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Holocene sedimentary environmental changes at sites PSM002118 and PSM002123 offshore Simpevarp

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Abstract

This work deals with litho-, bio- and chronostratigraphic descriptions of two sediment cores collected offshore Simpevarp, as part of the Oskarshamn site investigation. During 2002 and 2003, sediment cores 06H0030 and 06H0035 were collected by the Geological Survey of Sweden at sites PSM002118 and PSM002123, respectively. The purpose of our work was to describe changes in the sedimentary environment especially regarding erosion/transport/accumulation and to calculate the accumulation rates of bulk sediment and organic carbon during different Baltic Sea stages.

Stratigraphic descriptions based on lithology and diatom analyses were used to reveal variations in salinity, water depth and bottom conditions. AMS radiocarbon dating of bulk sediment was used to establish a time/depth model. This model was combined with water- and organic carbon contents and resulted in bulk sediment accumulation rates (SAR) and organic carbon accumulation rates ($C_{org}AR$). The following conclusions were drawn:

- At the sampling point PSM002118, the water depth is 38.9 m. The main part of the core 06H0030 consist of clayey sediment with a low content of organic matter. Reworked organic material has been incorporated in the glacial melt water streams that emptied in the Yoldia Sea basin, since all dates are of pre-Holocene age. Based on the lithostratigraphy and diatom analysis, sediment origin can be divided in the following Baltic Sea stages; the Baltic Ice Lake, the Yoldia Sea and the Ancylus Lake. The uppermost part of the sediment core consists of gyttja sand, i.e. sand with organic matter, indicating that the bottom at the sampling site is dominated by erosion during the late Littorina Sea stage.
- At the sampling point PSM002123, the water depth is 40.9 m. The sediment core 06H0035 is characterized by its laminated appearance and consist of repeated layers of silty clay, clayey silt, gyttja sand and sand with gravel. Radiocarbon dates and diatom analyses indicate that the lowest part of the sediment core was accumulated in the Baltic Ice Lake, the Yoldia Sea, the Ancylus Lake and the Mastogloia Sea (early Littorina Sea). The main part of the sediment is accumulated with an average rate of c. 1.1 mm/yr in the Littorina Sea, and the highest calculated bulk sediment accumulation rate is c. 1,058 g m^{-2} yr^{-1}. Lower accumulation rates during the oldest Baltic Sea stages, as well as during latest 4–5,000 yrs, are probably caused by erosion. The accumulation rates of organic carbon are < 5 g m^{-2} yr^{-1} until the Littorina Sea stage, when values increase reaching at the most c. 56 g m^{-2} yr^{-1}. There is a similarity between our results and high organic carbon accumulation rates found in present eutrophicated coastal lagoons of the southern Baltic Sea.

Sammanfattning

Arbetet består av lito- och bio- och kronostratigrafiska beskrivningar av två marina sedimentkärnor, vilka togs upp utanför Simpevarp åren 2002–2003 av Sveriges geologiska undersökning i samband med Oskarshamns platsundersökning. Kärnorna 06H0030 och 06H0035 kommer från provplatserna PSM002118 (vattendjup 38,9 m) respektive PSM002123 (vattendjup 40,9 m). Syftet med arbetet är att beräkna ackumulationshastigheten för organiskt kol och sediment i allmänhet, samt beskriva hur erosion, transport och ackumulation har förändrats över tid på undersökningsplatserna.

Analysmetoderna omfattade beskrivning av litostatigrafi, diatoméanalyser, mätning av organiskt kol och vattenhaltbestämning i sedimentet. Diatomé- och litostratigrafin användes för att rekonstruera salthaltsvariationerna i Östersjön. Beräkningar av kol- och sedimentackumulation baserades på organiska kolhalter och torrvikter i sedimentet. Bulksediment daterades med AMS-^{14}C metoden, och resultaten av dessa användes för att konstruera en tid/djupmodell. Följande slutsatser kunde dras av arbetet:

- På provplats PSM002118 består största delen av kärnan 06H0030 av leriga sediment. Dateringarna från denna kärna är av pre-Holocen ålder, vilket är resultatet av inlagring av äldre organiskt material från glaciala smältvattenströmmar som rann ut i Yoldiahavet. Enligt litostratigrafi och diatoméanalys har dock tre olika Östersjöstadier urskiljts; Baltiska Issjön, Yoldiahavet och Ancylussjön. Sediment som avsattes under dessa stadier innehåller låga halter organiskt kol. Under senare delen av Littorinastadiet har havsbottnen utsatts för erosion vid undersökningsplatsen.
- På provplats PSM002123 karakteriseras kärnan 06H0035 av laminerade sediment med upprepade lager av siltig lera, lerig silt, gyttjig sand och grusig sand. Dateringar, litostratigrafi och diatoméanalys indikerar att den nedre delen av kärnan består av sediment ackumulerad i Baltiska Issjön, Yoldiahavet, Ancylussjön och Mastogloiahavet (tidiga Littorinahavet). Största delen av sedimentet har ackumulerats i Littorinahavet med en hastighet av ca 1,1 mm/år. Det högsta beräknade ackumulationen av bulksediment är ca 1 058 g m^{-2} yr^{-1}. Lägre ackumulationshastigheter under de äldsta Östersjöstadierna samt under de senaste ca 4–5 000 år är troligtvis orsakade av erosion i sedimentbassängen. Ackumulationshastigheten för organiskt kol är < 5 g m^{-2} yr^{-1} i den nedre delen, men ökar under Littorinastadiet till 56 g m^{-2} yr^{-1}. Våra resultat motsvarar värden som registrerats i nutida eutrofa vikar i södra Östersjön.

Contents

1 Introduction

This document reports the results gained by the Investigation of Marine geological sediment core offshore Simpevarp, which is one of the activities performed within the site investigation at Oskarshamn. The work was carried out in accordance with Activity Plan AP PS 400-06-027. Controlling documents of this activity are listed in Table 1-1. Both Activity Plan and Method Descriptions are SKB's internal controlling documents. This work deals with stratigraphic analyses of the sediment cores 06H0030 (site PSM002118) and 06H0035 (site PSM002123) collected offshore Simpevarp (Figure 1-1). The purpose is to interpret the results in terms of environmental changes in the water column and to calculate the accumulation rates of bulk sediment and organic carbon during different Baltic Sea stages. The work was performed between 2004 and 2006. The original results are stored in the primary data bases (SICADA) and are traceable by the Activity Plan.

Table 1-1. Controlling documents for the performance of the activity.

Activity plan	Number	Version
Förekomst och stratifiering av diatoméer och sedimentationshastighet i två marina sedimentprover	AP PS 400-06-027	1.0

