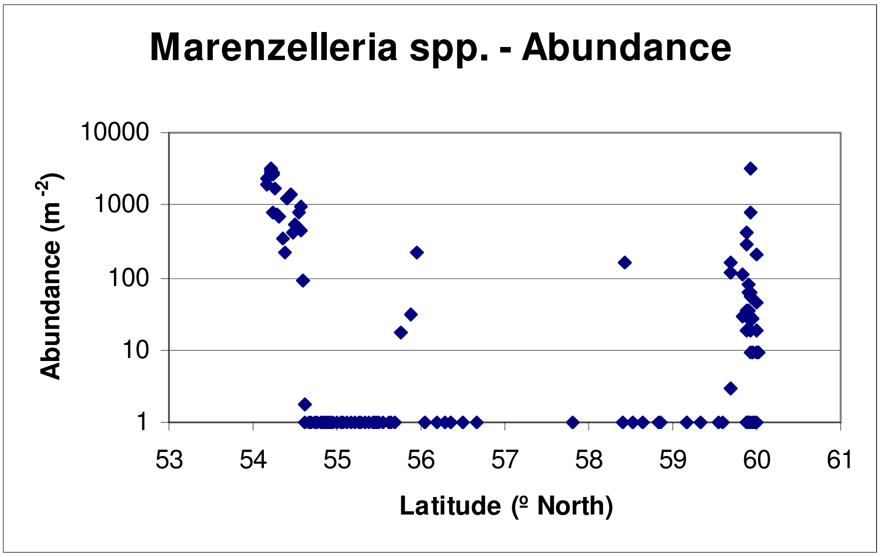


Figure 5.5 *Abundance of Marenzelleria spp. vs. Latitude. Please note the logarithmic scale. 1 on the abundance scale is equal to zero (0) animals.*

Bylgides (*Harmothoe*) *sarsi* was also widely distributed in deeper water but less abundant than *Marenzelleria* spp. in 2006, 2007 and 2008 (Figure 5.6).

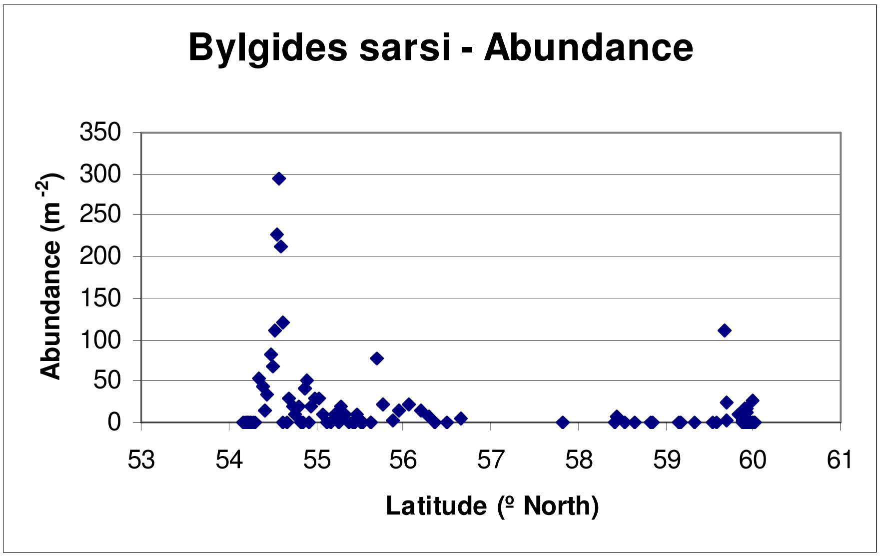


Figure 5.6 *Abundance of Bylgides (Harmothoe) impar vs. Latitude.*

Other species tolerant to lower salinity such as *Hediste* (*Nereis*) *diversicolor* and *Scoloplos armiger* were most abundant in the EEZ of Germany and Denmark, respectively. *Scoloplos armiger* (Figure 5.7) was formerly the most abundant polychaete together with *Bylgides sarsi* in deeper water also in the Baltic Proper and in the northern Baltic /5/. However, the species was absent in these areas in 2006, 2007 and 2008.

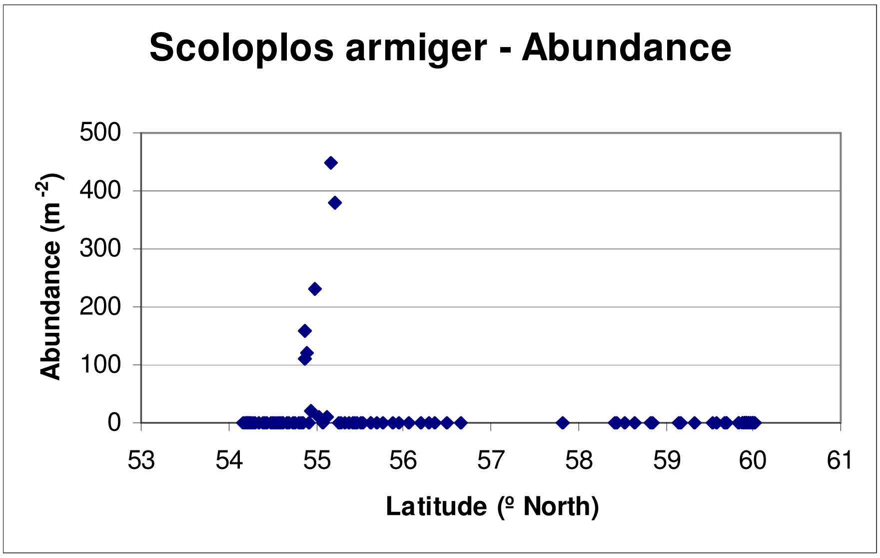


Figure 5.7 Abundance of Scoloplos armiger vs. Latitude.

The tube building polychaete *Pygospio elegans*, abundant on sandy shallow water in the German EEZ was present in the EEZ of Denmark and Sweden but in lower numbers. The soft bottom and the lower oxygen concentrations in deeper water are probably sub-optimal for the species.

6 STRUCTURE OF THE BENTHIC COMMUNITY

6.1 Analysis based on abundance

Classification and ordination
Results of the classification is presented in Figure 6.1, top and the MDS-ordination in Figure 6.1, bottom.