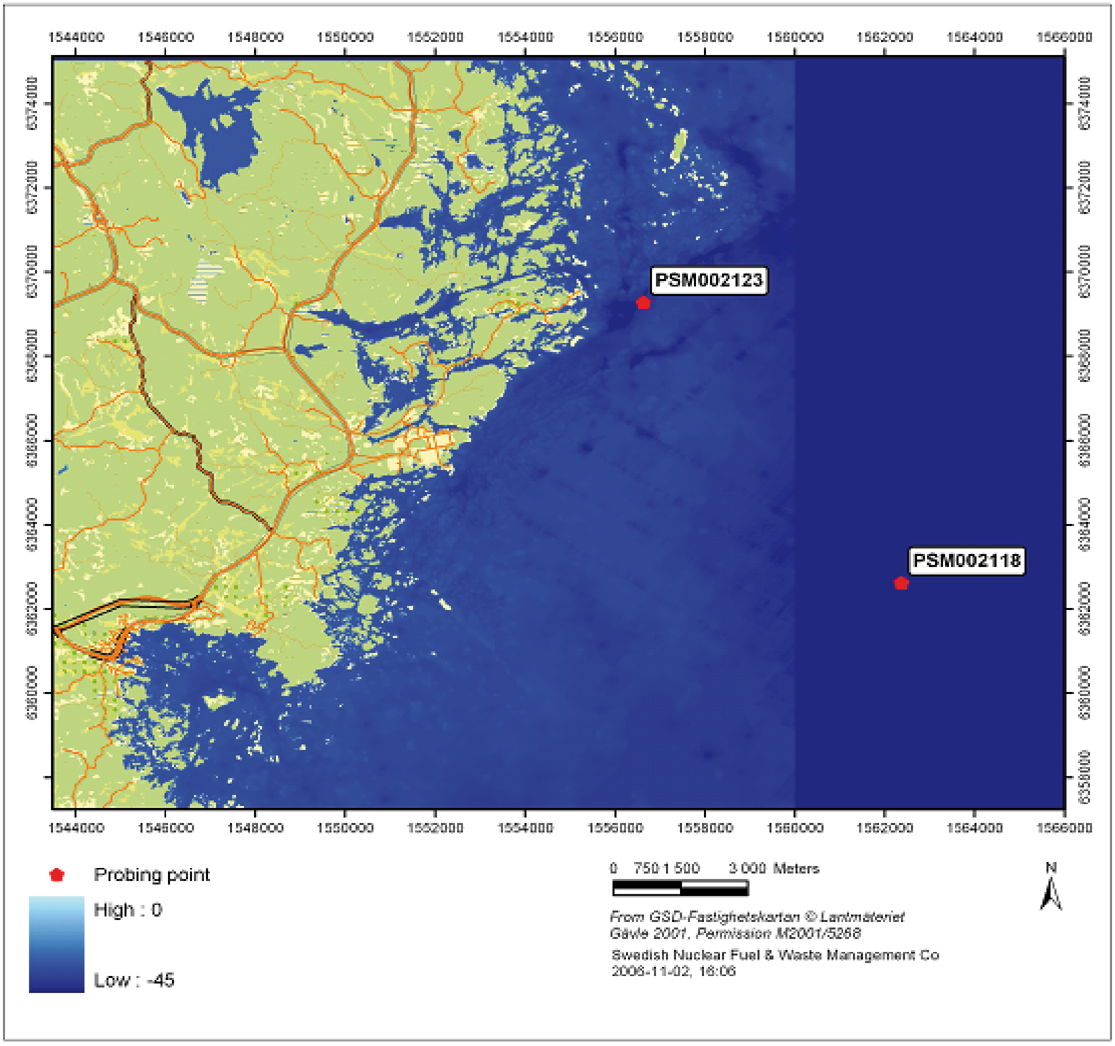

***Figure 1-1**. A map showing sampling points in SGU site investigation outside Simpevarp (SKB P-05-35). Sites, which the analysed cores 06H0030 and 06H0035 originate from, are marked with green dots. The positions of site PSM002118 (core 06H0030) is N6362626, E1562379 and the position of site PSM002123 (core 06H0035) is N6369280, E1556641 according to Swedish RT-90 2.5 g W map projection.*

2 Objective and scope

The Swedish Geological Survey conducted a detailed geologic mapping of the sea bottom offshore Simpevarp during 2002 and 2003 /Elhammer and Sandkvist 2005/. The investigation consisted of hydro-acoustic mapping combined with sampling of short and long sediment cores. Two sediment cores were collected at site PSM002118 (core 06H0030) and site PSM002123 (core 06H0035). At the first site, the water depth was 38.9 m and at the latter the depth was 40.9 m. Core 06H0030 was 550 cm long and consisted mainly of sediment with low content of organic matter, while core 06H0035 was 494 cm long and displayed a major portion with laminated sediment. At the time of collection, there was no plan of what type of analyses that should be performed on the sediment, and the cores were stored on the ship Ocean Surveyor under alternating thawing and freezing conditions. After thawing in the storage at the Department of Physical Geography and Quaternary Geology, Stockholm University (SU) 2004, it was noted that abundant water had collected at the very ends of cores and the sediment sequences displayed contractions at random intervals.

The main part of the work at the laboratory consists of stratigraphic analyses of siliceous microfossils, i.e. diatoms, Chrysophyceae stomatocysts, sponge spiculae, ebridians, silicoflagellates and phytoliths. Focus was put on compilation of the diatom assemblages. The composition of diatom taxa reflects changes in e.g. salinity and was used to detect and delimit the main stages of the Baltic Sea.

AMS radiocarbon dating of bulk sediment was applied to establish an age model of the sediment sequences. Determinations of organic carbon content were used to describe the sediment composition and to calculate the accumulation rate of organic carbon ($C_{org}AR$) in g m^{-2} yrs^{-1}. The main purposes of this activity are as follows:

- to identify which Baltic Sea stages different sediment layers represent,
- to describe variations in organic carbon content,
- to estimate the accumulation of organic carbon per area unit and year,
- to detect erosive phases in the sedimentary records,
- to estimate the bottom character of today in terms of accumulation/transport/erosion.

3 Equipment

3.1 Sample treatment

The cores were split into halves on the ship resulting in two half cylinder cores with a diameter of 60 mm (Figure 3-1). These were sealed with plastic surround wrap and tightened at both ends. The sealing had in some cases been broken during storage on the ship. The litho-stratigraphy was determined with respect to visible changes in sediment texture, grain size and inclusions.

3.2 Organic carbon

In total, 30 sub-samples were collected from core 06H0030 and core 06H0035. Sample intervals were chosen after visual judgement from the most undisturbed levels, because of deformities and broken parties in the sediment records due to earlier storage in varying temperatures. Sample volumes were calculated from the inside diameter of the 5 ml syringe used for sampling, and actual sample thickness. Samples were weight before and after drying at 105°C for 24 hours in order to remove both free water and interstitial water. Dry sediment weights were calculated as the difference between total weight and water content. The dried samples were mottled in order to homogenise the sediment, and again dried > 1 hour at 105° before analysis. The measuring method is based on the principle of sample combustion, oxidation of the carbon as CO_2 and analysis of the gas through infrared absorption. Between 100–200 mg of standard and sediment samples were weight accurately and combusted at 550°C in Carbon Sulfur determinator (Eltra CS 500) resulting in organic carbon content (% C). Standard samples were used for quality control. Carbon accumulation rates in the sediment layers are possible to calculate if sample weights, sample volumes, carbon contents and accumulation rates are known. This was performed according to the formula below

$$C_{org}AR = \rho \times SR \times \frac{C_{org}}{100}\left[\frac{g}{m^2 \cdot yr}\right], \text{ where}$$

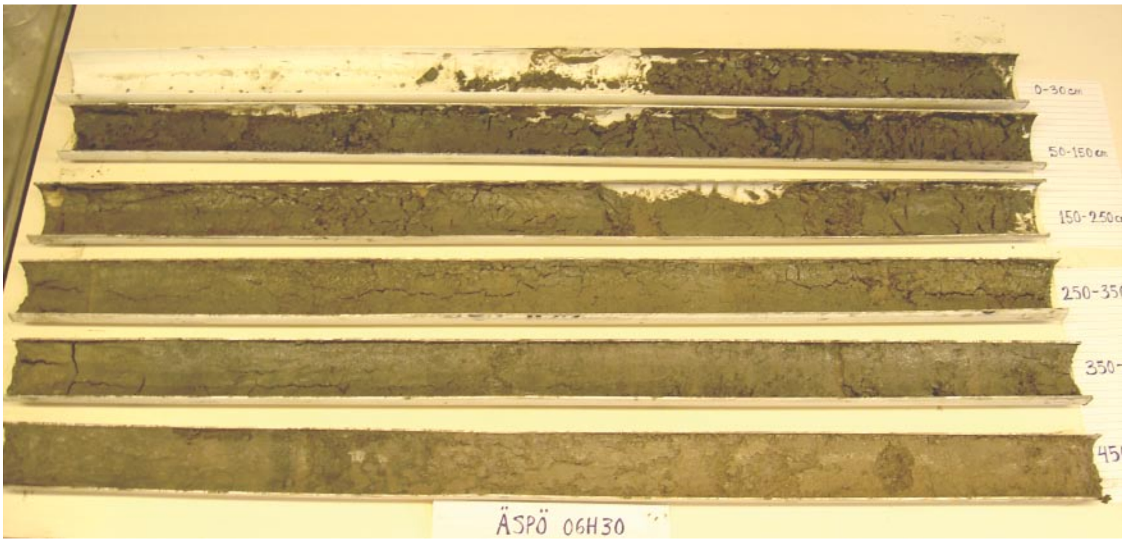

Figure 3-1. *Core 06H0030 from coring site PSM002118 outside Simpevarp (Äspö) was cut in one metre long cylinders and split into halves on the ship Ocean Surveyor. The photo was taken before sub-sampling at Stockholm University.*

$C_{org}AR$	=	accumulation rate of organic carbon
ρ	=	sample density = m_S/V = dry sample weight (g)/wet sample volume (m^3)
SR	=	linear accumulation rate = d/t = wet sediment distance between two adjacent dates (m)/time period between two adjacent dates (calendar yrs)
C_{org}	=	organic carbon content (%)

The accumulation rates of organic carbon were also compared with the accumulation rate of the bulk sediment (SAR). $SAR = \rho \times SR\left[\frac{g}{m^2 \cdot yr}\right]$, also given in the text as g m^{-2} yr^{-1} and in the diagrams as g/m^2/yr (or g/cm^2/yr in order to facilitate comparison with other similar investigations).

3.3 Diatom analysis

The analyses were performed on totally 20 sediment sub-samples of c. 0.5 cm^3, collected at 50 cm intervals from each core. Siliceous microfossils were extracted from the sediment following the compilation described in /Battarbee 1986/. 10% HCl was added to dissolve carbonates before the oxidation of organic matter with 17% H_2O_2. After boiling and washing with distilled water and weak HNO_3, the residue was mounted on slides with Naphrax®. The identification and counting was performed under a Leica DMLB with X1000 magnification and immersion oil. Proportions of diatom taxa were calculated as percentages of the total sum in the sample and grouped according to their salinity preferences/tolerance into Ancylus Lake freshwater-, marine-brackish water -, halophilous -, indifferent taxa, and varia (taxa of unknown ecology).