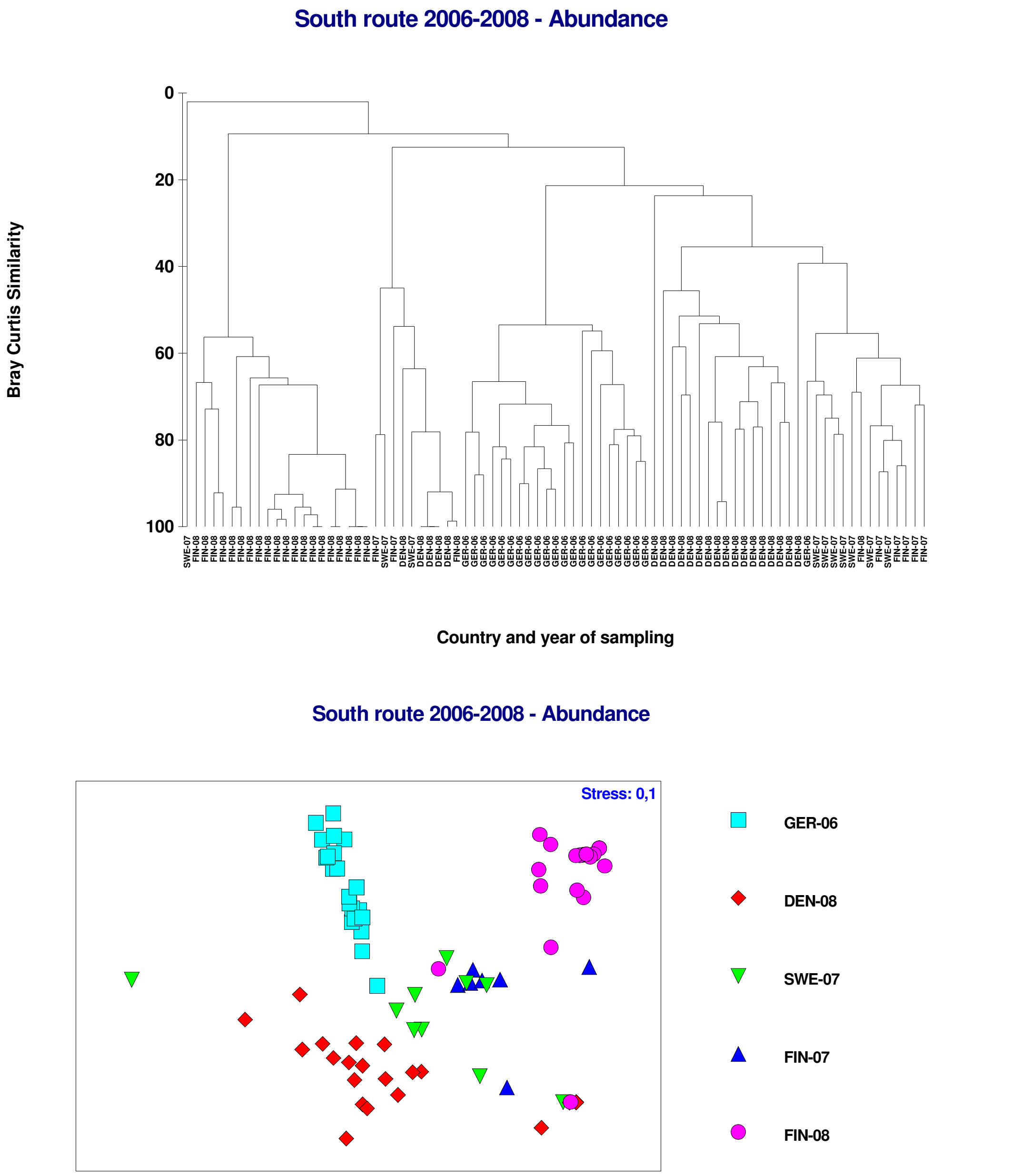


Figure 6.1 Results of classification (top) and ordination (bottom) based on benthic abundance in 2006, 2007 and 2008.

The similarity of the benthic community ranges between 0 (0%), when the benthic fauna is totally different and 1 (100%), when the benthic fauna is similar in any respect at the stations. The overall similarity along the pipeline route is low mainly because of the changes in species richness and abundance along the salinity gradient but sampling in different years and seasons may also affect the similarity.

The changes in the similarity of the benthic community are evident in Figure 6.1, bottom. The result of the ordination presented in the MDS plot should be read as a “map”, where the position and distance between the stations in the two dimensional space indicates the similarity (or dissimilarity) between the stations. The stress (=0,1) is a measure of the adequacy of the ordination to present the multidimensional characteristics of benthic similarity in the low (two) dimensional space in the MDS plot. A stress <0,1 corresponds to a good ordination and a stress <0,2 still gives a potentially useful presentation /17/. The result of the ordination is therefore satisfactorily.

According to a One-Way Anosim test /17/, the similarity of the benthic community in the EEZ of Germany and Denmark is significantly different. The similarity in the EEZ of Germany and Denmark and the EEZ of both Sweden and Finland are also different. The similarity of the benthic community in the EEZ of Sweden and Finland in 2007 was similar. However, the similarity of the community in the EEZ of Finland in 2007 and in 2008 was different.

The benthic community in the EEZ of Germany, Denmark, Sweden and Finland is characterized in Table 6.1.

Table 6.1 Depth range, number of species and abundance (mean ± SD) of the benthic fauna in the EEZ of Germany, Denmark, Sweden and Finland in 2006, 2007 and 2008. The similarity and the species, which together accounts for 50% of the similarity of the benthic community are calculated on the basis of SIMPER /17/.

<table>
<tr><th>Issues</th><th colspan="2">Germany</th><th colspan="2">Denmark</th><th colspan="2">Sweden</th><th colspan="2">Finland-07</th><th colspan="2">Finland-08</th></tr>
<tr><td>Depth range with benthic fauna (m)</td><td colspan="2">0.5-30</td><td colspan="2">30-91</td><td colspan="2">40-77 (101)</td><td colspan="2">51-68</td><td colspan="2">46(60)-82</td></tr>
<tr><td>Species: total number</td><td colspan="2">55</td><td colspan="2">21</td><td colspan="2">14</td><td colspan="2">8</td><td colspan="2">9</td></tr>
<tr><td>Species per station (0.1m^{-2}): Mean ± SD</td><td colspan="2">23±7</td><td colspan="2">7±4</td><td colspan="2">6±3</td><td colspan="2">5±2</td><td colspan="2">2±1</td></tr>
<tr><td>Species per station</td><td colspan="2">14-39</td><td colspan="2">1-13</td><td colspan="2">1-10</td><td colspan="2">2-7</td><td colspan="2">1-7</td></tr>
<tr><td>Abundance (m^{-2}): Mean ± SD</td><td colspan="2">8640±8220</td><td colspan="2">750±720</td><td colspan="2">740±780</td><td colspan="2">215±170</td><td colspan="2">315±985</td></tr>
<tr><td>Abundance (range: m^{-2})</td><td colspan="2">1940-40200</td><td colspan="2">10-3060</td><td colspan="2">4-2550</td><td colspan="2">6-400</td><td colspan="2">9-4650</td></tr>
<tr><td colspan="11">Similarity and mean abundance (m^{-2}) and contribute of species (Sim), which together accounts for 50% of the similarity of the benthic community in the EEZ of the countries</td></tr>
<tr><td>Similarity</td><td colspan="2">60.3%</td><td colspan="2">36.9%</td><td colspan="2">41.5%</td><td colspan="2">54.8%</td><td colspan="2">59.7%</td></tr>
<tr><td>Species</td><td>m^{-2}</td><td>Sim</td><td>m^{-2}</td><td>Sim</td><td>m^{-2}</td><td>Sim</td><td>m^{-2}</td><td>Sim</td><td>m^{-2}</td><td>Sim</td></tr>
<tr><td>Marenzelleria spp.</td><td>1230</td><td>11.4</td><td></td><td></td><td></td><td></td><td>65</td><td>25.8</td><td>240</td><td>98.4</td></tr>
<tr><td>Macoma balthica</td><td>325</td><td>9.5</td><td>165</td><td>22.4</td><td>140</td><td>25.0</td><td>100</td><td>29.6</td><td></td><td></td></tr>
<tr><td>Hydrobia spp.</td><td>2140</td><td>9.3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Pygospio elegans</td><td>1180</td><td>9.5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Oligochaeta indet</td><td>785</td><td>9.1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mya arenaria</td><td>755</td><td>7.9</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Bylgides sarsi</td><td></td><td></td><td>16</td><td>22.9</td><td>17</td><td>22.5</td><td>24</td><td>30.8</td><td></td><td></td></tr>
<tr><td>Pontoporeia femorata</td><td></td><td></td><td>60</td><td>11.2</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Pontoporeia affinis</td><td></td><td></td><td></td><td></td><td>445</td><td>24.2</td><td></td><td></td><td></td><td></td></tr>
</table>

The average similarity (uniformity) of the benthic fauna is highest in the EEZ of Germany and lowest in the EEZ of Denmark. The high similarity in the EEZ of Germany is explained by a high abundance of a few dominant species characteristic of shallow water such as the newly introduced polychaete *Marenzelleria*, mud snails *Hydrobia* spp., the bivalves *Macoma balthica* and *Mya arenaria*, the polychaete *Pygospio elegans* and oligochaetes.

The widely distributed and abundant bivalve *Macoma balthica* also contribute much to the benthic similarity in the EEZ of Denmark, Sweden and Finland in 2007. The same is true for the less abundant polychaete *Bylgides sarsi*. The polychaete *Marenzelleria* is the most abundant species in the EEZ of Germany and totally dominant in the EEZ of Finland in 2008. The crustaceans *Pontoporeia femorata* and *Pontoporeia affinis* contributes to the similarity of the benthic community in the EEZ of Denmark and Sweden, respectively.

The importance of environmental factors

The results of a comparison based on the similarity of the benthic abundance and environmental variables measured at the same stations in 2006, 2007 and 2008 are shown in Table 6.2. Biological and environmental data were only measured at 7 of the same stations in the EEZ of Finland in 2007.

*Table 6.2 Spearman coefficient of correlation based on benthic abundance and environmental variables measured in 2006, 2007 and 2008. Bold indicates the single best environmental variable and an * indicates one or more environmental variables, which in combination gives the Best overall coefficient of correlation. Based on BioEnvir and Spearman Rank correlation method /17/.*

Environmental variables	Germany	Denmark	Sweden	Finland-07	Finland-08
Water Depth	**0.771***	**0.787***	0.599*	**0.451**	0.531
Loss on ignition	0.173*	0.749*		-0.139	0.200
Median grain size of sediment	0.196	0.370*			**0.534**
Silt/clay fraction of sediment	0.348	0.725			0.477
Dry matter		0.718*		0.225	0.174
Total organic carbon		0.743*		0.105	0.289
Salinity		0.687			0.324
Oxygen		0.637*	**0.695***		0.147
Temperature			0.300		0.373
***Best overall**	**0.834**	**0.849**	**0.699**	**0.451**	**0.534**

Water depth was the single most important factor for the similarity of the benthic community in the EEZ of Germany, Denmark and Finland in 2007. The importance of depth was higher in Finland in 2008 than in 2007, but the importance of the median grain size of the sediment was even higher in 2008. The importance of water depth was equally high in the EEZ of Sweden but the importance of oxygen was even higher and the single most important environmental factor in this area.

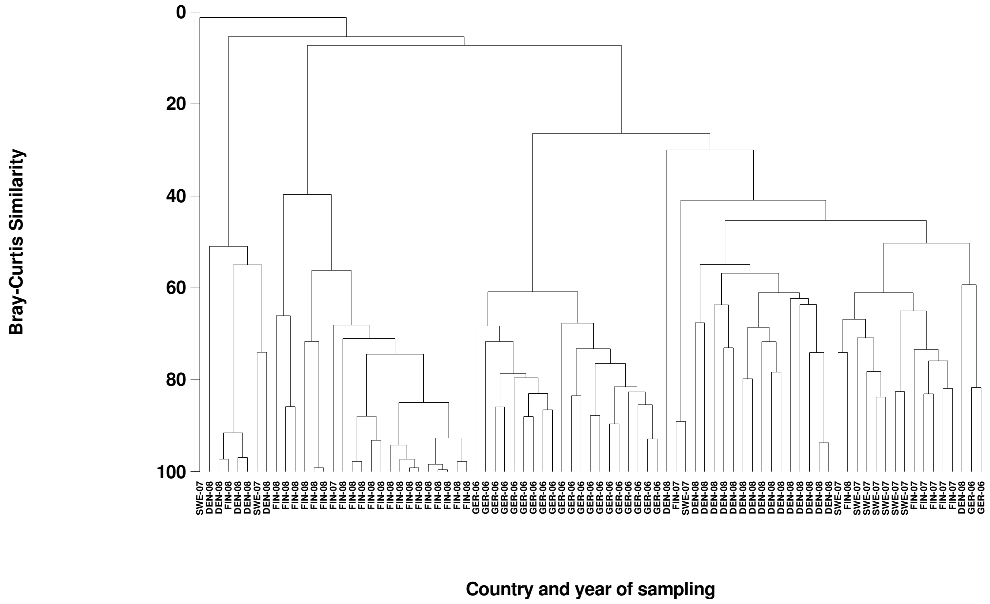
In addition to depth, factors characteristic for the composition of the sediment contributed to the best overall combination of environmental variables of importance for the structure of the benthic community in the EEZ of Germany and Denmark. The oxygen concentration also contributed in the overall best combination of environmental variables in the EEZ of Denmark.

6.2 Analysis based on biomass

Classification and ordination

The results of the classification are presented in Figure 6.2, top and the MDS ordination in Figure 6.2, bottom.

South route 2006-2008 - Biomass



South route 2006-2008 - Biomass

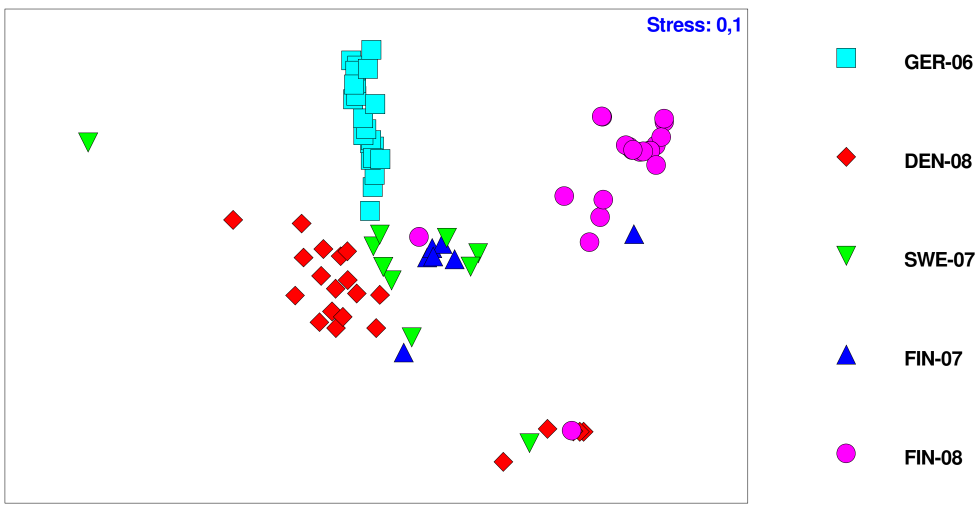


Figure 6.2 Results of classification (top) and ordination (bottom) of the benthic community based on biomass in 2006, 2007 and 2008.

The overall similarity of the benthic community along the pipeline route is low mainly because of changes in the species most important for the biomass along the salinity gradient but sampling in different years and seasons may also affect the similarity.

The results of analyses based on abundance and biomass of the benthic community in the EEZ of Germany, Denmark, Sweden and Finland are almost similar, cf. Figure 6.1, bottom and Figure 6.2, bottom.

According to a One-Way Anosim test, the similarity of the benthic community in the EEZ of Germany is significantly different from the EEZ of Denmark, Sweden and Finland. The similarity of the benthic community in the EEZ of Denmark and Sweden is significantly different. The similarity of the community in the EEZ of Denmark and in Finland 2007 and in the EEZ of Sweden and Finland in 2007 is not different.