3.4 Chronology

In total, 13 bulk sediment samples (three samples from the core 06H0030 and 10 samples from 06H0035) were collected from spread sediment levels representing Baltic Ice Lake, Yoldia Sea, Ancylus Lake and/or Littorina Sea stages. The stages were based on combined litho- and biostratigraphy (diatom assemblage zones). Sample thicknesses of 10 mm were regarded as minimum to obtain enough material, as removing of the outer layer of cores was necessary to avoid possible contamination. Samples were chosen from the most undisturbed parts avoiding deformities and contracted intervals. Dating samples were weighed and stored at +4°C in closed capsules before sending to the Poznan radiocarbon laboratory in Polen. Resulting ^{14}C-ages were first subtracted by a reservoir age of 400 yrs for marine sediments accumulated during the Littorina Sea stage /Hedenström and Possnert 2001/ and a reservoir age of 300 yrs for Baltic Ice Sea/Ancylus Lake sediment, and then calibrated against atmospheric carbon using the OxCal version 3.10 /Bronk Ramsey 2001/ (Table 5-4). These approximations of the reservoir ages make it difficult to state uncertainties in percentages of our calibrated radiocarbon ages. The mean values of calculated ages (± 1 σ) were used for estimation of the linear sedimentation rate (SR) at different depth intervals (Table 5-4).

In the interpretation of the sediment cores the following ages for the main Baltic Sea stages are adopted according to Table 3-1 /Björck 1995, Björck and Svensson 2002, Yu 2003/. AD 1,950 is used as the reference year for all ages quoted in ^{14}C yrs and calendar years BP.

Table 3-1. Adopted ages for the main Baltic Sea stages.

Baltic Sea stage	Cal yrs BP	Cal yrs BC/AD
Baltic Ice Lake	15,000–11,550 BP	13,050–9,600 BC
Yoldia Sea	11,550–10,800 BP	9,600–8,850 BC
Ancylus Lake	10,800–9,500 BP	8,850–7,550 BC
Littorina Sea (Mastogloia Sea)	9,500 BP–today (9,500 BP–c. 8,500 BP)	7,550 BC–today (7,550 BC–c. 6,550 BC)

4 Methods

4.1 General

The methods used are according to the Activity Plan SKB AP PS 400-06-027.

4.2 Preparations

Diatom identification and ecological information of the noted taxa were extracted from the following reference literature: /Cleve-Euler 1951–1955, Mölder and Tynni 1967–1973, Krammer and Lange-Bertalot 1986, 1988, 1991ab, Snoeijs 1993, Snoeijs and Balashova 1994, Snoeijs and Vilbaste 1994, Snoeijs and Potapova 1995, Snoeijs and Kasperoviciene 1996/.

4.3 Data handling/post processing

The results from the analysis were treated in the computer program Tilia /Grimm 1991–1993, 1992/ and the diagrams were created in Tilia graph /Grimm 1992/.

In the diagrams the following groups of diatoms were established in order to define various stages of the Baltic Sea (Appendix 1):

- Baltic Ice Lake freshwater taxa that lived in the mainly oligotrophic, somewhat acid freshwater body /cf. Kabailiene 1995/.
- Yoldia Sea brackish-marine taxa that lived during the very short brackish-marine phase of this stage /Björck et al. 1996/ (the main part of this stage was freshwater with similar species as in the Baltic Ice Lake, cf. /Eronen 1974, Kabailiene 1995/).
- Ancylus Lake freshwater taxa that lived in the freshwater body with somewhat enhanced concentrations of dissolved solids /Eronen 1974, Robertsson 1997/.
- Mastogloia Sea brackish-halophilous taxa lived in a low level of salinity on the onset of the Littorina Sea /Hyvärinen and Eronen 1979/ (sublittoral sediments deposited during this stage in deeper water contain ordinary Ancylus Lake floras with little or no admixture of brackish species /Hyvärinen 1984/).
- Littorina Sea brackish-marine taxa that lived during the youngest phase when the Baltic has been in topographic contact with the oceans /Alhonen 1971, Miller 1986, Miller and Risberg 1990, Risberg 1990/.
- Varia consists of taxa that were not possible to identify to species level, mainly because of diatom fragmentation or problematic diatom orientation in the sample slide.

4.4 Analyses and interpretations

The result from the diatom analysis are presented as Tilia-diagrams (Figures 5-2, 5-3, 5-4, 5-5 and 5-6) that show from the left: radiocarbon dates (^{14}C yrs BP in core 06H0030, not calibrated because of their old ages, and cal yrs BP in core 06H0035), simplified lithology, the various species identified in groups (as percentages), summarised groups, and the zonation based on interpretation of the Baltic Sea stages. Different diatom species are listed in Appendix 1. The results from organic carbon analyses are presented in diagrams for organic carbon content (Figure 5-7) and accumulation rate of organic carbon (Figure 5-8).

4.5 Nonconformities

The sampling intervals were not evenly distributed, because of dried and broken sequences in the cores 06H0030 and 006H0035. There was not enough material for dating of terrestrial macrofossils, which gives more reliable results compared with bulk sediment dating. The latter technique includes a reservoir age making calibrations uncertain.

The activity was conducted without any other nonconformities.

5 Results

The original results are stored in the primary data base SICADA, and will be used for further interpretations (modelling). The data is traceable in SICADA by the Activity Plan number (AP PS 400-06-027).

The four general Baltic stages during the Holocene have been used for subdivision of the constructed diagrams. These include the Baltic Ice Lake (freshwater), the Yoldia Sea (brackish and freshwater), the Anclylus Lake (freshwater) and the Littorina Sea (brackish water). The early Littorina Sea (weak brackish phase in near shore areas) is named the Mastogloia Sea.

5.1 Lithology

The main part of the core 06H0030 consist of clayey sediment with a low content of organic matter (Table 5-1).

The sediment core 06H0035 is dominated by its laminated appearance and the regular accumulation of shells (Table 5-2). The bulk sediment shows no reaction with HCl and therefore it is concluded that shells occur only as major pieces.

Table 5-1. Lithology of sediment core 06H0030, based on ocular inspection.

Depth from sediment surface (cm)	Lithology	Lower boundary appearance
000–012	Gyttja sand, grey	Gradational over 5 cm
012–165	Gyttja silt/silt, dark grey	Gradational over 10 cm
165–212	Clay, dark grey	Abrupt
212–213	Fine sand, grey	Abrupt
213–476	Clay, dark grey	Abrupt
476–477	Clay, brown	Abrupt
477–492	Clay, dark grey	Gradational over 5 cm
492–550	Clay, brown	

Table 5-2. Lithology of sediment core 06H0035, based on ocular inspection. Lower boundaries are in general abrupt.

Depth from sediment surface (cm)	Lithology	Comments
000–020	Gyttja sand with gravel	Organic macroscopic remains and single shells
020–051	Silty clay, laminated	Organic remains and shells. Each laminae 5–10 mm
051–052	Sand with occasional gravel	
052–395	Silty clay, laminated	Organic remains and shells. Each laminae 5–10 mm
395–407	Gyttja silty sand	
407–417	Silty clay	Single laminae of gyttja silty sand
417–433	Gyttja silty sand	Single laminae of silty clay
433–452	Silty clay	Single laminae of gyttja silty sand
452–464	Clayey silt	
464–494	Silty clay	

5.2 Chronology

The AMS ^{14}C-dates from core 06H0030 are based on 8.0–8.5 g clay with low organic carbon content (see Chapter 5.4). All dates are of pre-Holocene age (Table 5-3), which likely is a consequence from incorporation of early/middle Weichselian organic matter. The dates from the Baltic Sea contain a reservoir age depending on type of organic material imbedded in the sediment. No calibrations were made because the oldest age was outside the calibration curve and the two younger ages were too old making the calibration process for atmospheric carbon uncertain. The old ages can be a result of reworking processes incorporating organic matter. Therefore, these dates do not contribute to our aim, which is to estimate the accumulation rate of organic carbon in the study area after the retreat of the Weichselian ice sheet.

The AMS radiocarbon dates from the sediment core 06H0035 are based on 5.5–7.8 g sediment, with higher organic carbon content compared with core 06H0030. An average age of 400 yrs has been subtracted before calibration for the Littorina Sea stage and 300 yrs for the Baltic Ice Lake stage /cf. Olsson 1996, Hedenström and Possnert 2001, Risberg et al. 2005/. The dating resulted in ages between 9,000 and 4,240 calendar years BP (Table 5-4). Calibrated dates are shown both with 68.2% and 95.4% probability (± 1σ and ± 2σ). A time/depth model (Figure 5-1) is based on these results to illustrate the sediment accumulation rate during the Holocene.