The benthic community in the EEZ of Germany, Denmark, Sweden and Finland is characterized in Table 6.3.

Table 6.3 Biomass (mean ± SD) of benthic fauna in the EEZ of Germany, Denmark, Sweden and Finland in 2006, 2007 and 2008. The similarity and the biomass of species, which together accounts for 50% of the similarity of the benthic community are calculated on the basis of SIMPER /17/.

Issues	**Germany**		**Denmark**		**Sweden**		**Finland-07**		**Finland-08**	
Biomass per station (gDW/m^2): Mean ± SD	257±270		20±18		28±40		13±9		3.4±14	
Biomass ($gDW\ m^{-2}$)	20-965		0.001-58		0.005-117		0.01-21		0.004-64	
Similarity and mean biomass ($gDW\ m^{-2}$) and contribute of species (Sim), which together accounts for 50% of the similarity of the benthic community in the EEZ zones of the countries										
Similarity	64.3%		37.4%		40.2%		54.6%		54.7%	
Species	gDW	Sim	gDW	Sim	gDW	Sim	gDW	Sim	gDW	Sim
Macoma balthica	29	19.5	16	45.8	25	39.0	12	60.1		
Mya arenaria	177	18.7								
Marenzelleria sp.	1.8	8.6							0.25	98.0
Mytilus edulis	20	7.8								
Hediste diversicolor	1.9	7.8								
Bylgides sarsi			0.01	15.2						
Saduria entomon					1.5	18.6				

The average similarity of the benthic community is highest in the EEZ of Germany and lowest in the EEZ of Denmark. The bivalve *Macoma balthica* is the single most important species contributing to the similarity of the benthic community in the EEZ of all countries except in the EEZ of Finland in 2008, where the polychaete *Marenzelleria* contributed most to the similarity. The average biomass of *Macoma balthica* was higher than the average biomass of *Marenzelleria* in the EEZ of Finland in 2008. However, the bivalve was only found at the shallow station 270 with a water depth of 46m. The biomass of the polychaete *Marenzelleria* was also highest at station 270, but the species was present at all stations except at station 286.

Characteristic shallow water species like the bivalves *Mya arenaria* and *Mytilus edulis* and the polychaetes *Marenzelleria* and *Hediste diversicolor* also contributes to the benthic similarity in the EEZ of Germany. The polychaete *Bylgides sarsi* and the isopod

Saduria entomon contributed to the similarity in the EEZ of Denmark and Sweden, respectively.

The importance of environmental factors
The results of the analyses based on benthic abundance and biomass are basically similar, cf. Table 6.2 and Table 6.4.

Water depth was the single most important factor for the similarity of the benthic community in the EEZ of Germany, Denmark and Finland in 2008. However, water depth was of limited importance in the EEZ of Finland in 2007, where dry matter of the sediment was the single most important factor. The importance of water depth was high in the EEZ of Sweden but the importance of oxygen was even higher and the single most important environmental factor in this area.

*Table 6.4 Spearman coefficient of correlation based on benthic biomass and environmental variables measured in 2006, 2007 and 2008. Bold indicates the single best environmental variable and an * indicates one or more environmental variables, which in combination gives the Best overall coefficient of correlation. Based on BioEnvir and Spearman Rank correlation method /17/.*

Environmental Variables	Germany	Denmark	Sweden	Finland-07	Finland-08
Water Depth	**0.746***	**0.760***	0.504	0.226	**0.572***
Loss on ignition	0.117*	0.688*		-0.133	0.201
Median grain size of sediment	0.128	0.236*			0.486
Silt/clay fraction of sediment	0.289	0.639			0.419
Dry matter		0.683*		**0.324**	0.141
Total organic carbon		0.664		0,235	0.279
Salinity		0.684*			0.375
Oxygen		0.664*	**0.614***		0.208
Temperature			0.304		0.429*
***Best overall**	**0.756**	**0.792**	**0.614**	**0.324**	**0.577**

In addition to water depth, factors characteristic for the sediment composition was also of importance for the similarity of the benthic community in the EEZ of Germany and Denmark.

7 SUMMARY OF SURVEYS IN THE EEZ / TERRITORIAL WATERS OF THE COUNTRIES

7.1 Germany

Presentation of species, abundance and biomass and multivariate analysis of macrozoobenthos were based on 22 grouped stations along the south route in 2006, cf. Table 2.1.

The depth range at the stations was between 0.5m to 30m. The sediment at stations with benthos consisted mostly of fine and median sand (Median grain size: 0.125-0.5mm). The silt/clay fraction was below 3% of the dry matter of the sediment and the content of organic matter measured as loss on ignition was mostly less than 1%.

The structure of the benthic community was affected by the water depth whereas the importance of the variables measured in the sediment and potentially related to depth were of less importance for the similarity, cf. Table 6.2 and Table 6.4.

The salinity and oxygen has been measured at the bottom during the sampling campaign. The samples were taken above the expected depth of the halocline (about 50m) and are characterised by low salinity and high oxygen concentrations.

The relatively high number of species recorded (about 56, cf. Figure 4.2) is therefore mostly attributed to the large number of samples distributed in varied benthic habitats in shallow, intermediate and deeper low saline but well oxygenated water.

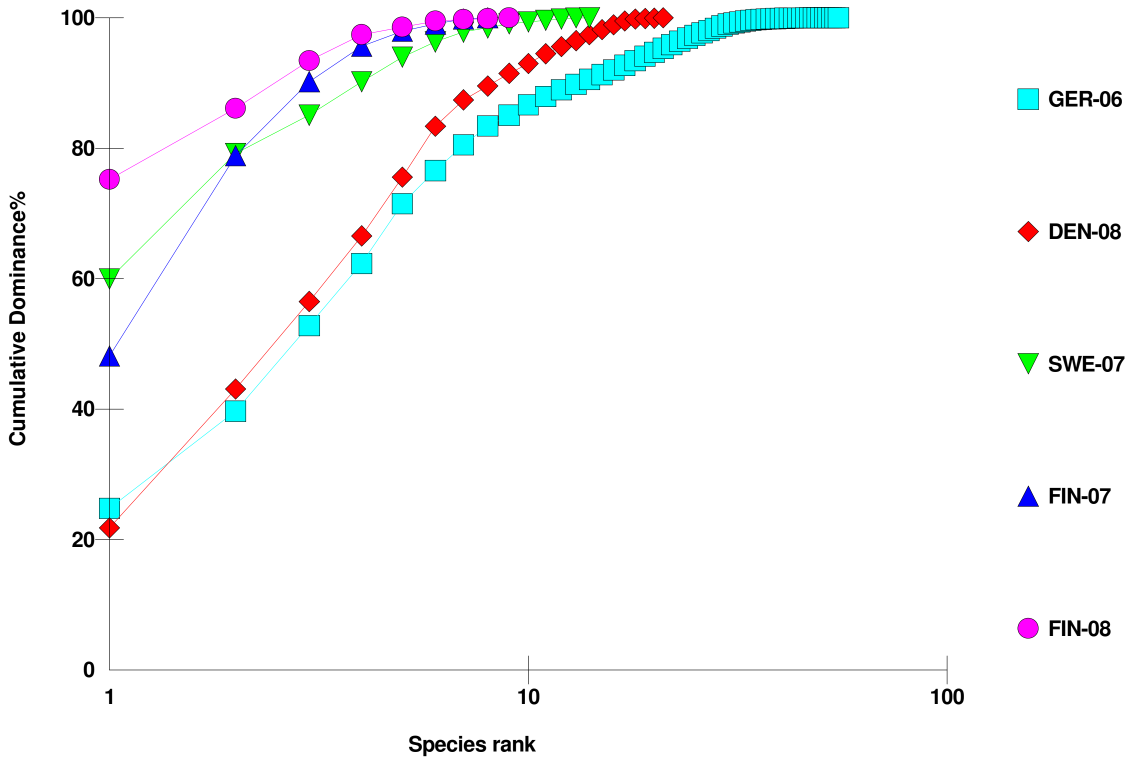
However, most of the species is only recorded at a few stations and in low numbers. The benthic fauna is characterised by a predominance of less than ten species, which accounts for more than 80% of the benthic abundance (Figure 7.1, top). Only two species account together for more than 80% of the benthic biomass (Figure 7.1, bottom).