The lowermost date (12,940–12,810 cal yrs BP) indicates that the sediment was accumulated in the Baltic Ice Lake. The next date upwards (9,000–8,640 cal yrs BP) suggest an accumulation in the early Littorina Sea (the Mastogloia Sea). If these dates are correct it means that sediment from the Yoldia Sea and Ancylus Lake are not dated. This is illustrated in the age/depth model (Figure 5-1), where these Baltic Sea stages occur between c. 460 and 430 cm depth. The low accumulation rate for this part of the sequence could be caused by the occurrence of one or several hiatuses, indicated by sandy laminae (see Table 5-2). The remaining dates have resulted

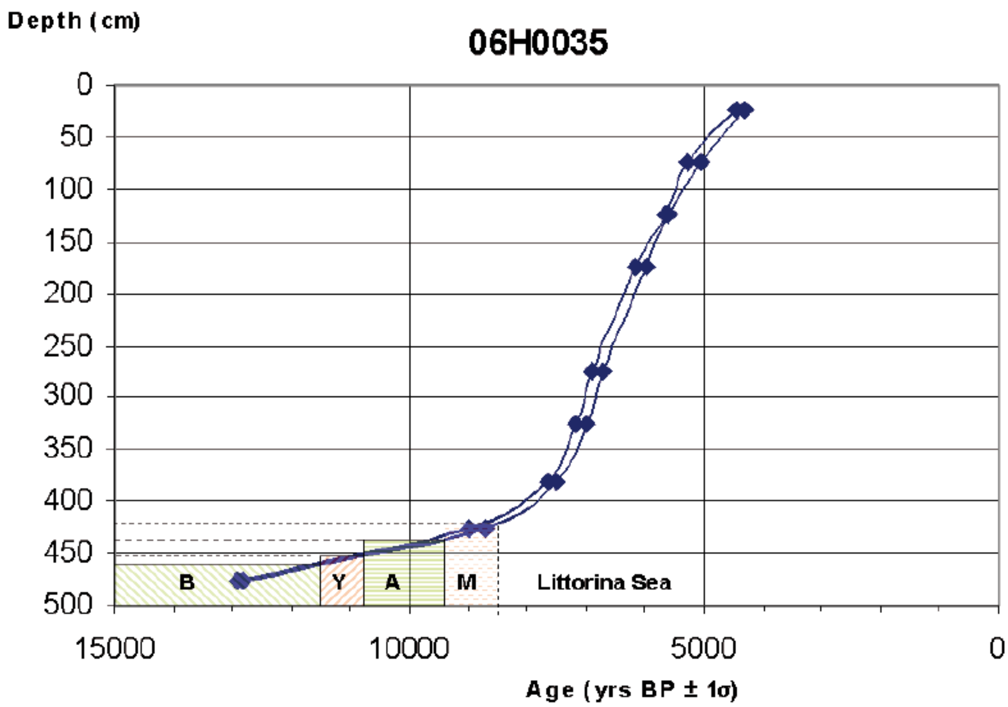

Figure 5-1. Age/depth model for the sediment core 06H0035 collected offshore Simpevarp. In the lower part there are both chronological and lithological indications of a hiatus, as well as at the top of the core. According to the Baltic Sea stages adopted in Table 3-1, the sediment was accumulated in B = the Baltic Ice Lake, Y = the Yoldia Sea, A = the Ancylus Lake, M = the Mastogloia Sea (early part of the Littorina Sea) and in the Littorina Sea.

Table 5-3. Radiocarbon dates (^{14}C yrs BP) from the core 06H0030, based on clay with low carbon content (0.2–0.4%).

Depth (cm)	Bulk sediment wet (g)	Lab. no.	Date (^{14}C yrs BP)
170	8.0	Poz-16545	19,160 ± 120
330	8.1	Poz-16546	18,260 ± 140
470	8.5	Poz-16547	28,140 ± 400

Table 5-4. Radiocarbon dates (^{14}C years BP) and calibrated ages (cal yrs BP) from the core 06H0035. The linear sedimentation rate (SR) is calculated as the ratio of differences in sediment depth (mm) and mean age (cal yrs BP ± σ) between the actual and the overlying sediment depths. The organic carbon content is c. 3–10% in laminated silty clay and c. 1% below 400 cm depth.

Depth (cm)	Bulk sediment wet (g)	Sediment type	Lab. no.	Date (^{14}C yrs BP)	Estimated reservoir age	Cal yrs BP ± 2σ (95.4%)	Cal yrs BP ± σ (68.2%)	SR (mm/yr)
25	7.6	Silty clay, laminated	Poz-16617	4,330 ± 35	400	4,520–4,240	4,430–4,290	–
75	6.7	Silty clay, laminated	Poz-16501	4,880 ± 40	400	5,300–4,970	5,290–5,040	0.62
125	6.0	Silty clay, laminated	Poz-16548	5,300 ± 40	400	5,720–5,580	5,655–5,595	1.09
175	5.8	Silty clay, laminated	Poz-16492	5,680 ± 40	400	6,190–5,940	6,180–5,950	1.14
275	5.8	Silty clay, laminated	Poz-16635	6,365 ± 50	400	6,940–6,670	6,890–6,730	1.34
325	5.5	Silty clay, laminated	Poz-16636	6,580 ± 50	400	7,250–6,940	7,170–7,000	1.82
380	5.8	Silty clay, laminated	Poz-16689	7,120 ± 50	400	7,680–7,500	7,660–7,510	1.10
425	7.8	Gyttja silty sand	Poz-16690	8,360 ± 50	400	9,000–8,640	8,980–8,720	0.36
475	6.7	Silty clay	Poz-16637	11,190 ± 60	300	12,940–12,810	12,900–12,835	0.12

in ages corresponding to the Littorina Sea stage and suggest more or less uniform accumulation rates. There are possible hiatuses indicated by sandy laminae between 417–407 cm depth and sand layers between 407–395 cm and 52–51 cm depth. Note that the uppermost date from 25 cm depth (4,520–4,240 cal yrs BP) indicates that the present day bottom could is characterised by erosion. The average rate of sediment accumulation during the Littorina Sea period is c. 1.1 mm/yr.

5.3 Diatoms and the Baltic Sea stages based on salinity variations and lithology

The zonation of diatom diagrams is based on radiocarbon dates, lithology and diatom composition. The diatoms have been grouped according to salinity preferences explained in Chapter 4.3.

The diatom diagrams for the sediment core 06H0030 (Figures 5-2 and 5-3, Appendix 1) have been divided in three zones, representing the oldest stages of the Baltic Sea development. The

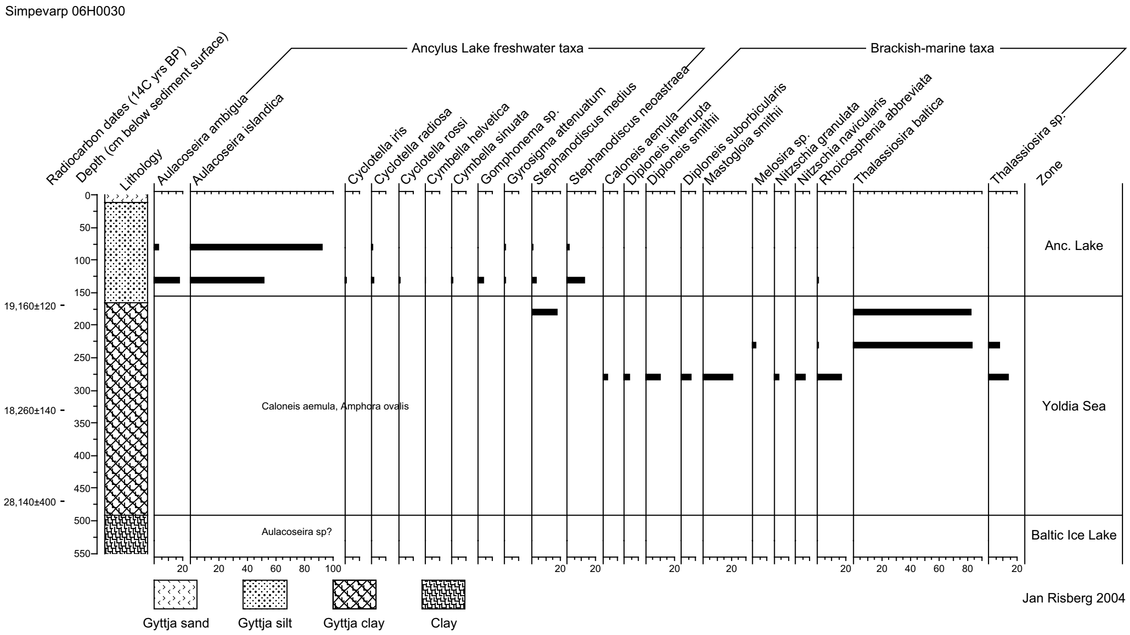

Figure 5-2. *The diatom diagram including Ancylus Lake freshwater taxa and brackish-marine taxa for the sediment core 06H0030.*

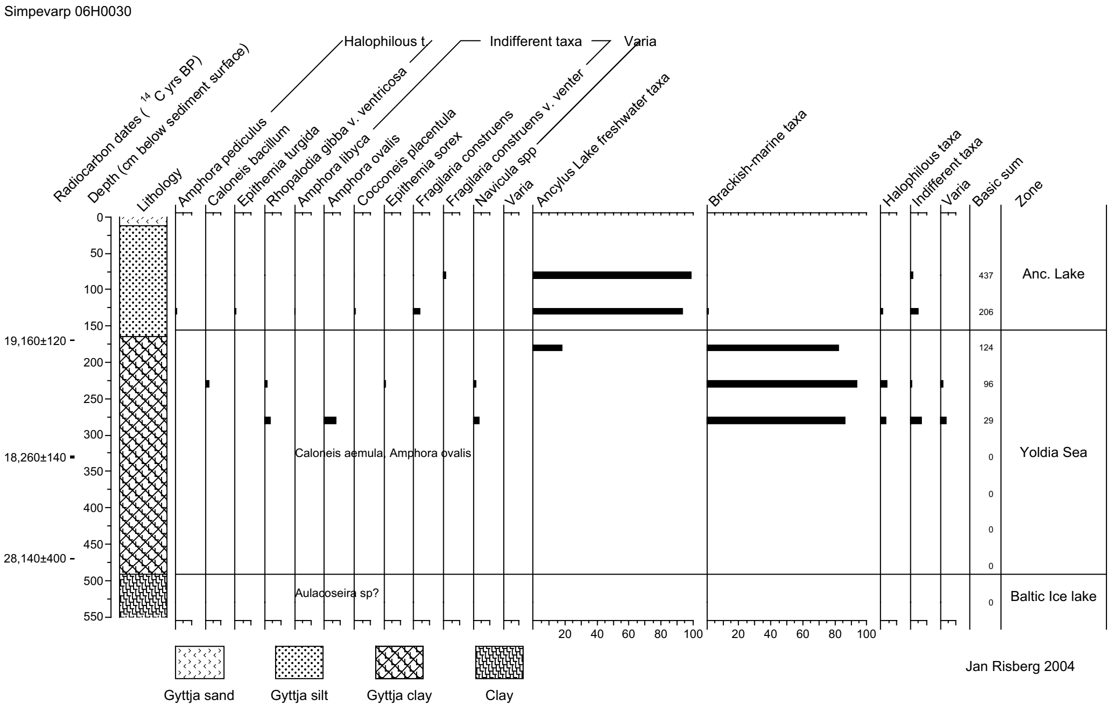

Figure 5-3. *The diatom diagram including halophilous taxa, indifferent taxa, varia and sums for all groups for the sediment core 06H0030.*

indication for deposition in the Baltic Ice Lake is week. We believe that the lowermost lithologic unit brown clay was accumulated during this phase based mainly on the sparse occurrences of diatoms (only one frustule of *Aulacoseira* sp. was observed) and the sediment type.

The overlying dark grey clay was probably accumulated during the Yoldia Sea phase of the Baltic basin. The lower half of this lithologic unit was barren of diatoms. In the upper part typical brackish-marine taxa, e.g. *Thalassiosira baltica*, *Rhoicosphenia abbreviata* and *Mastogloia* *smithii*, occur. Furthermore, there are three radiocarbon dates that gives very old ages indicating that reworked organic material has been incorporated in the glacial melt water streams that emptied in the Yoldia Sea basin.

Sediment representing the overlying unit gyttja silt was accumulated in the Ancylus Lake. This is indicated by typical freshwater taxa such as *Aulacoseira islandica* and *Stephanodiscus neoastraea*.

The uppermost 12 cm of the sediment core 06H0030 consist of gyttja sand indicating that the bottom at the sampling site is at present dominated by erosion. If the interpretation is correct, no sediment have been accumulated during the Littorina Sea phase, i.e. the last c. 9,500 yrs. Of course, sediment could have been accumulated during some time periods and eroded at a later stage. This interpretation is plausible since the regressive shore displacement lifts the bottom causing a gradual higher energy environment.

Also the diatom diagrams for the sediment core 06H0035 have been divided into three zones (Figures 5-4, 5-5 and 5-6, Appendix 1). The lowermost silty clay is assumed to have been deposited in the Baltic Ice Lake. This is based on few occurrences of diatom frustules being dominated by *Aulacoseira islandica*. Also the lowermost radiocarbon date supports this interpretation.

Since there is no diatom information from the layer consisting of clayey silt, we can not exclude the possibility that this unit was accumulated in the Yoldia Sea. The overlying thin minerogenic units that are dominated by silt and clay are interpreted as being accumulated in the Ancylus Lake. This is based only on one diatom sample that contained a number of typical taxa for this Baltic Sea stage, e.g. *A. islandica*, *Stephanodiscus medius* and *S. neoastraea*. It is obvious, however, that several phases with erosion took place at this sampling site. Since there are several halophilous taxa (*e.g. Epithemia turgida*), indifferent taxa (*e.g. Cocconeis placentula*) and the brackish-marine *Rhoicosphenia abbreviata* in the upper part of the unit it could represent the very onset of the Littorina Sea, i.e. the so called Mastogloia Sea /Hyvärinen 1984, Wastegård et al. 1998/. Salinity during the initial phase was low, resulting in a mixture

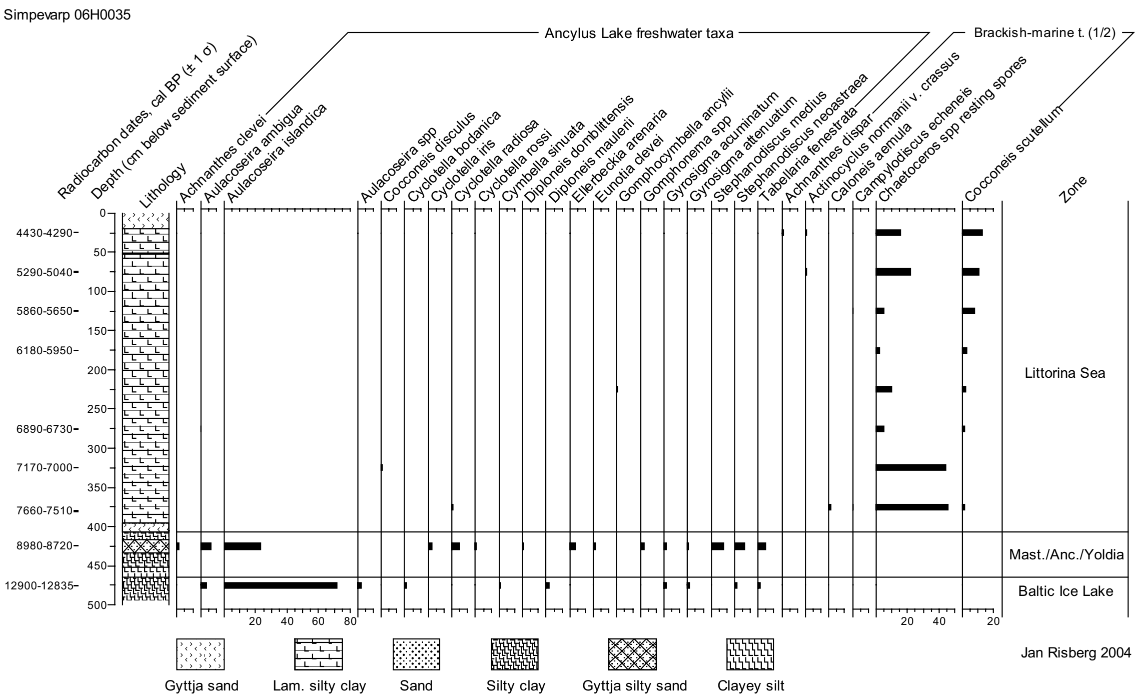

Figure 5-4. *The diatom diagram including the Ancylus Lake freshwater taxa and a part of the brackish-marine taxa (1/2) for the sediment core 06H0035. Mast. stands for the Mastogloia Sea, Anc. for the Ancylus Lake and Yoldia for the Yoldia Sea.*