The most common species, which accounts for most of the benthic abundance, biomass and similarity of the benthic community, are mud snails (*Hydrobia* spp.), polychaetes (*Marenzelleria* spp., *Pygospio elegans* and *Hediste diversicolor*), oligochaetes and bivalves (*Macoma balthica* and *Mya arenaria*), cf. Table 6.1 and Table 6.3.

7.2 Denmark

Samples for analysis of benthos and sediment were collected at 28 stations in 2008. The depth range of the stations was 30-91m. Benthic fauna was found at even the deepest station (91m), where the oxygen concentration was 2.59 mg/l in May 2008 /19/.

The sediment at stations with benthos consisted mostly of silt/clay and very fine to fine sand (Median grain size: <0.063mm-0.250mm) and medium to coarse sand at a few stations. The silt/clay content of the sediment was high and ranged between 8%-99% of the dry matter content of the sediment. The content of organic matter (loss on ignition) varied between 0.3% and 16% of the dry matter content.



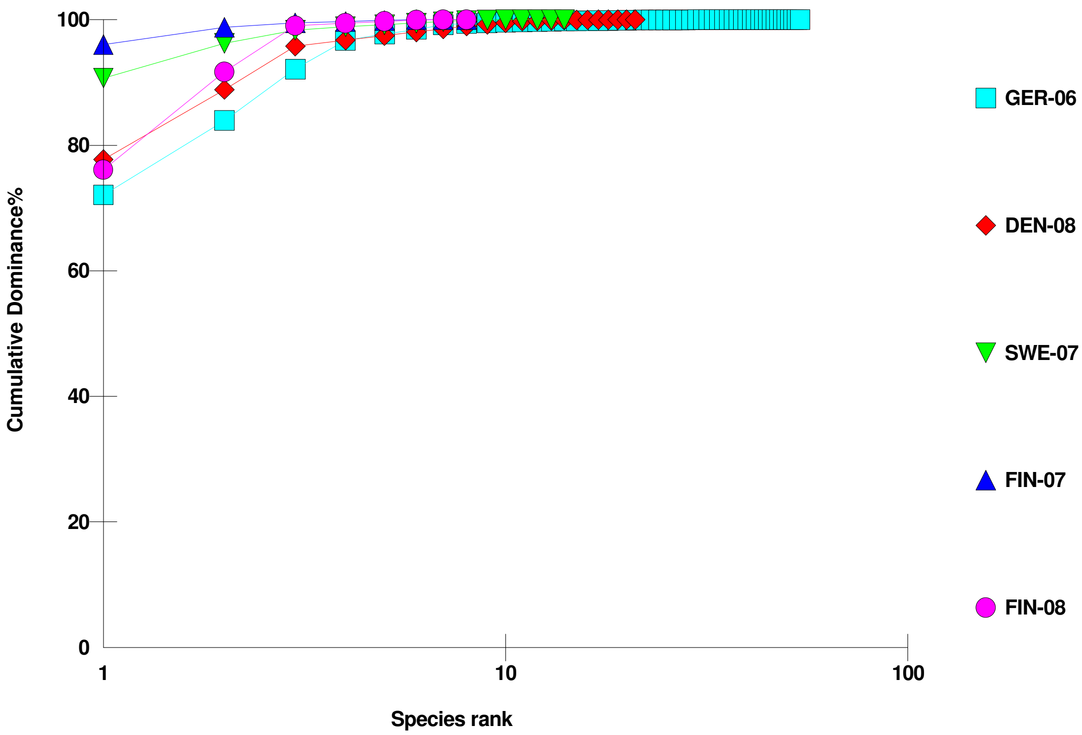


Figure 7.1 Relation between the number of species contributing to the cumulative dominance in abundance (top) and biomass (bottom) of the benthic fauna in the EEZ of Germany, Denmark, Sweden and Finland in 2006, 2007 and 2008.

The water depth was the most important single factor for the structure of the benthic community but variables characteristic for the composition of the sediment and oxygen also contributed to the structure of the community cf. Table 6.2 and Table 6.4.

The total number of species recorded was about 21 and fairly low. The number of samples was adequate to represent most of the species in the area, cf. Figure 4.2. In addition to water depth, the soft muddy sediments and periodic low oxygen concentrations are probably the main limiting factors for the species richness, abundance and biomass of the benthic fauna. Like in the EEZ of Germany, most of the species was only recorded at a few stations and in low numbers. The benthic fauna was characterised by a similar predominance in abundance and biomass in the EEZ of Germany and Denmark, cf. Figure 7.1.

However, the most common species, which accounts for most of the abundance, biomass and similarity of the benthic community, are totally different in the EEZ of Germany and Denmark. The dis-similarity between the structure of the benthic community in the EEZ zones of Germany and Denmark is 84% and 79% in analyses based on abundance and biomass, respectively.

The predominant and characteristic species in the EEZ of Denmark are the polychaetes *Bylgides sarsi*, the bivalve *Macoma balthica* and the crustacean *Pontoporeia femorata*, cf. Table 6.1 and Table 6.3.

7.3 Sweden

Samples for analysis of benthos and sediment were collected at 41 stations in 2007. The depth range of the stations was 38-179m. Benthic fauna was absent in samples deeper than 77m because the oxygen concentrations were too low (between 0-1.21 mg/l). However, one animal was found in one sample at station PLA-01 at 101m depth and an oxygen concentration of 0.47 mg/l.

The depth of the halocline is not known at the time of sampling. However, most of the 28 samples with benthos was collected at a water depth lower than 60m, which is probably mostly above or close to the depth of the halocline. Sediment characteristics are not known at the benthos stations.

A relationship between depth and number of species, abundance and biomass of the benthic fauna is not obvious. However, water depth has in impact on the similarity of the benthic community but the concentration of oxygen, which ranged between 0.47 mg/l and 10.48 mg/l, was the single most important factor for the benthic community, cf. Table 6.2 and Table 6.4.

The total number of species recorded (about 14) was low but close to the maximum species richness along the pipeline in the area at the time of sampling, cf. Figure 4.2.

In addition to the pronounced decline in species richness in the EEZ of Sweden compared to the EEZ of Germany, the benthic fauna is characterised by very few species accounting for most of the abundance and biomass, cf. Figure 7.1.

The two species, which accounts for most of the abundance, biomass and similarity of the benthic community, were the bivalve *Macoma balthica*, the polychaete *Bylgides sarsi* and the amphipod *Pontoporeia affinis* and, cf. Table 6.1 and Table 6.3. Other common but less important species were the polychaetes *Pygospio elegans* and the isopod *Saduria entomon*.

7.4 Finland

Sampling in 2007

Samples for analysis of benthos and sediment were collected at 44 stations in August-September 2007. The depth range of the stations was 49m to 176m. Benthic fauna was present in the depth range between 49m and 64m but absent in samples between 51m and 176m. The oxygen concentration, which was not measured at the benthos stations, declined rapidly below 60m and was below 1 mg/l or zero deeper than 80m, cf. Figure 3.3.

The depth range is narrow at the stations with benthos and a relationship between depth and number of species, abundance and biomass of the benthic fauna is not apparent. However, an analysis based on only 7 stations with data of benthos and sediment at the same stations suggested that water depth has in impact on the similarity of benthic abundance, cf. Table 6.2. However, the importance of water depth and the sediment factors on similarity based on biomass was insignificant (Table 6.4).

The total number of species recorded (about 8) was even lower than in the EEZ of Sweden but close to the maximum species richness along the pipeline at the time of sampling, cf. Figure 4.2.

The two species, which accounts for most of the abundance, biomass and similarity of the benthic community, were the bivalve *Macoma balthica* and the polychaetes Bylgides sarsi and the recently introduced *Marenzelleria*, cf. Table 6.1 and Table 6.3. Other common but less important species was the crustacean *Saduria entomon*.

Sampling in 2008

Samples for analysis of benthos and sediment were planned to be taken at 34 stations along the planned and alternative Kalbådagrund route in May 2008. The depth range of the stations was 46m to 82m. Benthic fauna was present in the entire depth range. The lowest oxygen concentrations were close to 2 mg/l at the deepest stations around 80m, cf. Figure 3.3.

The water depth was the most important single factor for the structure of the benthic community, cf. Table 6.2 and Table 6.4.

The total number of species recorded (about 9) was even lower than during the sampling in 2007 if the number of samples is taken into account, cf. Figure 4.2.

The structure benthic community in 2007 and 2008 was significantly different. The benthic fauna in 2008 was totally dominated by the polychaete *Marenzelleria*, which accounted for 75% of the average abundance, cf. Figure 7.1. *Marenzelleria* also accounted for more than 90% of the similarity of the benthic community in 2008.

8 COMPARISON OF THE PLANNED AND ALTERNATIVE ROUTE IN THE GULF OF FINLAND

8.1 Species richness, abundance and biomass

Samples of macrozoobenthos were collected along the planned and the alternative Kalbådagrund route in May 2008 /4/.

Sampling was possible at 23 stations along the planned route and at 8 stations along the alternative route (Table 8.1). The depth at stations, where sampling was possible, was approximately between 60m and 80m except at station 270 along the planned route, where the depth was only 46m. The maximum number of species (7), abundance (4650m^{-2}) and biomass (64g DW/m^{2}) was recorded at station 270, which deviated totally from all the other stations deeper than 60m.

Table 8.1 Number of stations and depth range surveyed, total and average number of species, abundance and biomass at the planned and the alternative Kalbådagrund route in 2008. Average values±SD and range in parenthesis.

Variables	Planned route	Alternative route
Number of stations where sampling was possible (sampling not possible)	23	8 (3)*
Depths (m) at stations, where sampling was possible	46(60)-82	64-79
Number of stations with live animals	17	5
Depths (m) at stations with live animals	46(60)-82	64-79
Total number of species recorded	8	4
Number of species per station (0.1m^{-2})	1.6± 1.5 (1-7)	1±1 (1-2)
Abundance (m^{-2})	400±1115 (9-4650)	31±8 (18-36)
Biomass (gDWm^{-2})	4.4±15 (0.004-64)	0.09±0.10 (0.004-0.25)

** The sample from station 286 was leaking and therefore not truly quantitative. However, the result was included in the analysis.*

The average number of species is a little higher at the planned route than at the alternative route. However, the species richness is almost the same at the planned and the alternative route if the number of samples is taken into account (Figure 8.1).

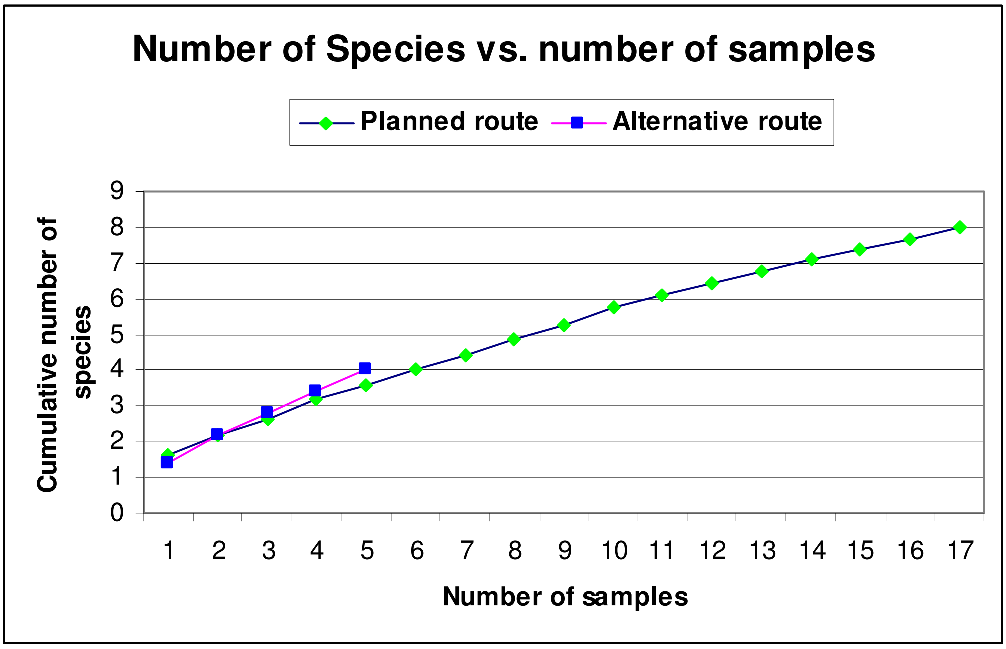


Figure 8.1 Cumulative number of species vs. number of samples collected at the planned and at the alternative Kalbådagrund route in the Gulf of Finland 2008. Based on all data inclusive station 270 and station 286.