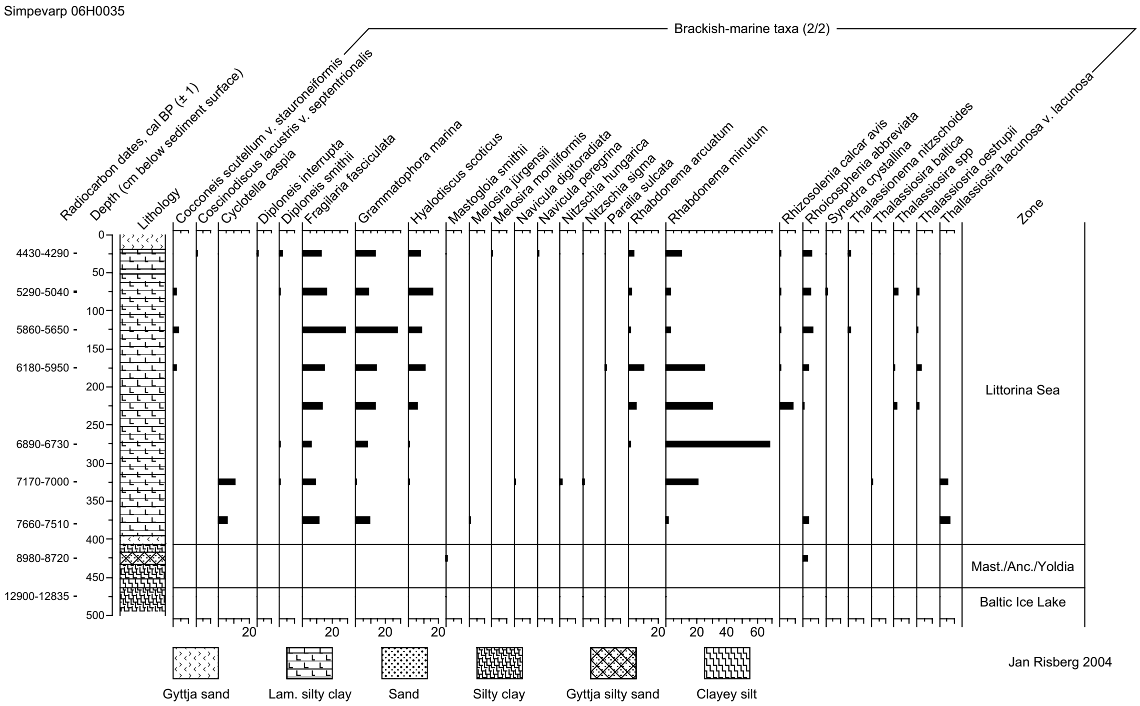

Figure 5-5. The diatom diagram including a part of the brackish-marine taxa (2/2) for the sediment core 06H0035. Mast. stands for the Mastogloia Sea, Anc. for the Ancylus Lake and Yoldia for the Yoldia Sea.

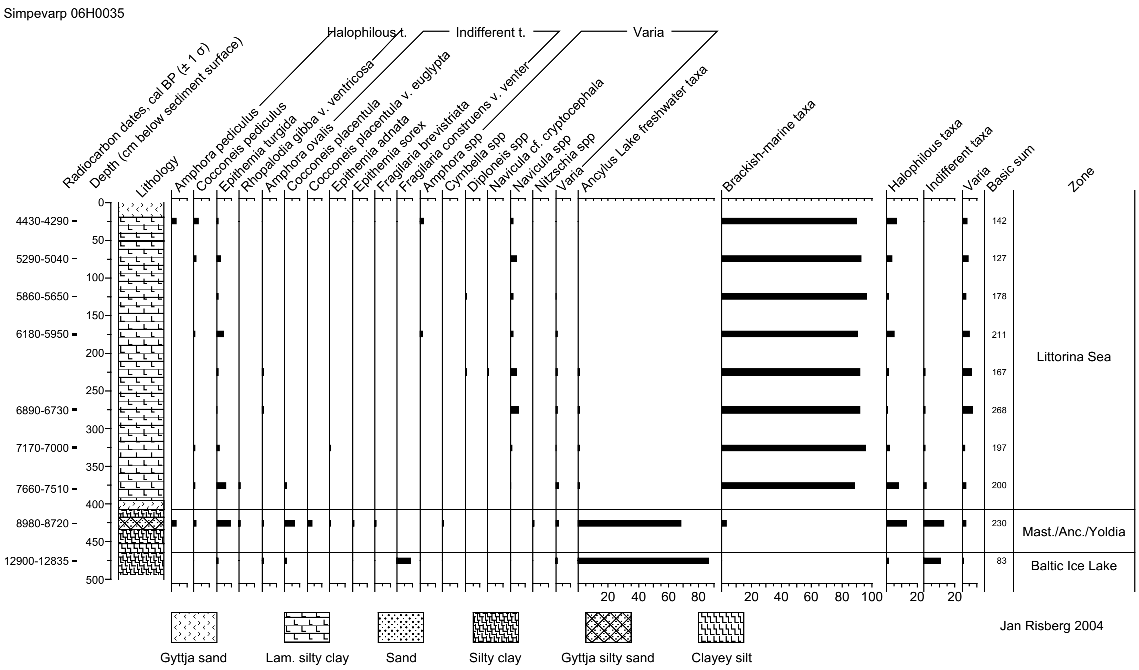

Figure 5-6. The diatom diagram including the halophilous taxa, the indifferent taxa, varia and sums for all groups for the sediment core 06H0035.

of different diatom taxa. At the actual site the water depth was > 40 m at that time, which can explain that Ancylus Lake taxa dominate the diatom flora. The radiocarbon date from this phase is in line with this interpretation.

The main part of the sediment sequence was accumulated in the Littorina Sea. This is clearly shown by the high percentages of brackish-marine taxa. The most common species are *Rhabdonema minutum*, *Hyalodiscus scoticus*, *Grammatophora marina* and *Fragilaria fasciculata* together with resting spores from *Chaetoceros* spp.

5.4 Organic carbon

Samples from core 06H0030 were analysed from 178, 215, 260, 285, 310, 333, 360, 390, 430 and 460 cm sediment depths for the organic carbon content (C_{org}). According to our diatom analysis (Figures 5-2 and 5-3), they origin from sediment accumulated in the Yoldia Sea. Carbon analyses result in generally low values, between 0.2 and 0.4% (Figure 5-7).

From core 06H0035, carbon analyses were made from 40, 60, 90, 110, 140, 169, 186, 211, 241, 270, 298, 314, 334, 365, 392, 410, 420, 433, 450 and 471 cm depths. The lowermost samples originate from sediment accumulated in the Baltic Ice Lake, the Ancylus Lake and the Mastogloia Sea according to the time/depth model in Figure 5-1. They display low values in the organic carbon content, between 0.6 and 1.3% (Figure 5-7). It is not until the onset of the Littorina Sea that values increase reaching at the most 10%.

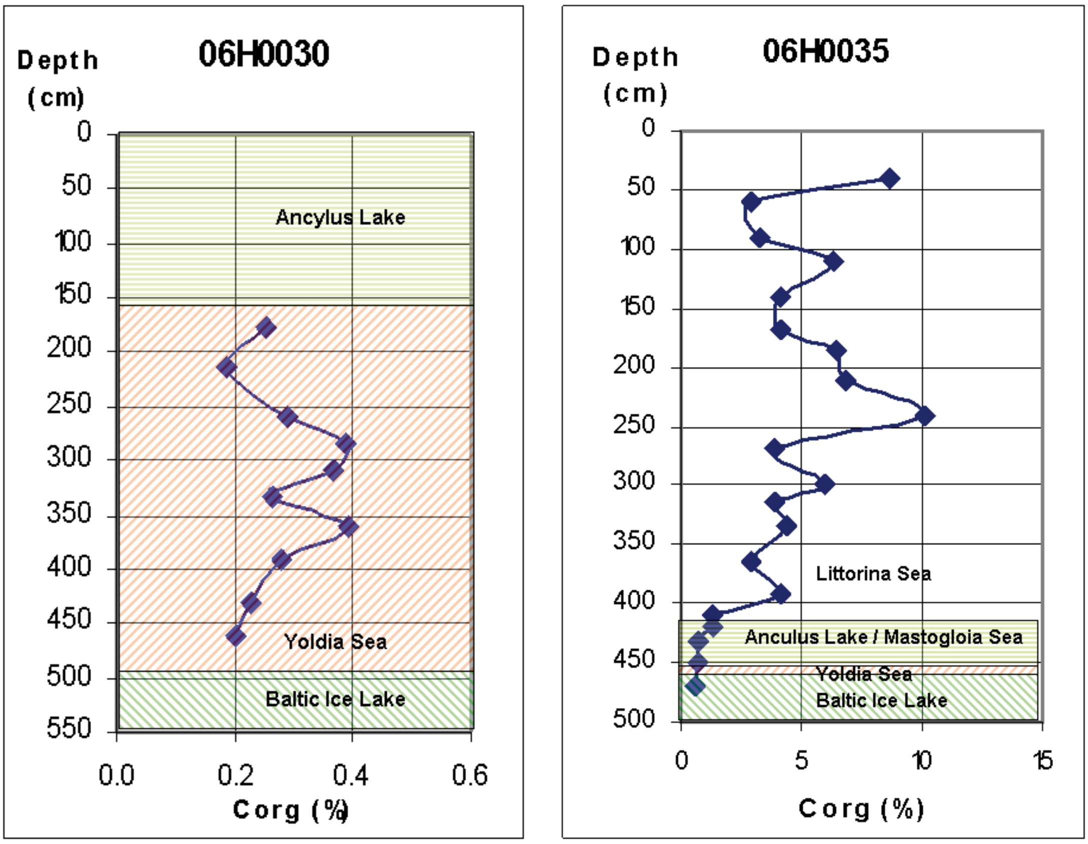

***Figure 5-7**. Graphs showing the content of organic carbon in cores 06H0030 and 06H0035 (note: in different scales). In core 06H0030 all values are low, interpreted to represent sedimentation in the Yoldia Sea according to diatom analyses (Figures 5-2 and 5-3). In core 06H0035, the values are low in the lower part, which represent sedimentation in the Baltic Ice Lake, the Ancylus Lake and the Mastogloia Sea according to the age/depth model (Figure 5-1) and diatom analyses (Figures 5-4, 5-5 and 5-6). The beginning of the Littorina Sea stage is characterized by an increase in organic carbon, reaching at the most c. 10%.*

Our aim is to estimate the accumulation rate of organic carbon in the study area. As we found out in Chapter 5.2, the dates from core 06H0030 do not contribute to the aim at the site PSM002118 and thus unable further calculations. For the site PSM002123, the accumulation rate of organic carbon is calculated from sample densities (ρ), organic carbon contents (C_{org}) and linear sedimentation rates (SR) from core 06H0035, and is compiled in Figure 5-8.

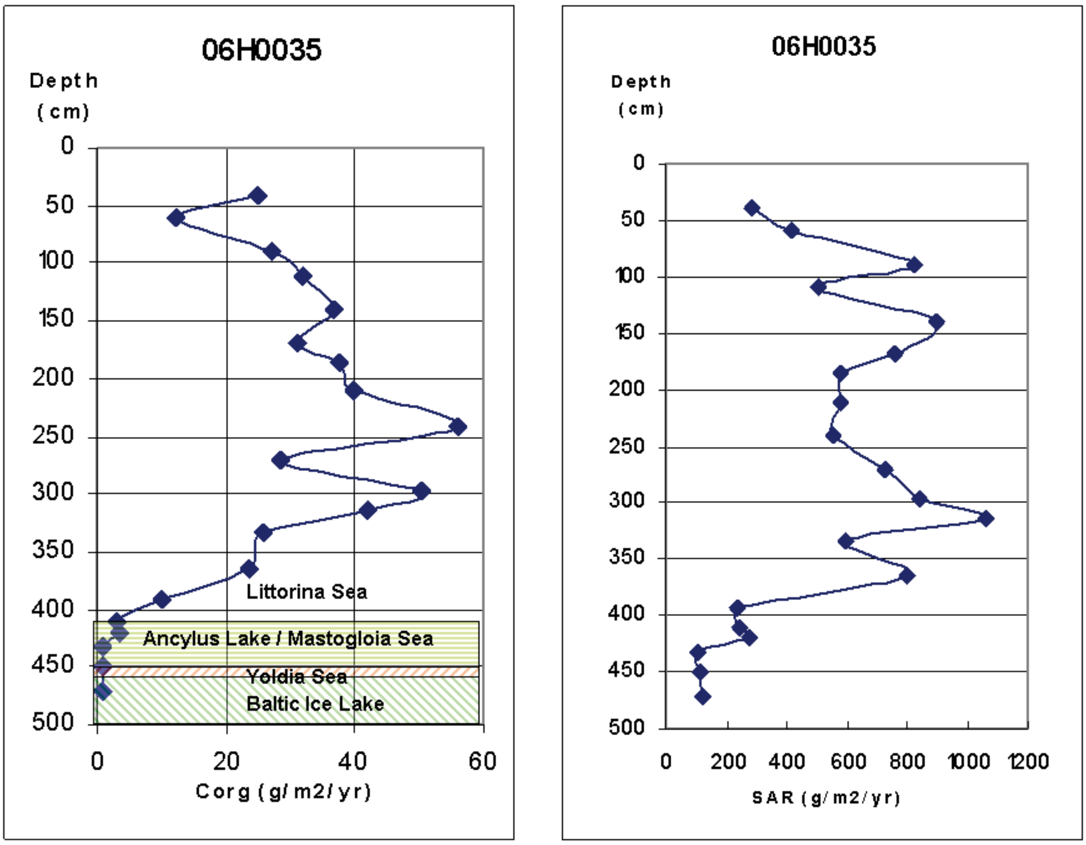

***Figure 5-8**. Graphs showing variations in the accumulation rates of organic carbon C_{org} and bulk sediment SAR (g m^{-2} yr^{-1}) in the core 06H0035 at different sediment depths. According to the age/depth model in Figure 5-1, the samples originate from sediment that was accumulated in the Baltic Ice Lake, the Ancylus Lake, the Mastogloia Sea and the Littorina Sea. The organic carbon accumulation rate is < 1 g m^{-2} yr^{-1} during the Baltic Ice Lake and rises to c. 3.5 g m^{-2} yr^{-1} during the Ancylus Lake/ the Mastogloia Sea stages. In the Littorina Sea, values vary between 10–56 g m^{-2} yr^{-1}. The highest sediment accumulation rate is c. 1,058 g m^{-2} yr^{-1}during the Littorina Sea stage.*

6 Summary and discussions

Despite poor storage conditions it seems as the achieved results represent changes in the sedimentary environment relatively well.

In Figure 6-1 we have constructed a diagram, which compares accumulation rates of organic carbon (C_{org}AR) with general sediment accumulation rates (SAR) in core 06H0035. In order to facilitate comparison with a similar investigation of sediment from bays along the northeast coast of Germany /Müller 2002/, we have chosen to show C_{org}AR and SAR as g cm^{-2} yr^{-1} instead of g m^{-2} yr^{-1}. In their investigation high organic carbon accumulation rates (C_{org}AR) were noted from sediment receiving high organic matter both from land and from the above water body. Our data suggest similar high C_{org}AR values during the Littorina Sea stage, as in the eutrophicated bays in the southern Baltic Sea.

We have separated samples originating from different Baltic Sea stages in order to show differences in accumulation rates. The separation was possible when limits for these stages were defined by means of salinity variations (based on diatom analyses), dates and lithostratigraphy. Since sub-sampling was made at c. 20–30 cm intervals, thin sandy and silty layers have not been analysed. Thus, no samples originate from sediment accumulated during the Yoldia Sea stage.

The Baltic Ice Lake sediment marked with a grey triangel show low C_{org}AR and SAR. These rates are based on only one sample at 471 cm depth, which most likely represents the uppermost part of a thicker sediment sequence accumulated in the Baltic Ice Lake. Thus, the distance to the sediment source is supposed to be considerable and it is expected that SAR would be higher below the sampled interval.

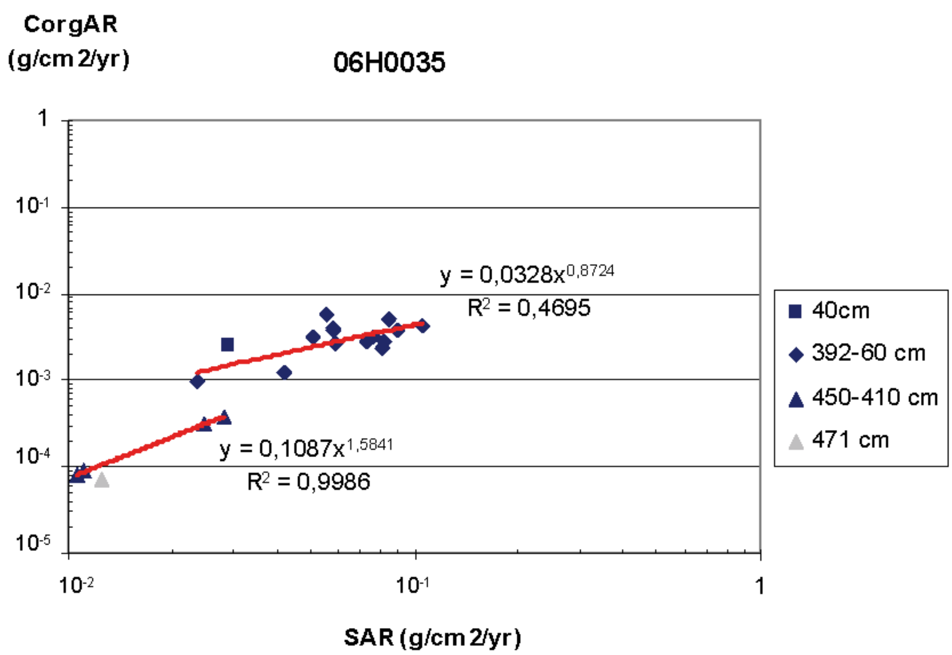

***Figure 6-1**. Logarithmic plot of dry bulk sediment accumulation rates (SAR) versus organic carbon accumulation rates (C_{org}AR) from core 06H0035. A sample from 471 cm depth originates from the Baltic Ice Lake. Samples between 450 cm and 410 cm depth originate from sediment accumulated in the Ancylus Lake (two lower values) and the Mastogloia Sea (two higher values). Samples from 392 cm depth to sediment surface originate from the Littorina Sea stage. Note, that ascending plot values do not follow the accumulation chronology – for example, the uppermost sample from 40 cm depth (marked with a quadrate) shows relatively low C_{org}AR and SAR values.*

The lower trend line, with samples from 450–410 cm depths marked with dark blue triangles, represents accumulation in the Ancylus Lake and the Mastogloia Sea. The position of samples originating from the Ancylus Lake is caused by similar or somewhat higher C_{org}AR and SAR than in the uppermost part of Baltic Ice Lake sediment. Samples originating from the Mastogloia Sea are found in a position between samples from the Ancylus Lake and the Littorina Sea.

The upper trend line represents samples from the Littorina Sea marked with dark blue diamonds. It is obvious that both C_{org}AR and SAR have increased. A dark blue quadratic plot, with relative low C_{org}AR and SAR, represents the uppermost sediment layers accumulated above a sandy layer with gravel at 52–51 cm depth.