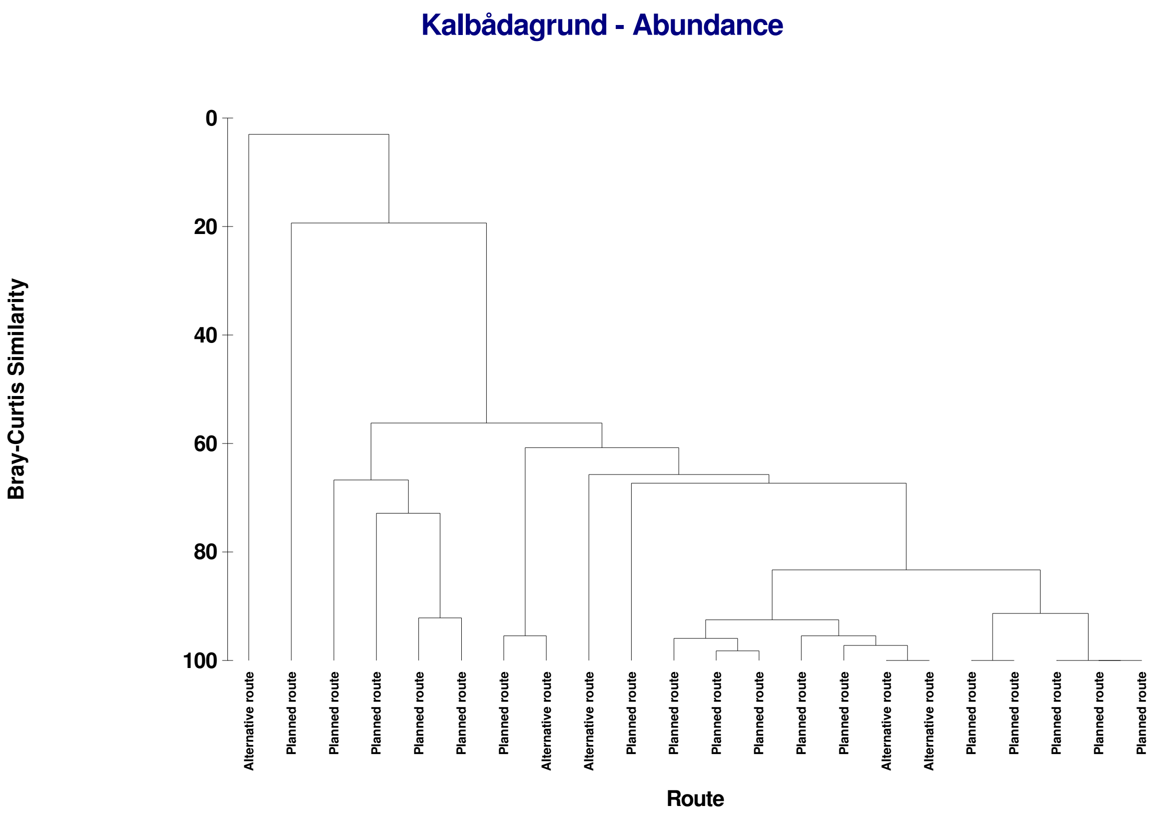
The polychaete *Marenzelleria* is the most common and abundant species and accounts for 75% of the average abundance of the benthic fauna along both the planned and the alternative route. However, the average abundance was very low along the alternative route. The polychaete *Bylgides sarsi* and the isopod *Saduria entomon* are also distributed in both areas but in low numbers. The bivalve *Macoma balthica*, the polychaete *Pygospio elegans*, the crustaceans *Pontoporeia affinis* and *Gammarus sp*. and *Halicryptus spinulosus* are only recorded along the planned route.

The average biomass of the benthic fauna along the planned route is dominated by the bivalve *Macoma balthica* (77%), the isopod *Saduria entomon* (15%) and the polychaete *Marenzelleria* (7%). The biomass of the benthic fauna was extremely low along the alternative route. The polychaete *Marenzelleria* accounted for 52% of the average biomass and the isopod *Saduria entomon* for 46%.

A comparison of the alternative stations in a strict sense shows that *Marenzelleria* is the only species found at station 264-272 along the planned route if the atypical shallow station 270 is disregarded. *Marenzelleria* is less abundant at station 281-290 along the Kalbådagrund alternative route but is equally dominant and accounts for 87% of the abundance.

8.2 Structure of the benthic community

According to Anosim-tests based on both abundance and biomass the structure of the benthic community was similar along the planned and alternative route in 2008. Therefore only the results of classification and ordination based on abundance is shown in Figure 8.2.



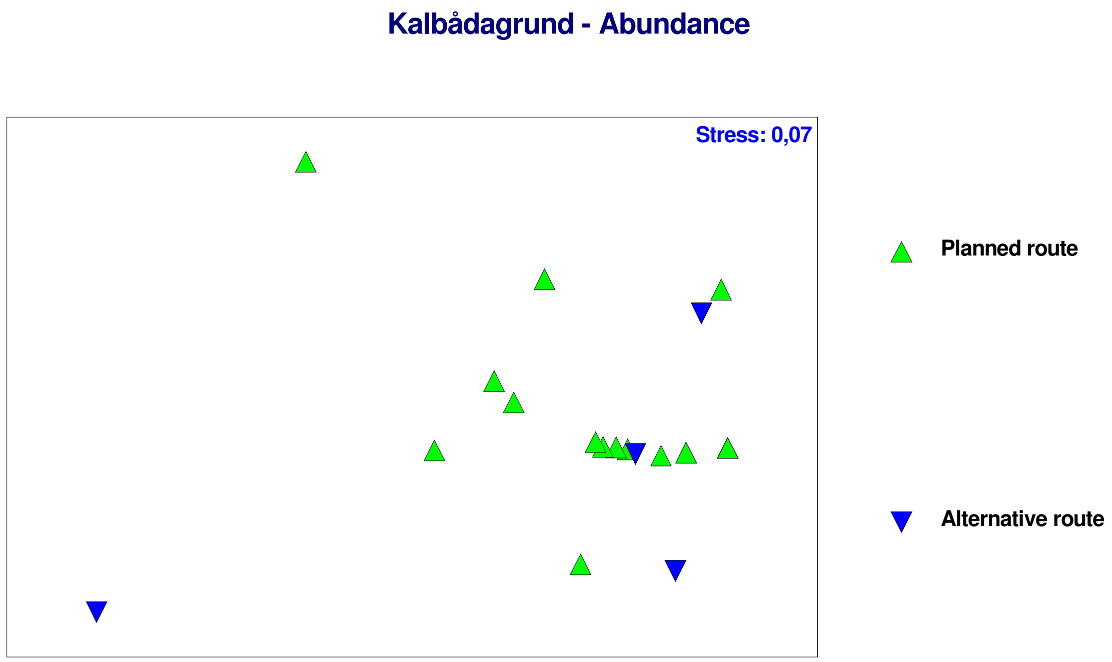


Figure 8.2 Classification (top) and ordination (bottom) based on abundance of the benthic fauna along the planned and alternative Kalbådagrund route in 2008. Based on all data inclusive station 270 and station 286.

The similarity was more than 50% with the exception of station 286 at the alternative route and station 270 at the planned route. The dominant polychaete Marenzelleria was not recorded at station 286 and very abundant (3035 m^{-2}) at the shallow station 270. The species accounting for the dis-similarity between the planned and the alternative route are summarized in Table 8.2.

Table 8.2 Dis-similarity and average abundance (m^{-2}) and biomass ($gDWm^{-2}$) of the species accounting for 90% of the dis-similarity of the benthic community along the planned and alternative Kalbådagrund route in 2008. Rounded values.

Species	Analysis based on abundance		Analysis based on biomass	
	Planned route	Alternative route	Planned route	Alternative route
Dis-similarity	45.2%		49.3%	
Marenzelleria	301	23	0.31	0.05
Bylgides sarsi	3	4	0.003	0.001
Saduria entomon	4	2	0.67	0.04
Mysis mixta	0	2	0	0.0004

The dis-similarity of the benthic community at the planned and alternative route is below 50%. Most of the similarity (and dis-similarity) of the benthic fauna is caused by the polychaete *Marenzelleria*, which is the only species, which occurs at almost all stations both along the planned and the alternative route. The other species, which also occurs along both the planned and alternative route, are far less common and abundant.

The benthic fauna along the planned and the alternative route was similar according to a One Way AnoSim tests based on all data. An analysis based on a comparison of the alternative stations in a strict sense gave similar results both including and excluding the atypical station 270 along the planned route and station 286 along the Kalbådagrund alternative route.

9 SUMMARY AND CONCLUSIONS

9.1 Sampling and analyses

Quantitative samples for analysis of macrozoobenthos were collected in the EEZ of Germany in 2006, Denmark in 2008, Sweden in 2007 and Finland in 2007 and 2008 along the south route of the planned Nord Stream pipeline between Germany and Russia. The water depth along the pipeline, which passes south of Bornholm and east of Gotland and via the Gulf of Finland, is highly variable and range between 0.5m and 179m at the sampling stations.