Abrupt boundaries between lithological units in core 06H0030, occurrences of sand layers in both cores, and low accumulation rates of sediment (SAR) in core 06H0035, indicate erosive phases during the oldest Baltic Sea stages until the early Littorina Sea at coring sites PSM002118 and PSM002123.

At coring site PSM002118, the bottom sediment of today is characterized by erosion. The uppermost 12 cm consist of gyttja sand, which cover sediment accumulated in the Ancylus Sea (Figures 5-2 and 5-3). This lithostratigraphy suggests low accumulation rates throughout the Littorina Sea period, i.e. the latest 9,500 yrs.

At coring site PSM002123, the bottom sediment of today consists of gyttja sand with gravel indicating that erosion is the dominating factor. According to our time-depth model (Figure 5-1), only 25 cm of sediment has accumulated during the latest 4,000 yrs. Since coarse grained material is found already at 52–51 cm depth (Table 5-2), the erosive period may have started already c. 5,000 yrs ago.

It should be noted that the observed sequences could be the result from a number of different scenarios. Periods of accumulation, transportation and/or erosion could have interacted in an un-predictable way resulting in the observed sequences. Similar observations were made in the sediment sequence PFM004396 accumulated off-shore Forsmark. Also at this site there are indications of low accumulation rate during the last c. 4,000 yrs /Risberg 2005/. These three investigated sites are all situated in more or less open conditions in the present Baltic Sea. Also in more protected bays along the Swedish east coast it is possible that erosive conditions prevail at the bottom /Bergkvist et al. 2003/.

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Appendix 1

Diatom species

Core 06H0030										
Sample distance from sediment surface (cm)	**80.0**	**130.0**	**180.0**	**230.0**	**280.0**	**330.0**	**380.0**	**430.0**	**480.0**	**530.0**
Ancylus Lake freshwater taxa	**431.5**	**192.0**	**22.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Aulacoseira ambigua	13.0	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aulacoseira islandica	404.0	106.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclotella iris	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclotella radiosa	3.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclotella rossi	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymbella helvetica	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymbella sinuata	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gomphonema sp.	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gyrosigma attenuatum	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stephanodiscus medius	4.0	7.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stephanodiscus neoastraea	5.5	24.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brackish-marine taxa	**0.0**	**2.0**	**102.0**	**90.0**	**25.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Caloneis aemula	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Diploneis interrupta	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Diploneis smithii	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0
Diploneis suborbicularis	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
Mastogloia smithii	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0
Melosira sp.	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia granulata	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Nitzschia navicularis	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
Rhoicosphenia abbreviata	0.0	2.0	0.0	1.0	5.0	0.0	0.0	0.0	0.0	0.0
Thalassiosira baltica	0.0	0.0	102.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0
Thalassiosira sp.	0.0	0.0	0.0	7.0	4.0	0.0	0.0	0.0	0.0	0.0
Halophilous taxa	**0.0**	**2.0**	**0.0**	**3.5**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Amphora pediculus	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Caloneis bacillum	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Epithemia turgida	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhopalodia gibba v. ventricosa	0.0	0.0	0.0	1.5	1.0	0.0	0.0	0.0	0.0	0.0
Indifferent taxa	**5.0**	**10.0**	**0.0**	**1.0**	**2.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Amphora libyca	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora ovalis	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
Cocconeis placentula	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Epithemia sorex	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Fragilaria construens	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fragilaria construens v. venter	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown ecology (Varia)	**0.0**	**0.0**	**0.0**	**1.5**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Navicula spp	0.0	0.0	0.0	1.5	1.0	0.0	0.0	0.0	0.0	0.0
Basic sum	**436.5**	**206.0**	**124.0**	**96.0**	**29.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Core 06H0035										
Sample distance from sediment surface (cm)	**25.0**	**75.0**	**125.0**	**175.0**	**225.0**	**275.0**	**325.0**	**375.0**	**425.0**	**475.0**
Ancylus Lake freshwater taxa	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**	**1.0**	**1.0**	**1.0**	**157.5**	**71.5**
Achnanthes clevei	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
Aulacoseira ambigua	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	15.0	3.0
Aulacoseira islandica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.0	59.0
Aulacoseira spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
Cocconeis disculus	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Cyclotella bodanica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Cyclotella iris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0
Cyclotella radiosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	11.5	0.0
Cyclotella rossi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Cymbella sinuata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Diploneis domblittensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
Diploneis maulerii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
Ellerbeckia arenaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0
Eunotia clevei	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0
Gomphocymbella ancylii	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Gomphonema spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0
Gyrosigma acuminatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	1.0
Gyrosigma attenuatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.0
Stephanodiscus medius	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	0.0
Stephanodiscus neoastraea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	1.0
Tabellaria fenestrata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	1.0
Brackish-marine taxa	**127.5**	**118.0**	**171.0**	**191.0**	**153.0**	**245.5**	**188.0**	**176.5**	**7.0**	**0.0**
Achnanthes dispar	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Actinocyclus normanii v.crassus	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Caloneis aemula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
Campylodiscus echeneis	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Chaetoceros spp resting spores	22.0	28.0	9.0	5.0	16.0	13.0	87.0	91.0	0.0	0.0
Cocconeis scutellum	18.0	13.0	13.5	6.0	3.0	4.0	0.0	2.5	0.0	0.0
Cocconeis scutellum v.stauroneiformis	0.0	3.0	6.5	4.5	0.0	0.0	0.0	0.0	0.0	0.0
Coscinodiscus lacustris v.septentrionalis	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclotella caspia	0.0	0.0	0.0	0.0	0.0	0.0	21.0	11.0	0.0	0.0
Diploneis interrupta	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis smithii	3.0	1.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0
Fragilaria fasciculata	17.5	21.0	51.0	30.5	22.0	16.5	17.0	22.5	0.0	0.0
Grammatophora marina	19.0	11.0	49.5	29.5	22.5	21.0	2.0	19.5	0.0	0.0
Hyalodiscus scoticus	11.5	20.5	16.0	23.0	10.0	3.0	2.0	0.0	0.0	0.0
Mastogloia smithii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Melosira j rgensii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
Melosira moniliformis	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula digitoradiata	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Navicula peregrina	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia hungarica	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0
Nitzschia sigma	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Paralia sulcata	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhabdonema arcuatum	5.0	3.0	2.5	21.5	8.0	4.0	0.0	0.0	0.0	0.0
Rhabdonema minutum	14.0	3.0	5.0	52.5	51.0	183.0	40.5	3.0	0.0	0.0

Rhizosolenia calcar avis	1.0	1.0	1.0	1.0	14.0	0.0	0.0	0.0	0.0	0.0
Rhoicosphenia abbreviata	8.0	6.5	12.0	8.5	1.5	0.0	0.0	8.0	6.0	0.0
Synedra crystallina	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thalassionema nitzschoides	2.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thalassiosira baltica	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0
Thalassiosira spp	0.0	3.5	0.0	1.0	3.0	0.0	0.0	0.0	0.0	0.0
Thalassiosria oestrupii	0.0	1.5	1.0	7.0	2.0	0.0	0.0	0.0	0.0	0.0
Thallassiosira lacunosa v.lacunosa	0.0	0.0	0.0	0.0	0.0	0.0	10.5	14.0	0.0	0.0
Halophilous taxa	**9.0**	**4.0**	**2.0**	**10.5**	**1.5**	**1.0**	**3.5**	**15.0**	**30.0**	**1.0**
Amphora pediculus	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0
Cocconeis pediculus	4.0	1.5	0.0	1.0	0.0	0.0	1.0	1.0	2.0	0.0
Epithemia turgida	1.0	2.5	2.0	9.5	1.5	1.0	2.5	12.5	20.0	1.0
Rhopalodia gibba v.ventricosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.0	0.0
Indifferent taxa	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**	**2.0**	**1.0**	**2.0**	**29.5**	**9.0**
Amphora ovalis	0.0	0.0	0.0	0.0	1.0	2.0	0.0	0.0	2.0	1.0
Cocconeis placentula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	15.0	1.0
Cocconeis placentula v.euglypta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0
Epithemia adnata	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.5	0.0
Epithemia sorex	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
Fragilaria brevistriata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Fragilaria construens v.venter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0
Unknown ecology (Varia)	**5.0**	**5.0**	**5.0**	**9.5**	**10.5**	**18.0**	**3.0**	**5.0**	**6.0**	**1.0**
Amphora spp	3.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0
Cymbella spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Diploneis spp	0.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0
Navicula cf. cryptocephala	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Navicula spp	2.0	5.0	3.0	4.0	6.5	15.0	2.0	1.0	0.0	0.0
Nitzschia spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Varia	0.0	0.0	1.0	2.0	2.0	3.0	1.0	3.0	4.0	1.0
Basic sum	**141.5**	**127.0**	**178.0**	**211.0**	**167.0**	**267.5**	**196.5**	**199.5**	**230.0**	**82.5**