In addition to depth, a number of variables characterizing the composition of the sediment (e.g. median grain size and silt/clay fraction of the sediment, content of organic matter) were measured in samples at the benthos stations in the EEZ of Germany, Denmark and at a reduced number of benthos stations in the EEZ of Finland. Oxygen concentrations at the bottom were measured at the benthos stations in Germany, Denmark, Sweden and Finland in 2008, but only at a number of other stations in Finland in 2007. Profiles of salinity, temperature and oxygen were only measured in the EEZ of Denmark and at the benthos stations.

The species of macrozoobenthos in the samples were identified and counted. The total biomass of the species including shells of gastropods and bivalves were determined as dry weight.

The abundance and biomass data and the variables measured in the sediment at benthos stations were stored in a database together with the positions and water depth at the sampling stations.

In addition to graphical presentations of summary community measures (number of species, abundance and biomass) and distribution of characteristic species in relation to Latitude and depth, the structure of the benthic community and the importance of the measured environmental variables have been analyzed using multivariate techniques based on the Primer software package.

9.2 Gradients in salinity and oxygen

The Baltic Sea is characterized by pronounced horizontal and vertical gradients in salinity due to inflow of marine water via the Danish Belts and outflow of freshwater from the rivers in the large catchments area. The depth and strength of the halocline varies and a halocline may be developed between 50m and 90m. The concentration of dissolved oxygen decreases with increasing depth below the halocline due to hampered vertical mixing across the halocline and infrequent intrusion of oxygen rich marine water.

The gradients in salinity and oxygen, of vital importance for the distribution and presence of the macrozoobenthos, are subject to spatial and temporal changes of various scales. The results of the surveys along the pipeline are therefore affected by the ambient levels of the limiting factors of salinity and especially oxygen prior to and during the surveys in 2006, 2007 and 2008. This fact should be taken into account in comparisons with results of future surveys especially at sub-halocline depths.

9.3 Distribution of benthos in relation to Latitude and depth

The total number of species in the EEZ of the countries and the average number of species at the stations along the pipeline declines from south to north due to the lower salinity at higher Latitudes. The declining trend observed in 2006, 2007 and 2008 is consistent with the long term horizontal gradient in bottom salinity and overall changes in species richness in the Baltic Sea /7/. The average abundance and biomass of the benthos are also lower in higher Latitudes probably mostly because of lower concentrations of oxygen in the bottom water at greater depths.

The number of species, abundance and biomass of the benthos decline with increasing depth due to reduced concentrations of oxygen and the depth limit for live benthos was close to 90m in 2006, 2007 and 2008.

9.4 Structure of the benthic community and dominant species

The similarity of the benthic community was significantly different in all combinations of the EEZ of Germany, Denmark, Sweden and Finland with the exception of the EEZ of Sweden and Finland. The overall dis-similarity is due to the profound changes in species richness, species composition, abundance and biomass of the benthic community along the pipeline. Results of analyses based on abundance and biomass were mostly similar because the dominant species accounting for most of similarity of the benthic community were the same in the respective EEZ of the countries.

The dominant species in the EEZ of Germany, which accounted for most the benthic abundance, biomass and similarity of the benthic community were mud snails (*Hydrobia spp*.), polychaetes (*Marenzelleria spp*., and *Pygospio elegans*), Oligochaetes and bivalves (*Macoma balthica* and *Mya arenaria*) characteristic of shallow water.

The dominant species in the EEZ of Denmark were the bivalve *Macoma balthica*, the polychaete *Bylgides sarsi* and the crustacean *Pontoporeia femorata*.

The dominant species in the EEZ of Sweden were the bivalve *Macoma balthica*, the polychaete *Bylgides sarsi* and the amphipod *Pontoporeia affinis*. In addition to *Macoma balthica* and *Bylgides sarsi* the newly introduced polychaete *Marenzelleria* spp. were the most important species in the EEZ of Finland in 2007 and dominant in 2008.

9.5 Comparison of the planned and alternative route in the Gulf of Finland

The depth range at the planned and alternative Kalbådagrund route was approximately between 60m and 80m with the exception of one shallow station with a depth of 46m at the planned route. The oxygen concentration was around 2 mg/l at the deepest stations in May 2008.

The benthic fauna along the planned and alternative route was not significantly different and characterized by a dominance of the newly introduced polychaete *Marenzelleria*. The species richness was low and similar at the planned and alternative route when the number of samples was taken in account. The abundance and biomass of the benthic fauna was low along the planned route except at the shallow station and extremely low at the alternative route. In addition to *Marenzelleria*, the polychaete *Bylgides sarsi* and the isopod *Saduria entomon* was present at the planned and alternative routes, but the abundance of the species was low.

9.6 Conclusions

- The results of the surveys along the south route of the pipeline are affected by the ambient levels of the limiting factors of salinity and especially oxygen prior to and during the surveys in 2006, 2007 and 2008. However, inter-annual and seasonal changes in the benthic fauna and environmental variables are unknown. This fact should be taken into account in comparisons with results of future surveys especially at sub-halocline depths. It is recommended to strengthen the coordination of future baseline and monitoring surveys with respect to time of sampling and variables to be measured in the bottom water and sediment at the benthos stations.

- The species richness and the average number of species, abundance and biomass declines along the pipeline from south to north. The declining trend observed in 2006, 2007 and 2008 is consistent with the long term horizontal gradient in bottom salinity and overall changes in species richness in the Baltic Sea.

- The number of species, abundance and biomass of the benthos decline with increasing depth due to reduced concentrations of oxygen and the depth limit for live benthos was close to 90m in 2007 and 2008.

- The similarity of the benthic community was significantly different in all combinations of the EEZ of Germany, Denmark, Sweden and Finland with the exception of Sweden and Finland in 2007. The similarity of the benthic in Finland was also different in 2007 and 2008. The overall dis-similarity is due to the profound changes in species richness, species composition, abundance and biomass of the benthic community along the pipeline.

- The dominant species in the EEZ of Germany, which accounted for most the benthic abundance, biomass and similarity of the benthic community were mud snails (*Hydrobia* spp.), polychaetes (*Marenzelleria* spp., *Pygospio elegans* and *Hediste diversicolor*), Oligochaetes and bivalves (*Macoma balthica* and *Mya arenaria*) characteristic of shallow water.

- The dominant species in the EEZ of Denmark were the bivalve *Macoma balthica*, the polychaetes *Bylgides sarsi* and the crustacean *Pontoporeia femorata*.

- The dominant species in the EEZ of Sweden were the bivalve *Macoma balthica*, the polychaete *Bylgides sarsi* and the amphipod *Pontoporeia affinis*. In addition to *Macoma balthica* and *Bylgides sarsi*, the newly introduced polychaete *Marenzelleria* spp. was the dominant species in the EEZ of Finland in 2007 and dominant in 2008.

- The total number of species was higher at the North route than at the South route in the EEZ of Germany, but the average species richness, abundance and biomass of the benthic fauna was almost similar. The same species of polychaetes, bivalves, snails and crustaceans characteristic of shallow water were dominating at the North at the South route but in different numbers and biomass.

- The benthic fauna at the planned and alternative Kalbådagrund route is similar due to a dominance of the polychaete *Marenzelleria* in 2008. The number of species, abundance and biomass are low at stations with depths between 60m and 80m. The oxygen concentration is about 2 mg/l at the deepest stations.

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Bathymetry of the Baltic Sea

A P P E N D I X   2

Average salinity summer/winter in the Baltic Sea (1900-2005)

A P P E N D I X   3

Species Name List – database

A P P E N D I X 4

Stations - database

A P P E N D I X 5

Transects - database

A P P E N D I X 6

Conversion factor - Shell free soft tissue

A P P E N D I X 7

Maps of Macrozoobenthos Transects

A P P E N D I X 8

Maps of Macrozoobenthos Stations

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